Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. LI.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM OCTOBER, 1904, TO MARCH, 1905, LIEUT.-COMMANDER L. M. GARRETT, U.S.N., COMMANDING.

XXXV.

THE DINOFLAGELLATA: THE DINOPHYSOIDAE.

By CHARLES ATWOOD KOFOID AND TAGE SKOGSBERG.

WITH THIRTY-ONE PLATES.

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CAMBRIDGE, U. S. A.
Printed for the Museum.
December, 1928.

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I. INTRODUCTION AND COLLECTIONS

This report deals with the pelagic Dinophysoidae, a tribe of the subclass Dinoflagellata, taken by the U. S. Fish Commission Steamer Albatross during an expedition to the Eastern Tropical Pacific, from October, 1904, to March, 1905, under the leadership of the late Alexander Agassiz.

The Mastigophora or Flagellata are represented in the plankton of all seas, and especially in the tropics, by three main groups, called orders in Doflein's (1916) system, namely, the Chrysomonadina, the Dinoflagellata, and the Cystoflagellata. The first-named group is represented by two divergent families, the Silicoflagellidae and the Coccolithophoridae. Owing to their minute size, the Silicoflagellidae are not taken in numbers in the net plankton even with the finest of silk bolting cloths. One must turn to the centrifuge or filter as an effective means of determining the relative abundance of these representatives of the nannoplankton. The natural filters of Salpa and other feeders upon the nannoplankton also offer remarkable resources for observing this group. The calcareous internal skeletal elements of the Coccolithophoridae formed the coccoliths of the mythical "Bathybius" of the reputed primordial slime discovered by the Challenger Expedition. They are retained in calcareous oozes, but the flagellates which produce them, owing to their small sizes, must also be sought in the nannoplankton or in the digestive tracts of animals feeding thereon.

The Dinoflagellata, on the other hand, are of much larger size and are to be found in great numbers in the plankton taken in silk nets, even as coarse as number 12. They are very numerous in most plankton collections, vying with the diatoms for preëminence in numbers and variety. In northern waters the species are less numerous, but the individuals are at times extraordinarily abundant, the total production massive, and their predominance extreme. In the tropics, on the other hand, the number of individuals of any one species is quite generally small, but the number of species is greatly increased and the processes of differentiation reach here their highest expressions.

The Chrysomonadina and the Dinoflagellata are both included in the Phytomastigina, but the Dinoflagellata contain many holozoic genera and species, notably among the Gymnodinioidae. In this tribe also cell-organs such as ocelli, nematocysts, and tentacles have arisen. Because of these facts and also because of the size and differentiation within the group Kofoid and Swezy (1921) have treated the Dinoflagellata as a subclass coördinate with the Phytomastigina and the Zoömastigina.

The third main group of Flagellata represented in the plankton of the ocean is the Cystoflagellata, containing the widely known genus Noctiluca. This, however, as Kofoid (1919) has shown, is only a highly specialized form of a gymnodinioid dinoflagellate. Since the other representatives of the Cystoflagellata are probably either highly modified dinoflagellates or radiolarians, this group should ultimately disappear from the scheme of classification of the Mastigophora.

The Dinoflagellata are of special interest to the observer of marine life because of their extraordinary power of luminescence. This appears upon stimulation by contact, shock, or chemical irritation, at night only, as shown by experiment. The extent to which luminescence is present among the various dinoflagellates is unknown. It occurs, however, in the Gymnodinioidae in Noctiluca, in the Peridinioidae in Gonyaulax, Ceratium, Blepharocysta, and Peridinium. No critical records of this phenomenon in the Dinophysoidae are known to us, but its occurrence among them is highly probable. Much more remains to be done in relation to the occurrence, location, duration, cause, and nature of the light thus produced in Dinoflagellata generally. These flagellates are also the cause of the notorious outbreaks of "red water" in tropical and warm-temperate seas (Torrey, 1902, and Kofoid, 1911) in which the enormous numbers present give a reddish, brownish, or yellowish discoloration to the surface waters, often for long distances along shore, or in great areas of the off-shore tropical currents.

The collections of the Expedition have been found to contain 132 species of Dinophysoidae, including 82 new species and four new genera. All but one of the known genera are represented or occur in the area traversed by the Expedition and 132 of the 198 known species, or 66.7%, occur in the Expedition material. The species not recorded are mainly those restricted to colder regions or they are very rare tropical forms. The report upon the tribes Gymnodinioidae and the Peridinioidae of this Expedition is in the course of preparation.

The Dinophysoidae are marine and widely distributed in the plankton of coastal waters and in the uppermost 300 fathoms of the illumined zone of the high seas in all latitudes. The species of this group are remarkable for their diversity, for their occasional brilliant coloring, and for the extraordinary evolution of organs of flotation in the form of processes of the body or in the form of lists differentiated as parachutes, sails, wings, or rudders. The thecal wall or cuirass which forms the surface of the body retains throughout the whole group the structural simplicity in the matter of the numbers of its constituent plates found in the simplest and most primitive members. It is bivalved and each valve contains three elements, an epithecal, a cingular, and a hypothecal plate. In certain genera such as Dinofurcula, Amphisolenia, Triposolenia, and in a few of the more divergent tropical species of Dinophysis, the body, while retaining its bivalved simplicity of component parts, undergoes a remarkable evolutionary flare of elongation, bifurcation, multiple branching, and distal twisting into asymmetrical form, all of which serve the function of flotation. In this assemblage of species in which the body proper undergoes these extensive diversifications in form, there is very little evolution of the lists of the girdle and the sulcus.

Since the Dinophysoidae are predominantly, if not wholly, either photosynthetic, or associated with commensal photosynthetic phaeosomes, they find their optimum conditions of life within the lighted zone in the upper levels of the sea. Adaptations to flotation and to hydrostatic adjustments thus loom large in their structural evolution. The structural expansions of the surface lend themselves to regulatory control by resorption, especially at binary fission, and to extension by renewed outgrowth to meet diverse conditions of the environment.

Acknowledgments

No investigation involving so extensive collections, so prolonged search of the diversified constituents of the tropical marine plankton, so much drawing and sketching for purposes of record and comparisons, and the use and clerical analysis of so widely scattered a literature, can be brought to completion without the collaboration of several workers.

During the Cruise the senior author made daily observations and notes on the plankton as collected, and throughout the work has continued in close collaboration in the microscopical, morphological, and systematic analysis of the material. He has resolved the structure of the individuals utilized in the elaborately finished drawings, and supervised the completion of the illustrations. He is responsible for the plan of the work, of the method of treatment of species, and jointly with Dr. Skogsberg for the morphological analysis and systematic arrangement of the text.

The manuscript of Part II of the work has in the main been prepared by Dr. Skogsberg, with the continuous collaboration and joint analysis of all moot points with the senior author.

The original drawings and records of occurrences based on the painstaking examination of the plankton collections are the work of Mrs. Michener from May 1905 to June 1908, and from June 1909 to July 1910. Her sketches have been utilized in the text figures and her detailed drawings, finished in pencil, have been transferred and prepared for reproduction on Ross board by Mr. A. B. Streedain. His skill in portraying contour and detail by this method has contributed much to the accuracy and beauty of the plates.

We are indebted to the late Dr. Alice Robertson for assistance in organizing the multitudinous details of several of the genera.

For grants in aid of the work we are also indebted primarily to Alexander Agassiz, who after the close of the Cruise continued to manifest a deep interest in the progress of the work; and to the Carnegie Institution of Washington, through the late Dr. Alfred G. Mayor, Director of the Department of Marine Biology, for a grant for assistance in the preparation of the manuscript.

The work could not have been completed except for substantial grants made by the Board of Research of the University of California for the past four years.

Methods of Collecting

The plankton collections were made, in the main, by the following methods:— Under normal conditions, except on the Manga Reva-Acapulco line, a collection was made each evening at 8 P.M. with number 12 and number 20 silk nets towed from the port boom on either side of the large 000 plankton net. The depth at which these nets fished was generally within the uppermost fathom. The nets were out for about twenty minutes.

The same nets were used in the morning collections at 8 A.M., but at this time sufficient cable was payed out to lower them to a depth of 300 fathoms. They were towed for twenty minutes, steaming slowly, and were then hauled in. They were open and fishing during both descent and ascent and the catch therefore represented the plankton from all levels traversed by the nets, but mainly from the level at which they were towed for twenty minutes, since the total time of lowering and hoisting was not more than one third of the time of towing at the lower level.

As a rule the number 12 and number 20 nets were attached to the cable when hydrographic samples were taken at a depth of 800 fathoms. These catches are thus from a vertical column of water from this depth to the surface.

On the line from San Francisco to Panama collections were made in vertical hauls with the number 12 and number 20 nets attached in series to a vertical bar lashed to the cable. This method was abandoned after leaving Panama.

The plankton nets used in these collections were of the Kofoid (1898) type, of number 12 and number 20 Dufour silk bolting cloth respectively, fourteen inches in diameter at the top, five feet in length, with a brass bucket at the lower end. Two such nets may be cut readily from two yards of silk and are of a size convenient to handle. They have a surface for filtration of such proportions to the opening that the coefficient of filtration is low.

These plankton collections made regularly in course of the routine of the Cruise were supplemented from time to time by wing-net catches taken in small nets (four inches in diameter) tied to the upper bars of the runners of the trawl when trawling. These catches contain samples of plankton from bottom to surface, since they were so suspended as to fish during both descent and ascent as well as while trawling.

An attempt was also made to utilize a silk filter connected with the ship's circulating system near the intake and running continuously during the Cruise. A number 20 silk net with a fourteen-inch opening was suspended in a vertical cylinder with suitable overflow for the filtered water. This net received a continuous stream from a pipe tapped into the circulating system within twenty feet of the intake. It functioned satisfactorily for the first fortnight, but its efficiency was destroyed by the accumulation of attached plankton-feeding organisms, principally barnacles, as shown by their faeces and remnants, which grew along the pipe line and so reduced the plankton in amount as to render the catches of little significance. Iron rust and the quick disintegration of the silk net in the warm waters of the tropical seas also added to the inefficiency of this method. Catches were made by this method for over half of the Cruise, but their contents are meager and add nothing of value to the material.

Local surface and a few short vertical hauls with the number 12 and number 20 nets were made in the harbors at Panama, Manga Reva, and Acapulco. Conditions at Callao, at Chatham Island in the Galapagos, and at Easter Island respectively were so similar to those of the environing ocean that local collections at these points were of no great significance. In the main these local collections added little to the material of the Dinophysoidae, since they were remarkably poor in organisms of this group except for a few of the hardier types which were invariably found also in the coastal waters.

As will be seen in the station lists our main resources were in the regular hauls from the surface and from 300–0 fathoms, especially in the latter, which, as a rule, have a wider range of species since they contain the contributions from practically all zones in which dinoflagellates normally live. The catches of the wing-nets from the greatest depth and those at the hydrographic stations from 800 fathoms contained no additional Dinophysoidae not found in hauls from 300 fathoms and no noticeable change in the proportionate representation of the species.

Distribution of Collections

The collections were taken at 127 stations on the Cruise. A list will be found in Part III, together with the pertinent data. A fuller account appeared in the General Report of the Cruise by Mr. Agassiz (1906). Their distribution on the six lines of the Expedition is shown in Plate **24**. Stations 4571 to 4627 are on the San Francisco-Panama line, 4631–4671 on the Panama-Callao line, 4673–4692 on the Callao-Easter Island line, 4694–4716 on the Easter Island-Galapagos line, 4717–4739 on the Galapagos-Manga Reva line, and 4740–4746 on the Manga Reva-Acapulco line.

The collections at regular stations number 225. Of these eighty-three are from the surface, twenty-four more from Salpa stomachs treated as from the surface, ninety-four from 300–0 fathoms, twenty from 800–0 fathoms, and four from various other depths to the surface. The surface hauls, those from Salpa, and those from deeper levels are distributed on the six lines of the Expedition as follows: — on the (first) San Francisco-Panama line, 19, 2, and 19; on the (second) Panama-Callao line, 21, 5, and 29; on the (third) Callao-Easter Island line, 11, 2, and 15; on the (fourth) Easter Island-Galapagos line, 13, 6, and 19; on the (fifth) Galapagos-Gambier line, 9, 6, and 31; and on the (sixth) Gambier-Acapulco line, 10, 3, and 5, respectively. In addition to these from the surface, from Salpa, and from the deeper levels there were incidental plankton collections at the anchorages at Panama, off Easter Island, and in the harbor at Acapulco, Mexico. These are, however, utilized only incidentally and are not treated as regular stations of the Cruise.

The few collections made with the Chun plankton closing net are also omitted as they add nothing of systematic significance to the Dinoflagellata from the other collections.

The distribution of the pelagic stations in the several oceanic currents is shown in detail in the following table: —

DISTRIBUTION OF PELAGIC STATIONS

	Total number of stations	Surface and vertical	Surface only	Total of vertical	Total of surface
California Current	4	4	..	4	4
Mexican Current	13	1	8	5	9
Panamic Area	17	2	11	6	13
Peruvian Current	27 [1]	15	5 [1]	22	20 [1]
Easter Island Eddy	10	..	5	5	5
Galapagos Eddy	4	..	2	2	2
South Equatorial Drift	45	1	22	23	23
South Equatorial Current	3	..	2	1	2
Equatorial Counter Current	2	..	2	..	2
North Equatorial Current	2	..	2	..	2
	127	23	59	68	82

[1] One of these is from Salpa only.

Examination of Collections

The plankton catch, as soon as it arrived on board ship, was released from the bucket into glass sorting dishes, treated with chloretone for anaesthetizing the larger organisms, and promptly fixed in 10% formalin. The plankton consisted of the fine sedimented residues remaining after the larger organisms such as the Coelenterata, larger Copepoda, Amphipoda, pelagic Mollusca, Tunicata, and larval fishes were removed. Small amounts were occasionally preserved in various fixing agents. This Report is, however, based on the formalin material since formalin, far better than any other fluid, preserves and reveals the skeletal structures upon which in final analysis the systematic relationships are based, and in which individual variations are revealed.

The collections were examined in the original sea-water and formalin without other treatment than replacing the loss by evaporation with distilled water in some cases. It is thus often possible to roll the organisms about under the cover-glass and to secure diverse views in many cases of the same individual, and sometimes also to shatter it into its constituent plates when this is necessary. The method has the disadvantage of not making it possible to reëxamine the same individual with certainty a second time. There is, unfortunately, no safe and certain method of sealing permanent microscopical mounts in formalin. Whenever it was desired to isolate some special individual organism, the material under the cover-slip was washed carefully into a vial instead of into the general catch. The type specimens and cotypes are thus preserved.

After a sufficient knowledge of the more abundant species had been acquired, each catch was searched by use of the mechanical stage until no additional species were detected. The lists of occurrences at the record stations were thus made up. The station lists (Part III) incorporate these data as modified by all later more critical revision.

In order to have at least a quasi-quantitative record of *relative* frequency in individuals of the component species of each catch, records were made during the search of each collection of the number of individuals seen of each species, up to the total of the first one hundred individuals seen. Thereafter each additional species detected at that station was merely recorded as "also present." The number of individuals recorded is thus the percentage frequency at that station. These numbers have been used in mapping the local distribution of the genera. The numbers are recorded in Roman numerals at the ends of the radii from the circles marking the locations of stations on the route (Plate **24**).

The records of relative frequency used in the discussions of the distribution of each species, thus refer solely to the relative numbers of the different species in the one catch and give no indication of relative numbers of the species in question in different catches.

The data thus accumulated have involved certain difficulties and discrepancies, especially in those cases in which a species, originally conceived in the wider sense, was later in the preparation of the manuscript broken up into several species by the withdrawal of divergent groups. In all such cases only those individuals which had been drawn were perforce included in the groups thus segregated off. All others recorded in the original analysis were left under the original specific name in the later restricted sense.

The concept of each species in the inception of the work of necessity rested upon previously published figures or upon the characters of the first individual whose structures were analyzed and from which the first figures were made. As the allocating of the individuals to definite species progressed, our concept was widened or modified by the detection of variants from the figure of the type individual. To meet this condition and to make available for purposes of comparison the structure of individuals of the same species from different localities, it became necessary to sketch the outline of the most apparent and easily determined parts of an ever-increasing number of individuals. This was especially true in most cases of the more abundant and generally more widely varying complexes. These groups of sketches constituted the great mass of data on which the manuscript has been based, and they form the sources of the text figures which illustrate the range of variability and the aberrant types which are included within our concept of the several species.

The fact should be noted that these habitus sketches represent the range of variation observed and not the normal distribution within that range. The constant tendency quite naturally in the premises was to make graphic record of *all the aberrant* individuals even though these constituted only a very small proportion of the total representatives of the species. It thus follows that the diversity in the few individuals within the species is emphasized rather than the uniformity among the many.

Number of Genera and Species

The microplankton of the Expedition contains a total of 132 species of Dinophysoidae. No less than eighty-eight new species have been established in connection with this Report. Of these new species thirty-two were described by Kofoid (1907a), twenty-nine by Kofoid and Michener (1911), and twenty-seven are described in the present paper. Of these twenty-seven species, twenty-six were found in the material of the Expedition; one (*Phalacroma paulseni*, p. 60) was based on a figure published previously (Paulsen, 1911b, p. 305, fig. 2). The following is a list of the new species found in the material of the Expedition:

Described in Kofoid (1907a)

Phalacroma
- lenticula
- reticulatum
- striatum

Dinophysis
- triacantha

Amphisolenia
- asymmetrica
- bispinosa
- brevicauda
- clavipes
- curvata
- extensa
- laticincta
- lemmermanni
- palaeotheroides
- projecta
- quadrispina
- quinquecauda
- rectangulata
- schröderi

Dinofurcula (as Phalacroma)
- ultima

Triposolenia
- longicornis
- fatula
- ambulatrix

Ornithocercus
- carolinae
- heteroporus

Parahistioneis (as Histioneis)
- garretti
- reticulata

Histioneis
- carinata
- josephinae
- longicollis
- navicula
- paulseni
- pulchra

In Kofoid and Michener (1911)

Phalacroma
- circumcinctum
- expulsum (as Dinophysis)
- favus
- fimbriatum
- giganteum
- limbatum
- porosum
- praetextum
- pulchrum
- turbineum

Dinophysis
- collaris

Histiophysis (as Dinophysis)
- rugosa

Amphisolenia
- astragalus
- quadricauda
- truncata

Ornithocercus
- truncata
- orbiculatus

Parahistioneis (as Histioneis)
- diomedeae
- karsteni
- rotundata

Histioneis
- costata
- elongata
- hippoperoides
- hyalina
- inclinata
- inornata
- panda
- reginella
- striata

Described in this Report

Heteroschisma
- aequale
- inaequale

Phalacroma
- apicatum
- bipartitum
- contractum
- cuneolus
- lativelatum
- lens
- mucronatum
- protuberans
- pyriforme

Dinofurcula
- ventralis

Dinophysis
- exigua
- jörgenseni
- monacantha
- okamurai
- similis
- swezyi
- trapezium
- urceolus

Amphisolenia
- complanata
- elongata

Triposolenia
- intermedia

Parahistioneis
- paraformis

Histioneis
- pacifica
- panaria

Besides the new species mentioned above, the following new specific and subspecific names are introduced in this Report: —

Dinophysis baltica (p. 229) for *D. ovum* Schütt var. *baltica* Paulsen (1908)

Dinophysis caudata f. *acutiformis* (p. 227) for *D. homunculus* var. *ventricosa* Pavillard (1916)

Dinophysis recurva (p. 228) for *D. lenticula* Pavillard (1916)

Dinophysis reniformis (p. 228) for *D. pavillardi* Schröder (1906a)

As shown in the following table there are in all fourteen genera, of which five are new.

	Total number of specific and subspecific names established in literature	Number of valid species and subspecies	Number of new species and subspecies described in connection with this Report	Total number of species and subspecies found by the Expedition
Thecadinium, gen. nov.	2	2	..	..
Pseudophalacroma	1	1	..	..
Oxyphysis	1	1	..	..
Heteroschisma, gen. nov.	2	2	2	2
Phalacroma	73	50	23	31
Dinofurcula, gen. nov.	2	2	2	2
Dinophysis	123	52	10	20
Histiophysis, gen. nov.	1	1	1	1
Amphisolenia	32	31	19	26
Triposolenia	9	9	4	8
Ornithocercus	16	8	4	9
Parahistioneis, gen. nov.	9	9	6	7
Histioneis	45	28	17	24
Citharistes	2	2	..	2
Totals	318	198	88	132

Of the five new genera, four — viz., Heteroschisma, Dinofurcula, Histiophysis, and Parahistioneis — are based on species found in the material of the Expedition; one, Thecadinium (p. 32), was founded on two previously described species, *Amphidinium kofoidi* var. *petasatum* Herdman (1922, p. 26) and *Phalacroma ebriola* Herdman (1924, p. 34).

Up to April 1, 1926, there have been described 318 species and subspecies in the Dinophysoidae. Of these only 198 are regarded as valid. Of the 198 valid species 132 or 66.7% of the known species were found in the collections of the Expedition. The eighty-seven new species constitute 65.9% of the total number (132) found on the Expedition, and an increase of 80% to the 111 species previously known. This has resulted from the large representation of the rich tropical fauna in the collections and from the intensive search of the richer plankton collections and of the contents of Salpa stomachs for the rare and often minuter species.

The accompanying table records under each genus the number of species and subspecies in literature, the numbers of these which in our opinion, with some reservations, are to be considered valid, the numbers of new species established in connection with this Report, and the total numbers of species found in each of fourteen genera.

Orthogenesis and Convergence

The species are arranged within the genera according to their structural resemblances, upon the assumption that the degrees of structural resemblances are indications of commensurate degrees of genetic relationship. It is fully realized that such resemblances may, however, not be accurate quantitative measures of the degrees of genetic relationship, or unequivocal demonstrations of genetic origins. Nevertheless they are the only evidences of the nature and results of the evolutionary process in this highly diversified group, and while their quantitative value may well be quite hypothetical, their qualitative significance is undoubtedly of high value in showing the method, direction, and trend of the evolutionary process in the group.

The record is all the more definite and clear because of the fact that it is registered in the non-mobile exoskeleton or theca of the body and its outgrowths. While it is true that the more superficial structures such as lists, fins, and sails are subject to regulatory modifications and to considerable individual variation, we nevertheless find beneath such variation the more basic similarities and differences, which may serve as guides in the establishment of genetically related groups.

The groups of species thus established within the genera exhibit relationships in structure among themselves which make feasible their grouping in a dendritic, diverging fashion, suggestive of phylogenetic descent.

Within the subgenera or other secondary groups of several of the genera, the known species, even though there be but a few, may usually be arranged in something of an orthogenetic fashion according to the degree of specialization of one or more structural features, in ascending series from the simpler to the more complex. These series, which are not always equally spaced, are orthogenetic, since they appear to exhibit progressive (or regressive) movements in their evolution or speciation.

The orthogenetic tendencies within these lines may be summarized as (*1*) increase in size; (*2*) increase in relative length, especially in Amphisolenia and Triposolenia; (*3*) branching or extensions of the body, as in Amphisolenia and Dinofurcula; (*4*) increase in the development of the reticulations on the surface of the theca, often by heavier ribbing and larger size of the reticulations; (*5*) extension and ribbing of the anterior and posterior cingular lists about the girdle culminating in *Ornithocercus splendidus* and *Histioneis josephinae;* (*6*) extension and structural modifications of the right and left sulcal lists, as in Histioneis; and (*7*) the progressive elaboration of the phaeosome chamber in Ornithocercus, Histioneis, Parahistioneis, and Citharistes.

The net result of our analysis of the process of speciation in the Dinophysoidae has been a growing conviction that there is in this group a more or less orderly divergence from primitive species with a small, spheroidal body, with a smooth undifferentiated surface, low, simple cingular and sulcal lists, and no phaeosome chamber, toward the more elaborate types along a number of divergent lines. Furthermore the progress of this process of evolutionary divergence is marked to a surprising degree by an orthogenetic aspect. The evolutionary steps seem to be represented in living Dinophysoidae, at least to such a degree that the path presumably followed in the process is still indicated by them. It may be that they represent only laterals along this path, but these still-existing types have seemingly remained near enough to their levels of divergence from the main paths to mark their courses.

A striking feature is that the process of speciation has proceeded in this group to a marked degree of specialization in the seeming absence of sexual reproduction. There is as yet no evidence of the occurrence of this mode of reproduction in the Dinophysoidae.

Another striking feature of the evolution of the Dinoflagellata is the fact that there is no evidence of closely related species being isolated from each other either geographically or bathymetrically. Both the most primitive and the most divergent and highly specialized genera and species occur together in the same region, and very closely related forms are not infrequently recorded in the same surface catch or from the same Salpa stomach. Specific adaptations to zones of illumination and temperature undoubtedly exist, but diurnal migrations in heliotropic responses to the rhythm of solar energy and to other cosmic and meteorological factors may be expected to produce some vertical extension of the zones inhabited by each species, and to vary these extensions with changing conditions. Save for the larger differences due to latitude and depth, areal distribution affords little aid in the solution of evolutionary problems. Along broad lines the species are widely distributed in all seas in waters of comparable temperatures and illuminations. The ecologic niche which each fills is in reality a wide shelf girdling the tropical seas and extending to a considerable depth. Moreover, many of these areas of distribution appear to be to a large degree coincident, even within the species of a single orthogenetic line. The factor of geographical isolation, so significant among birds and mammals in which feeding range and sexual behavior so immediately affect the genetic processes and evolutionary progress, sinks into relative insignificance, if indeed it ever had any considerable part, in the process of speciation among the Dinophysoidae.

It is also interesting to note that the most highly specialized genera such as Citharistes and Histioneis and the most highly specialized species within the genera, are, in the main, relatively rare in individuals. The development of adaptive structures of a highly specialized type is not in many instances accompanied by a corresponding reproductive vigor or equal enlargement of survival value.

Attention may also be invited to another phenomenon of evolutionary significance which has emerged in the analysis of the Dinophysoidae, namely, the appearance in Heteroschisma and Pseudophalacroma of a structural character identical in location and morphological relations with a fundamental structural feature of the Peridinioidae. This character in Heteroschisma is the marking out by structural lines of an area corresponding to plate 1 of the postcingular series of the latter tribe.

The Peridinioidae differ from the Dinophysoidae in the facts that the skeletal elements of the former are (*1*) in five (or six) instead of three horizontal zones and (*2*) that the pre- and postcingular zones have five instead of two plates or elementary subdivisions. It is a striking fact that the postcingular zone of Heteroschisma has developed the structural features of the first plate of the postcingular series next to the flagellar pore, sulcus, and blepharoplast (see Hall, 1925). This is illustrated in detail in the discussion of *Heteroschisma aequale* and *inaequale* (Plate 1). In the genus Pseudophalacroma there are evidences of a comparable emergence of a structural field homologous in morphological relations with plate 1 of the precingular series and also located near the flagellar pore. Both of these genera are among the less specialized members of the tribe, although the species of Heteroschisma have a somewhat advanced development of the surface.

The phenomenon here observed is of the same category as that described by Kofoid (1926) in *Oxyphysis oxytoxoides*, in which a rather highly specialized genus, Oxyphysis, of the Dinophysoidae, has the facies of Oxytoxum, of the Peridinioidae. In the cases of Heteroschisma and Pseudophalacroma the convergence of characters is found in a single one of the plates or unitary elements of the skeleton. In the case of Oxyphysis it appears in the external form of the body as determined by the total skeleton, the location of the girdle and sulcus, and the shaping of the two apices. These three instances of convergent features of structure between the Dinophysoidae and the Peridinioidae lead strongly to the inference that the structure of the species or larger systematic category, as well as that of the individual, may not wholly reveal its genetic potentialities. The Dinophysoidae appear to carry potentialities of producing in the course of their evolution, in these three genera only, so far as is known, certain structural features which belong primarily in the tribe Peridinioidae and are characteristic of it, in the case of the plate of Heteroschisma and Pseudophalacroma, or of a single genus in the tribe, as in the case of Oxyphysis.

Procedure used in the Accounts of Genera and Species

Nearly all the descriptions of genera, species, and subspecies published up to the present time are short and incomplete, with but few data concerning the nature and amplitude of variation. Ours is the first attempt at a more or less exhaustive treatment of the various systematic units. A consequence of this is that we have had to elaborate a new technique of description and treatment. Our basic principle is to keep everything that implies comparisons as stereotyped as possible in order to obtain the greatest possible perspicuity and ease of comparison and reference. A usual shortcoming of current taxonomic papers is that the various systematic descriptions are not treated in a consistent arrangement and manner. Frequently it is necessary to traverse a mass of facts in order to find the one that is desired. In short papers this defect may be more or less inconsequential, in large monographs and in genera with numerous species it creates almost insuperable difficulties and an annoying loss of time. In the present paper each character has the same relative place in all of the diagnoses and descriptions and in so far as possible is discussed in the same phraseology.

The families have been treated under the following headings: — (*1*) Diagnosis; (*2*) Subdivisions. Relationships among the genera; (*3*) Distribution; (*4*) Key to the genera.

In the case of the genera the following arrangement has been adopted: — (*1*) Synonyms; (*2*) Diagnosis; (*3*) Organology; (*4*) Reproduction; (*5*) Distribution; (*6*) Historical discussion; (*7*) Adaptive and systematic value of the characters. Principles used in the descriptions of the species; (*8*) Subdivisions. Relationships among the species; (*9*) Key to the species.

These are the subheadings under each species: — (*1*) Synonyms; (*2*) Diagnosis; (*3*) Description; (*4*) Dimensions; (*5*) Variations; (*6*) Comparisons; (*7*) Synonymy; (*8*) Occurrence.

On account of the fact that the various genera are quite decidedly different morphologically, it is impossible to apply the same procedure of description to all of them. The differences in descriptive technique are, however, not very great and inside each genus the treatment conforms to the type established. In the general account of most genera a diagrammatic figure elucidates our terminology and methods of measuring proportions and angles.

At the end of the description of each species information is given as to the number of specimens, the proportions of which were measured. With the exception of the length of the body, all statements as to proportions and dimensions refer to these specimens only. The following random example: — "the posterior cingular list is 0.50 (0.49–0.53) the length of the body from the apex" should be understood as follows: — the figures inside the parenthesis indicate the range of variation; the figure in front of the parenthesis, the average. This average is not weighted and based on random sampling, but is the average of the drawings which are based on selected specimens, some of which were "typical," others more or less extreme and selected because of their departure from the norm.

In describing curves: — gently, moderately, and strongly (or boldly) convex or concave indicates an increasing degree of convexity or concavity (quantitative); in order to express an increasing uniformity of curvature, the terms irregularly, somewhat irregularly, subuniformly, and uniformly convex or concave (qualitative) are used.

In recording the species all the samples from the same depth are counted as a single record; for instance, if a species is found at one station in two or more samples from 300 fathoms to the surface, all these records are considered as one. In the accounts of the distribution of the species, according to previously published literature, the material is arranged geographically. Beginning with the data from the northern Atlantic Ocean we proceed south to the Antarctic Ocean; then the data from the Mediterranean, proceeding from the west to the east; from the eastern Mediterranean we proceed through the Red Sea, the Gulf of Arabia, the Indian Ocean, Antarctic Ocean, Malay Archipelago, Australian waters, Chinese and Japanese waters, and finally in an easterly direction across the Pacific Ocean.

II. SYSTEMATIC ACCOUNT

Classification

Phylum 1. Protozoa Goldfuss
 Superclass 1. Plasmodroma Doflein
  Class 1. Mastigophora Diesing
   Subclass 1. Dinoflagellata Bütschli
    Order 1. Adiniferidea Kofoid and Swezy
     Tribe 1. Athecatoidae Kofoid and Swezy
     Tribe 2. Thecatoidae Kofoid and Swezy
    Order 2. Diniferidea Delage and Hérouard emend.
     Tribe 3. Gymnodinioidae Poche emend.
     Tribe 4. Amphilothoidae Kofoid and Swezy
     Tribe 5. Peridinioidae Poche emend.
     Tribe 6. Dinophysoidae Kofoid
      Family 1. Dinophysidae Stein emend.
       Genus 1. Thecadinium, gen. nov.
        2. Pseudophalacroma Jörgensen
        3. Oxyphysis Kofoid
        4. Heteroschisma, gen. nov.
        5. Phalacroma Stein
        6. Dinofurcula, gen. nov.
        7. Dinophysis Ehrenberg
        8. Histiophysis, gen. nov.
      Family 2. Amphisolenidae, fam. nov.
       Genus 9. Amphisolenia Stein
        10. Triposolenia Kofoid
      Family 3. Ornithocercidae, fam. nov.
       Genus 11. Ornithocercus Stein
        12. Parahistioneis, gen. nov.
        13. Histioneis Stein
      Family 4. Citharistidae, fam. nov.
       Genus 14. Citharistes Stein

DINOPHYSOIDAE

"der Dinophysiden" STEIN, 1883, p. 23.
Dinophysida BÜTSCHLI, 1885, p. 1009.
Dinophyseae SCHÜTT, 1896, p. 26.
Dinophysidae DOFLEIN, 1909, p. 464; 1911, p. 530; 1916, p. 436; KOFOID & MICHENER, 1911, p. 268; LEBOUR, 1925, p. 75.
Dinophysiaceae PAVILLARD, 1916, p. 44; JÖRGENSEN, 1923, p. 3.
Dinophysaceae OLTMANNS, 1922, p. 54.
Dinophysoidae KOFOID, 1926, p. 215.

Diagnosis:— Dinoflagellata with well-developed girdle and sulcus, with permanent longitudinal and transverse flagella located respectively in sulcus and girdle, with a single flagellar pore located in sulcus, and with body surrounded by theca composed of two subequal halves joined approximately in sagittal plane and, as a rule, made up of but three plates, epithecal, cingular, and hypothecal. Girdle usually anterior in position.

Exclusively marine.

DERIVATION. SUBDIVISIONS. RELATIONSHIPS AMONG THE FAMILIES

While several investigators have united the dinophysids and the peridiniids (*e.g.*, Lebour, 1925), we have adopted Kofoid's (1926) decision that they form two separate tribes, viz., Dinophysoidae and Peridinioidae, and have done so on account of the fundamental structural differences and because of the fact that all available evidence appears to support the opinion expressed in the pedigrees of the dinoflagellates constructed by Bütschli (1885, p. 1016) and Kofoid and Swezy (1921, p. 84), viz., that these groups have evolved independently from the tribe Gymnodinioidae.

In all the discussions of the interrelationships of the various taxonomic units of Dinophysoidae, we have (contrary to Kofoid and Swezy, 1921, p. 84) adopted the viewpoint that this tribe evolved from ancestral forms very closely resembling *Gymnodinium ovulum* Kofoid and Swezy (1921, pl. 5, fig. 58). These ancestral forms might be characterized briefly in the following manner:— (*1*) body small and spheroidal, its length, depth, and width subequal; (*2*) girdle subequatorial, its distal portion not displaced; (*3*) sulcus short on both epitheca and hypotheca; (*4*) cingular and sulcal lists small and structurally undifferentiated; (*5*) without accessory lists or sails. Small size and subrotund shape of body are features characteristic of the simply organized members of most of the genera of Dinophysoidae, *e.g.*, Heteroschisma, Phalacroma, Dinophysis, Ornithocercus, Parahistioneis, and Histioneis. It is an almost universal rule in this tribe that the increase in structural complexity is accompanied by an increase in size. The distal portion of the girdle is displaced only in one of the known species of Dinophysoidae, viz., in *Dinofurcula ultima* (Plate 5, fig. 4, 6). The shortness of the hypothecal sulcus is a characteristic of most genera, and its anterior prolongation occurs but seldom and only in genera (Pseudophalacroma, Oxyphysis) which show other indications of primitiveness. There is within most of the large genera a distinct tendency for the cingular and sulcal lists to increase in size and structural complexity; and accessory lists and sails occur only in a few genera and very seldom in the simply organized members of these. The assumption that the girdle originally was equatorial in position is somewhat more uncertain than the others. In Gymnodinioidae this structure has no fixed position but may be found anywhere between the apex and the antapex; in Amphidinium it is anterior, in Gymnodinium more or less equatorial, and in Torodinium posterior. In Dinophysoidae, on the other hand, it is either subequatorial or more or less anterior. The reasons for assuming the equatorial position as the most primitive in Dinophysoidae are as follows:— (*1*) the girdle is anterior in all the more or less highly differentiated families, viz., in Amphisolenidae, Ornithocercidae, and Citharistidae, and Histioneis, the most complex of all the genera of this tribe, is characterized by a smaller epitheca than any other genus; (*2*) in the Dinophysidae the epitheca is small in the two most differentiated genera, viz., Dinophysis and Histiophysis, and relatively large in most of the more or less primitive genera, Pseudophalacroma, Oxyphysis, Heteroschisma, and Phalacroma. The only striking exception to this rule is Thecadinium, and this genus is of uncertain systematic position and probably did not develop from the same ancestral forms as the rest of the family, but from Amphidinium-like forms.

The genera of the tribe Dinophysoidae are assigned to one of the four families, viz., Dinophysidae, Amphisolenidae, Ornithocercidae, and Citharistidae, all of which are either new or emended. As to the interrelationships of these four families but little can be said with any degree of certainty. The Dinophysidae comprises the structurally simplest members and presumably evolved directly from Gymnodinioidae. Amphisolenidae may have sprung from the same ancestral forms of Dinophysis which evolved into *Dinophysis caudata* and *D. miles* and which were characterized by the tendencies toward elongation, attenuation, and posterior bifurcation. Ornithocercidae presumably evolved from some ancestral forms closely related to Phalacroma, Dinophysis, and Histiophysis. Citharistes approaches Dinophysis in the shape and size of the anterior cingular and the sulcal lists. It differs strikingly from this genus in the differentiation of the dorsal portion of the girdle into the large phaeosome chamber. This chamber probably originated by a gradual increase in the dorsal width and concavity of the transverse furrow, such as can be seen in the genus Parahistioneis (*cf.* for instance, *P. reticulata*, Plate 19, fig. 7).

1. DINOPHYSIDAE Stein, 1883, emend.

Diagnosis: — Body of diverse shapes; ratio between length and depth usually somewhere between 1.0:1 and 1.7:1. Epitheca small, disk-like to large, sometimes even as large as hypotheca. Transverse furrow narrow and, as a rule, about as wide dorsally as ventrally; its dorsal width less than 0.30 the greatest depth of body. Cingular lists, when present, subhorizontal or inclined anteriorly, narrow or of moderate width, usually less than 0.30 the greatest depth of body. Phaeosomes occur only in one genus. Length of body, 21–148 μ.

Marine, usually eupelagic, in all seas.

Subdivisions. Relationships among the Genera

Dinophysis Ehrenberg (1840a), the type genus of Dinophysidae, was the first genus of the family to be established. Later Phalacroma was introduced by Stein (1883), Pseudophalacroma by Jörgensen (1923), and Oxyphysis by Kofoid (1926); and in the present paper four new genera, viz., Heteroschisma, Dinofurcula, Histiophysis, and Thecadinium, are described. Of these eight genera, Phalacroma and Dinophysis are by far the largest, the former comprising forty-seven, the latter forty-one presumably valid species. Pseudophalacroma was founded on a single species previously assigned by Stein (1883) to Phalacroma. Oxyphysis also comprises but one species, *O. oxytoxoides* Kofoid (1926). Of the four new genera, Heteroschisma is based on two new species; Dinofurcula on two species, one of which is new, the other previously described and figured by Kofoid (1907a) under the generic name of Phalacroma; and Histiophysis on one species previously (Kofoid and Michener, 1911) referred to Dinophysis. Thecadinium comprises two species, viz., *T. petasatum* and *T. ebriolum*. Of these, the first was described and figured by Herdman (1922, p. 26) under the name of *Amphidinium kofoidi* var. *petasatum* and later (Herdman, 1923, p. 34) transferred to Phalacroma as *P. kofoidi*. The second species was introduced by Herdman (1924, p. 34) as *Phalacroma ebriola*.

The members of Thecadinium are, on the whole, the most primitive representatives of this family. Indeed, even their assignment to the tribe Dinophysoidae must be considered as uncertain. It is true that they are characterized by a distinct theca (Lebour, 1925, pl. 11, fig. 1c, d), but the thickness of the pellicle in Gymnodinioidae is variable, and it appears probable that there are stages intermediate between unarmored forms with exceedingly thin and flexible pellicle and armored ones, *i.e.*, forms in which the pellicle has become more resistant and inelastic. If the theca is left out of consideration, the two species of Thecadinium are structurally much closer to Amphidinium than to any of the genera of Dinophysoidae. They evidently lack cingular lists and the left sulcal list is very narrow or absent. Furthermore, their longitudinal furrow appears to be deep, while in all the other members of this tribe it is flat or but slightly impressed. The close structural similarity between Amphidinium and Thecadinium indicates that the latter genus evolved directly from the former. It may be noted in this connection that the anterior position of the girdle is considered as secondary; in other words, in this respect these two genera are more advanced than some of the highly differentiated members of Phalacroma (*e.g.*, *P. limbatum*, Plate 3, fig. 5).

Next to Thecadinium, Pseudophalacroma and Oxyphysis appear to be the most primitive. This assumption is based on the following structural features: — (*1*) the longitudinal furrow continues anteriorly beyond the anterior cingular list (Stein, 1883, pl. 18, fig. 1; Kofoid, 1926, pl. 18, fig. 1); this peculiarity is found in a great number of the representatives of Gymnodinioidae, but in no other members of Dinophysoidae (Jörgensen, 1923, p. 4); (*2*) the epitheca is comparatively high and deep; (*3*) the cingular lists are very narrow and lack structural differentiation; (*4*) the sulcal lists are small, and the left of them lacks the three ribs and the posterior angularity characteristic of most of the members of the higher genera, viz., Phalacroma and Dinophysis. Pseudophalacroma appears to be very close to the evolutionary line that led to the development of Phalacroma and Dinophysis. Oxyphysis, on the other hand, forms an aberrant and in many respects highly differentiated branch that split off at a very early stage. It embodies many of the tendencies inherent in the peculiar genus Oxytoxum of the tribe Peridinioidae and furnishes one of the most striking examples of convergence known among the Protozoa (Kofoid, 1926).

The genus Heteroschisma is characterized especially by two structural features: — (*1*) the entire left sulcal list belongs to the right valve, its fission rib being located at the level of the posterior cingular list; (*2*) the left valve of the hypotheca has a triangular postcingular plate on the ventral side. The behavior of the left sulcal list in binary fission is not known in Thecadinium, Pseudophalacroma, and Oxyphysis. On the other hand, in the highly organized genera of

Dinophysidae, viz., Phalacroma, Dinophysis, and Histiophysis, the fission rib of this list is displaced posteriorly; in other words, the anterior portion of this list belongs to the left valve and the posterior to the right. Although there are no proofs in support of this assumption, Heteroschisma is considered primitive in this respect. Except in Heteroschisma, a triangular postcingular plate is not known to occur in any of the members of this tribe (with the possible exception of *Phalacroma fimbriatum*, Plate 2, fig. 1). For these reasons and because of the rounded outline of the body, the large size of the epitheca, and the simple structure of the left sulcal list, Heteroschisma is considered an independent evolutionary branch that split off at a very early stage. Furthermore, the entire organization of Heteroschisma, when compared with that of Thecadinium, Pseudophalacroma, Oxyphysis, and Phalacroma, indicates that this genus is much more closely related to Phalacroma and Pseudophalacroma than to Thecadinium and Oxyphysis.

Dinofurcula recalls Phalacroma in the great depth of the epitheca and in the moderate width, subhorizontal position, and ribbed structure of the cingular lists. On the other hand, it differs very strikingly from this genus in having the hypotheca bifurcate posteriorly. Another peculiarity of *Dinofurcula ultima* (Plate 5, fig. 4, 6) is the posterior displacement of the distal portion of the girdle, a feature not found in any other member of Dinophysoidae, but frequent in Gymnodinioidae and Peridinioidae. Dinofurcula, like Pseudophalacroma and Heteroschisma, represents an independent branch near the base of the evolutionary line that led to the differentiation of Phalacroma.

Of the three remaining genera of Dinophysidae, viz., Phalacroma, Dinophysis, and Histiophysis, all of which are structurally very closely related, the first is, on the whole, the most primitive. This is indicated by the following features: — (*1*) the body is frequently subrotund in lateral outline; (*2*) the epitheca is very large and the girdle is subhorizontal not only in some of the primitive, but also in some of the highly advanced species; (*3*) the cingular lists are relatively narrow. Phalacroma and Dinophysis embody several common tendencies, *e.g.*, the tendency to develop accessory sails and lists, and even their generic separation "seems . . . to be somewhat arbitrary" (Jörgensen, 1923, p. 5). It is very difficult to allocate generically not only several of their primitive but also some of their advanced members. Histiophysis, which is structurally more closely related to Dinophysis than to Phalacroma, shows certain similarities to Parahistioneis. For instance, its epitheca is very small, its anterior cingular list is unusually high, has a pronounced funnel shape, and simplified ribbing, its posterior cingular list is reticulated instead of ribbed as in Phalacroma and Dinophysis, and it has phaeosomes in the girdle. The highly developed structure of the sulcal lists and the lack of a posterior main rib in the left sulcal list should also be taken into account when the systematic position of Histiophysis is under consideration.

In short, of the eight genera, six, viz., Pseudophalacroma, Heteroschisma, Dinofurcula, Phalacroma, Dinophysis, and Histiophysis, are structurally quite closely related, while the two remaining, viz., Thecadinium and Oxyphysis, occupy rather isolated positions. Thecadinium is still on the borderland to Gymnodinioidae, and Oxyphysis is a highly differentiated genus that branched off at a very early stage from the evolutionary line that led to the differentiation of the first six genera. Of Pseudophalacroma, Heteroschisma, and Dinofurcula, which also split off very early, the last is in some respects very aberrant, while the others are still, on the whole, quite primitive (see also Hensen, 1891, pl. 2).

Distribution: — The Dinophysidae are very widely distributed, exclusively marine, and all the genera are eupelagic, except Thecadinium which is found on sandy beaches. Most of the species occur exclusively, or almost so, in tropical, subtropical, and warm-temperate seas, but some of them are endogenetic in the Arctic and the Antarctic Oceans, where no representatives of the other families of this tribe are to be found. Most species appear to be rare, but some have been recorded as rather frequent. The optimum habitat is the lower levels of photosynthesis.

Key to the Genera

1. Cingular lists absent . . . . *Thecadinium*, gen. nov.
1. Cingular lists present 2
2. Sulcus continues anteriorly beyond anterior cingular list . . . . 3.
2. Sulcus does not continue anteriorly beyond anterior cingular list . . . . 4.
3. Epitheca narrow, cone-shaped . . . . *Oxyphysis* Kofoid.
3. Epitheca rounded, dome-shaped . . . . *Pseudophalacroma* Jörgensen.
4. Body molariform in lateral outline . . . . *Dinofurcula*, gen. nov.
4. Body not molariform in lateral outline . . . . 5.
5. Entire left sulcal list belongs to right valve . . . . *Heteroschisma*, gen. nov.
5. Entire left sulcal list does not belong to right valve . . . . 6.
6. Posterior cingular list finely reticulated . . . . *Histiophysis*, gen. nov.
6. Posterior cingular list not finely reticulated . . . . *Dinophysis* Ehrenberg and *Phalacroma* Stein.

Heteroschisma, gen. nov.

Diagnosis: — Body subcircular to broadly subobovate in lateral outline. Epitheca large, but slightly narrower than hypotheca. Transverse furrow narrow, of subuniform width throughout, 0.43–0.70 the greatest height of epitheca. Posterior cingular list 0.36–0.46 the length of body from apex. Left hypotheca characterized by a triangular postcingular plate, occupying its ventroanterior corner; this plate is somewhat deeper than high, and its ventral height is 1.5–3.0 the width of the transverse furrow. Cingular lists subhorizontal and subequal, slightly wider to slightly narrower than transverse furrow; without structural differentiation except dorsally and ventrally, where they may have a few ribs. Right sulcal list about 0.33–0.45 as long as body, with a maximum width 0.66–0.75 the width of transverse furrow. The most important feature of the left sulcal list is that it belongs to the left valve in its entire extension; *i.e.*, that it crosses over from the left to the right valve at the level of the posterior cingular list. Other characteristics of this list are: — it is 0.53–0.67 as long as body, of subuniform width throughout the greater portion of its length, its average width being subequal to width of transverse furrow, forms a round to ear-shaped lobe posteriorly, and either lacks structural differentiation or has but a single rib near the posterior end.

Type.— *Heteroschisma inaequale*, sp. nov.

Distribution: — Heteroschisma has never been found outside the area investigated by the Expedition; and by the Expedition it was taken at five stations only. Two of these five stations (4665, 4671) are in the Peruvian Current; one (4699) is in the Easter Island Eddy; and two (4701, 4721) are in the South Equatorial Drift. All records refer to hauls from 300–0 fathoms except one (Station 4699) which refers to a specimen from the stomach of a Salpa taken in surface waters. The frequency is less than 1% at all the five record stations.

Heteroschisma aequale, sp. nov.

Plate 1, fig. 7, 8. Figure 1 : 1, 2

Diagnosis: — Body subcircular in lateral outline, deepest near the middle; in dorsoventral view obovate, widest at girdle. Posterior cingular list 0.45–0.46 the length of body from apex. Ventral margin of right sulcal list strongly sigmoid, concave anteriorly and convex posteriorly. Left sulcal list 0.53 the length of body, of subuniform width throughout the greater portion of its length; its average width subequal to width of transverse furrow; postmargin of list protracted into narrow, ear-shaped lobe; without ribs or other structural differentiation. Theca finely and faintly reticulate. Length, 43.2–51.0 μ.

Eastern tropical and subtropical Pacific.

Description: — Body subcircular in lateral outline and deepest near the middle. The margins are confluent and subuniformly convex, and the epitheca, which is highest in the center, is about as broadly rounded as the posterior portion of the body. The longitudinal axis is about perpendicular to the girdle. The transverse furrow is flat or gently convex, and its width is about 0.43–0.44 the greatest height of the epitheca. The posterior cingular list is about 0.45–0.46 the length of the body from the apex. The ventral height of the triangular field is about 1.5 times the width of the transverse furrow. In dorsoventral view the body is obovate and widest at the girdle.

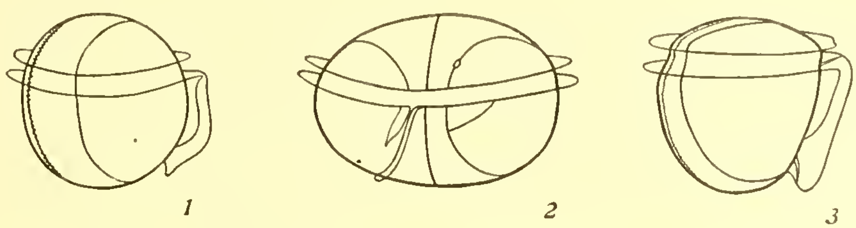

FIGURE 1.— 1, 2, *Heteroschisma aequale*, gen. et sp. nov. 1, right lateral view of type specimen, Station 4671 (300–0 fathoms); 2, ventral view, Station 4701 (300–0 fathoms); 3, *Heteroschisma inaequale*, gen. et sp. nov., right lateral view of type specimen, Station 4665 (300–0 fathoms). x 430.

The cingular lists are subhorizontal and subequal, about as wide as the transverse furrow or slightly narrower or wider, and, as far as the records go, without structure. The right sulcal list is 0.33–0.40 as long as the body; its ventral margin is strongly sigmoid, concave anteriorly, convex posteriorly; its maximum width is about 0.75 the width of the transverse furrow. The left sulcal list is about 0.53 the length of the body and of subuniform width throughout the greater portion of its length; its average width is subequal to the width of the transverse furrow; its greatest width is located in or somewhat behind the middle; its ventral margin is gently sigmoid, slightly concave or almost straight anteriorly, convex in the middle, and slightly concave posteriorly; its postmargin is protracted into a narrow, ear-shaped lobe at an angle of about 50°; there are no ribs or other structural differentiations. The thecal wall is finely and faintly reticulate; the meshes are of subuniform size and polygonal; pores were not seen.

Only megacytic stages were recorded. Two specimens had exceedingly wide intercalary zones.

Dimensions: — The dimensions of two specimens were: — Length of body, 43.2–51.0 μ (type, 51.0 μ). Total length of megacytic specimens, 54.0–55.4 μ.

Variations: — Judging by the few specimens available, this species appears to be quite constant in shape and structure and fairly variable in size.

Comparisons: — The description of the shape of the body is somewhat uncertain, since all the specimens examined are megacytic with very broad intercalary zones.

The simplicity of the structure of the thecal wall seems to indicate that *Heteroschisma aequale* is more primitive than *H. inaequale*.

Occurrence: — *Heteroschisma aequale* is recorded at four of the 127 stations. There are 0, 1, 0, 2, 1, and 0 stations on the six lines of the Expedition. Of these four stations, one (4671), the type locality, is in the Peruvian Current; one (4699) is in the Easter Island Eddy; and two (4701, 4721) are in the South Equatorial Drift. At one station (4699, Salpa stomach) the species was taken in surface waters. The remaining records refer to hauls from 300–0 fathoms.

The temperature range of these four stations at the surface is 66°–75°; the average was 72°. At Station 4699 the surface temperature was 75°.

The frequency in all the cases is less than 1%.

Heteroschisma inaequale, sp. nov.

Plate 1, fig. 1, 2. Figure 1 : 3

Diagnosis: — Body broadly subobovate in lateral outline, deepest at girdle. In dorsoventral view subbiconical, widest at girdle, side contours of epitheca and hypotheca almost straight or even slightly concave, except posteriorly where they are convex. Posterior cingular list 0.36 the length of body from apex. Ventral margin of right sulcal list almost straight anteriorly, gently convex posteriorly. Left sulcal list 0.67 the length of body, of subuniform width throughout; its average width subequal to width of transverse furrow; with rounded posteroventral lobe; with short posterior rib that ends at middle of postmargin. Wall of left hypotheca, except triangular field, has fine and rather faint reticulation; remaining portion of theca with well-developed and rather wide-meshed reticulation. Length, 51.0 μ.

Eastern tropical Pacific.

Description: — Body broadly subobovate in lateral outline and deepest at the girdle. The margins are subuniformly convex and confluent, and the epitheca, which is highest somewhat ventrally to the center, is somewhat more broadly rounded than the posterior portion of the body. The longitudinal axis is about perpendicular to the girdle. The transverse furrow is slightly concave, and its width is about 0.70 the greatest height of the epitheca. The posterior cingular list is about 0.36 the length of the body from the apex. The ventral height of the triangular field is about three times the width of the transverse furrow. In dorsoventral view the body is subbiconical and widest at the girdle; in the type specimen (megacytic) the ratio between the length and width is 1.20:1; the side contours of the epitheca and hypotheca are almost straight or even slightly concave, except at the posterior end of the body where they are more or less convex.

The cingular lists are subhorizontal and subequal, about as wide as the transverse furrow or somewhat narrower, and without structural differentiation except dorsally and ventrally where a few (1–4) ribs are to be found. The right sulcal list is about 0.45 as long as the body, of subuniform width throughout the greater portion of its length, and with a maximum width about 0.66 the width of the transverse furrow; its ventral margin is almost straight anteriorly and gently convex posteriorly. The left sulcal list is about 0.67 as long as the body, of subuniform width throughout its entire length, and its average width is subequal to the width of the transverse furrow; it is characterized by a rounded posteroventral lobe and has no structural differentiation, with the exception of a short posterior rib that ends at the middle of the postmargin of the list and has a posterior inclination of about 80°.

The thecal wall of the right valve and of the epitheca, the transverse furrow, and the triangular field of the left valve have a well-developed reticulum of rather large polygonal meshes. The meshes of the epitheca and of the right hypotheca are subuniform in size; and about twenty meshes border the girdle posteriorly on the right valve. In the entire triangular field about sixteen meshes are to be found. The polygons of the transverse furrow are arranged in two rows; on each valve there are about sixteen or seventeen polygons in each row. Except in the triangular field the wall of the left hypotheca is characterized by a fine and rather faint reticulation resembling the one found in *Heteroschisma aequale*. Scattered pores are to be found.

The only specimen examined was megacytic.

Dimensions: — Length of body, 51.0 μ. Total length of megacytic specimen (including intercalary zone), 54.8 μ.

Comparisons: — The description of the shape of the body is somewhat uncertain since the only specimen examined is megacytic.

This species is easily distinguished from *Heteroschisma aequale* by the well-developed and comparatively wide-meshed reticulation of its theca.

Occurrence: — *Heteroschisma inaequale* is recorded at only one (4665) of the 127 stations, on the second line of the Expedition, in the Peruvian Current, from a depth of 300–0 fathoms, and at a surface temperature of 68°. The frequency is less than 1% (one specimen).

Phalacroma Stein

Phalacroma Stein, 1883, p. 23. Bütschli, 1885, p. 940, 1009. Delage & Hérouard, 1896, p. 385. Schütt, 1896, p. 26. Paulsen, 1908, p. 19. Lebour, 1925, p. 75.
Phalarocoma Daday, 1888, p. 99 (*lapsus pennae*).
Phalacromo Nathansohn, 1908, p. 601 (*typ. err.*).

Diagnosis: — Body usually subcircular, subellipsoidal, subobovate, subbiconical, subcuneate, or fig-shaped in lateral outline, distinctly longer than deep (length: depth, 0.86–1.84:1), and more or less compressed bilaterally. Epitheca usually large (ratio between its depth and depth of hypotheca in most species somewhere between 0.8:1 and 1.0:1, sometimes as low as 0.54:1), either high, even as high as hypotheca, or more or less flattened. Transverse furrow narrow, of subuniform width throughout, flat or but slightly convex or concave; its width, 0.07–0.12 the length of body. Cingular lists usually subhorizontal and subequal, slightly wider to slightly narrower than transverse furrow, with or without ribs; sometimes somewhat inclined anteriorly. Right sulcal list usually somewhat narrower than the left and ends somewhere between R_2 and R_3 of left. Left sulcal list usually subtrapeziform, somewhat wider posteriorly than anteriorly, with pronounced posteroventral angle, and with three main ribs, one (R_1) in front, and one (R_3) behind fission rib (R_2); R_2 somewhat behind girdle; sometimes this list extends to antapex, sometimes its length is only 0.33 the length of hypotheca; R_2 and R_3 at most 0.22 and 0.55 the greatest depth of body, respectively; margin may be rounded posteroventrally. Sometimes with accessory lists and sails.

Type. — *Phalacroma porodictyum* Stein.

Organology: — The *body* (*theca*) in Phalacroma is simple in structure, but diverse in shape. When seen laterally, it usually is somewhat asymmetrical, but symmetrical species also have been found (*e.g.*, *P. ovum*, Figure 11:4). In dorsal or ventral view it appears always to be symmetrical. In many species the *longitudinal axis* (*a. l.*, Figure 29) has maintained its original position, *i.e.*, it is perpendicular to the girdle; frequently, however, it is more or less deflected posteroventrally. In the two species with the most pronounced posteroventral deflection of this axis, viz., *P. porodictyum* and *P. expulsum*, an inclination of 1°–20° and 5°–15°, respectively, was found. The only species in which this axis has a slight (2°) posterodorsal inclination is *P. circumcinctum* (Plate 1, fig. 5).

When seen laterally, the *body* usually is distinctly longer than deep, only seldom is it deeper than long. In the most elongated species (*P. turbineum*, Plate 2, fig. 3) the ratio between the length and the depth is 1.84: 1; in the species with the relatively deepest body (*P. giganteum*, Figure 14: 1) the corresponding ratio is 0.86: 1; in most species it is between 1.1: 1 and 1.3: 1. Sometimes the body is deepest in or near the middle, but usually the greatest depth has shifted to the anterior third of the body. As a rule, the body is deepest at or just behind the girdle. No species with the greatest depth located anterior to the girdle has been found.

Usually the *body*, seen in lateral view, is circular or subcircular (*Phalacroma lativelatum*, Figure 3: 2, 3), ellipsoidal or subellipsoidal (*P. parvulum*, Figure 3: 4–6), obovate or subobovate (*P. circumsutum*, *P. doryphorum*, Figure 23). Of these shapes the last two are by far the most common. Although the circular shape is the most primitive, it is found not only in some of the primitive but also in some of the highly differentiated members of the genus (Plate 3, fig. 5). The following shapes of body, seen laterally, have also been found: — subcircular, with a slight (*P. lens*, Figure 4: 3) or striking (*P. contractum*, Figure 3: 1) constriction at the girdle; subcircular, with the anterior end subtruncate (*P. porosum*, Plate 1, fig. 6; *P. pulchrum*, Plate 3, fig. 6); rounded subbiconical (*P. praetextum*, Plate 4, fig. 6); subbiconical, with well-rounded apices (*P. fimbriatum*, Plate 4, fig. 4); biconical, top-shaped, narrowly to fairly broadly rounded anteriorly, subacute posteriorly (*P. reticulatum*, Plate 4, fig. 3; *P. turbineum*, Plate 2, fig. 3); irregularly obovate, with strikingly conical epitheca, or sublozenge-shaped (*P. apicatum*, Figure 10); sac-like, truncate anteriorly, with a dorsal shoulder-like constriction at the girdle (*P. expulsum*, Figure 20: 1); subobovate, with a broadly rounded angle at the posterior end of the left sulcal list (*P. acutum*, Schütt, 1895, pl. 3, fig. 17: 1); cuneate, with a very broadly rounded epitheca (*P. cuneus*, Figure 12); subcuneate, with the posterior margin strikingly sigmoid, convex anteriorly, concave posteriorly (*P. mitra*, Schütt, 1895, pl. 4, fig. 18: 1); subcuneate, very broadly rounded to nearly flat anteriorly, narrowly rounded to subacute but not mammilliform posteriorly, and with the ventral margin strikingly angular at the posterior main rib of the left sulcal list (*P. rapa*, Figure 16); subcuneate, broadly rounded anteriorly, constricted, mammilliform posteriorly, and with the ventral margin more or less angular at the posterior main rib of the left sulcal list

(*P. favus*, Plate 2, fig. 7); inverted fig-shaped (*P. hindmarchi*, Figure 18). A peculiarity worth mentioning is that species with ovoidal body have not been found as yet in Phalacroma, although this shape is fairly common in the closely related genus Dinophysis.

Generally the *body* is more or less compressed bilaterally; only a few species (*e.g., Phalacroma globulus*, Schütt, 1895, pl. 2, fig. 12: 1; *P. fimbriatum*, Plate 4, fig. 4; *P. giganteum*, Plate 2, fig. 1) have the dorsoventral and transverse diameters subequal. It may also be mentioned that in the type specimen of *P. turbineum* (Plate 2, fig. 3; Plate 4, fig. 1) the transdiameter even exceeded the dorsoventral diameter, but this specimen possibly was megacytic (see p. 200). In the species with the most pronounced bilateral compression (*P. lens*, Figure 4: 1–3) the ratio between the length and the transdiameter is 2.38–2.66: 1, while the ratio between the length and the dorsoventral diameter is 1.05–1.11: 1. When seen in dorsoventral view, the body generally is obovate (*P. pulchrum*, Plate 3, fig. 1), ellipsoidal (*P. mucronatum*, Figure 22: 6), or lenticular (*P. limbatum*, Plate 3, fig. 3). In all the species with ellipsoidal or lenticular outline and in some of the species with obovate outline, the body is widest in or near the middle; in the remaining species with obovate outline the greatest width is located in the anterior third of the body, often near the girdle. The following shapes of body, seen dorsoventrally, have also been found: — subcircular (*P. globulus*, Schütt, 1895, pl. 2, fig. 12: 1, in which the body approaches the fundamental, spherical form); biconical, with more or less narrowly rounded apices (*P. apicatum*, Figure 10: 2; *P. circumcinctum*, Plate 1, fig. 4); biconical, with acute or subacute apices (*P. fimbriatum*, Plate 2, fig. 1; *P. reticulatum*, Plate 4, fig. 5); cuneate, broadly rounded anteriorly, narrowly rounded or subacute posteriorly; and with the side contours of the hypotheca straight, or evenly and gently convex or concave (*P. cuneolus*, Figure 22: 7), or more or less undulating (*P. expulsum*, Figure 20: 2, 5; *P. favus*, Figure 14: 2); inverted pyriform (*P. pyriforme*, Figure 4: 4); inverted fig-shaped (*P. hindmarchi*).

One of the most characteristic features of Phalacroma is the relatively large size of the *epitheca* (*epi.*, Figure 29). In lateral as well as in dorsoventral view, the epitheca usually is about as deep as or but slightly narrower than the hypotheca. In most species the ratio between the depth of the epitheca and that of the hypotheca is somewhere between 0.8: 1 and 1.0: 1; in the species with the relatively smallest epitheca (*P. expulsum*, Figure 20: 1, 3) the corresponding ratio is 0.60 (0.54–0.66): 1. Only in exceptional cases (*P. reticulatum*, Plate 4, fig. 3) is the epitheca slightly deeper than the hypotheca. In the ancestral forms of this genus the epitheca and the hypotheca presumably were subequal in size, and this condition is still found in some of the recent species, *e.g.*, in *P. limbatum* (Plate 3, fig. 5), *P. praetextum* (Plate 4, fig. 6), and *P. circumcinctum* (Plate 1, fig. 5). However, in most of the recent forms the height of the epitheca has been more or less reduced without a corresponding reduction in depth. In some species this reduction in height has proceeded so far that the epitheca has the shape of a large and but slightly vaulted disk (*P. porosum*, Plate 1, fig. 6; *P. giganteum*, Plate 2, fig. 2; Plate 3, fig. 2). Only in a few of the known species (*P. expulsum*, Figure 20:3) has this reduction in height been accompanied by a decided decrease in depth. *Phalacroma expulsum*, which in several respects is intermediate between Phalacroma and Dinophysis, is also the only representative of its genus in which the epitheca in lateral view is not at all or but slightly visible above the anterior cingular list. As a rule, the epitheca is highest in or near the center, and only in a few species has its greatest height shifted dorsally or ventrally (Figure 20).

In some species (*Phalacroma praetextum*, Plate 4, fig. 6; *P. limbatum*, Plate 3, fig. 5) the *transverse furrow* (*tr. f.*, Figure 29) has maintained its original equatorial position, but usually it is distinctly nearer to the anterior than to the posterior end of the body. Sometimes (*P. porosum*, Plate 1, fig. 6) it is even so close to the apex that its width exceeds the greatest height of the epitheca. Its distal portion is not displaced posteriorly, *i.e.*, it does not form a spiral about the body. It usually crosses the lateral faces of the body in an almost straight line, but in *P. porosum* (Plate 1, fig. 6) it forms a gentle, sigmoid curve. Its width is subject to but slight variations; in obovoidal and subcuneate species the width is about 0.07–0.09, in subrotund species about 0.11–0.12 the length of the body. Its floor usually is flat or but slightly concave or convex, and only in a few species (*P. contractum*, Figure 3:1) is the concavity pronounced; this character appears to be fairly variable even within the species.

The *longitudinal furrow* usually is about half as long as the hypotheca but may be somewhat longer or shorter; *e.g.*, in *Phalacroma porosum* (Plate 1, fig. 3, 6) it is about 0.63 and in *P. turbineum* (Plate 4, fig. 1) about 0.26 the length of the hypotheca. Anteriorly it does not extend beyond the girdle, *i.e.*, into the epitheca. It is at most but slightly impressed.

The *lists of the furrows* are not excessively developed. They arise from low and narrow basal ridges (Plate 3, fig. 1, 6) and are hyaline and usually exceedingly delicate.

In almost all the species the *cingular lists* (*ant. cing. l.*, *post. cing. l.*, Figure

29) are subhorizontal, subequal, of subuniform width throughout, and about as wide as or slightly wider or narrower than the transverse furrow. The anterior appears usually to be closed, but may be open ventrally in some species (Plate 2, fig. 1; Plate 1, fig. 5, of *Phalacroma fimbriatum* and *P. circumcinctum*). The posterior is always open ventrally. Only in exceptional cases are these lists strikingly inclined anteriorly; in *P. expulsum* (Plate 5, fig. 1) and *P. pulchrum* (Plate 3, fig. 6), which have this anterior inclination better developed than any other members of the genus, these lists are inclined at about 30°–45° and 20°–40°, respectively. It should be remembered, however, that the pressure of the cover-glass is likely to change the inclination of these lists. In the species with the widest cingular lists (*P. protuberans*, Figure 20:8), these are about 1.7–2.3 times wider than the transverse furrow; in *P. contractum* (Figure 3:1) and *P. lenticula* (Figure 3:7), which form the opposite extreme, they are only about half as wide as the transverse furrow. In the most primitive as well as in some of the highly developed species (*P. circumcinctum*, Plate 1, fig. 5; *P. pulchrum*, Plate 3, fig. 6), the cingular lists appear to lack structural differentiation, except for one or two ribs dorsally and ventrally on each valve near the sagittal suture. In the remaining species both these lists are ribbed. The ribs usually are rather strong, straight, simple, and nearly equidistant; but they may be fairly irregular (*P. striatum*, Plate 2, fig. 5), or they may even anastomose into a reticulum (*P. cuneus*, Schütt, 1895, pl. 3, fig. 14:2; *P. striatum*, Jörgensen, 1923, fig. 12). The number of ribs in the anterior list is either subequal to or somewhat larger than that in the posterior. In some species (*P. turbineum*, Plate 2, fig. 3) these lists have only a few ribs, but in others the number is fairly large; for instance, in *P. giganteum* (Plate 2, fig. 2), each of these lists has, on each valve, as many as seventy-five ribs.

The *sulcal lists*, which form a direct continuation of the posterior cingular list, run about parallel to each other on either side of the longitudinal furrow. While the entire right sulcal list belongs to the right valve, the anterior portion of the left list belongs to the left valve and the posterior portion to the right.

The *right sulcal list* (*r. sulc. l.*, Figure 29) is fairly variable in size and shape even within the species. It always is smaller than the left. In some species (*Phalacroma porosum*, Plate 1, fig. 6; *P. favus*, Plate 2, fig. 7) it extends to or slightly beyond the posterior main rib of the left sulcal list; in others (*P. striatum*, Plate 2, fig. 8) it ends at a point somewhere between the fission rib and the posterior main rib of the last-mentioned list; only exceptionally (*P. expulsum*, Plate 5, fig. 1) does it end at or even in front of the fission rib. Usually, it either (*P. limbatum*, Plate 3, fig. 5) is subtriangular to rounded triangular, about as wide as the transverse furrow anteriorly, and decreasing gradually in width posteriorly; or (*P. favus*, Plate 2, fig. 7) of subuniform width throughout the greater portion of its length, fairly strongly rounded posteriorly, and about as wide as the transverse furrow anteriorly. The following shapes have also been found: — crescent shape, wider in the middle than anteriorly and posteriorly (*P. porosum*, Plate 1, fig. 6); the anterior half to two thirds of the free margin is more or less concave and forms a distinct angle with the posterior portion of the margin which is either straight (*P. fimbriatum*, Plate 4, fig. 4) or more or less convex (*P. striatum*, Plate 2, fig. 8); the free margin is sigmoid, concave anteriorly and convex posteriorly (*P. giganteum*, Plate 2, fig. 2). Usually this list lacks structural differentiation, but sometimes it has a marginal rib (*P. striatum*, Plate 2, fig. 8; *P. argus*, Figure 8: 1), a T-shaped rib (*P. turbineum*, Plate 4, fig. 1), or a more or less developed reticulation (*P. striatum*, Plate 2, fig. 8; *P. circumcinctum*, Plate 1, fig. 5); the reticulation is always first developed along the base of the list. The ventral margin is always free.

The *left sulcal list* (*l. sulc. l.*, Figure 29) is also strikingly variable in size and shape. It usually is about half as long as the hypotheca or slightly longer, but sometimes (*Phalacroma turbineum*, Plate 2, fig. 3) it is only about 0.33–0.39 as long as the hypotheca, or (*P. striatum*, Plate 2, fig. 8) it may extend as far as to the antapex. In most species it is subtrapeziform, somewhat wider posteriorly than anteriorly, with a pronounced posteroventral angle, and with the ventral and posterior margins straight, or gently concave, convex, or sigmoid; in some of the species of this category (*P. porosum*, Plate 1, fig. 6) the ventral margin may be very broadly angular near the middle. The posteroventral angle frequently is between 80° and 95°, but sometimes this portion of the list is more or less acuminate (*P. bipartitum*, Figure 21:2; *P. circumsutum*, Figure 23:6), or it shows intermediate stages between an angular and a rounded outline. In some species (*P. apicatum*, Figure 10:4) the entire free margin of the list is almost evenly rounded, in others (*P. argus*, Figure 8:1) it is more or less sigmoid, concave anteriorly and convex posteriorly. It also should be mentioned that in one species, viz., *P. praetextum* (Plate 4, fig. 6), this list is subtriangular, decreasing gradually in width posteriorly. In nearly all the species this list has three well-developed cross-ribs, which in the present paper have been named the anterior main rib, the fission rib, and the posterior main rib. The anterior main rib (*ant. m.r.*, Figure 29) is located anteriorly, at the junction of this list and the posterior cingular list; the fission rib (*f.r.*, Figure 29), at the place where the list is divided in binary fission, *i.e.*, at the sagittal suture and usually somewhat in front of the middle of the list; the posterior main rib (*post. m. r.*, Figure 29), near the posterior end of the list. Usually the anterior main rib and the fission rib are subequal, or either of them is slightly longer than the other; and the posterior main rib, as a rule, is between 1.5 and 2.5 times longer than the fission rib. The relative length of the posterior main rib is more variable than that of either of the two anterior ribs. Sometimes (*P. doryphorum*, Figure 23; *P. ovum*, Figure 11) this rib is as much as 2.8–3.5 times longer than the fission rib, sometimes (*P. giganteum*, Figure 14: 1; *P. argus*, Figure 8: 1, 2) it is more or less reduced in length or even absent (*P. expulsum*, Plate 5, fig. 1). When the posterior main rib is well developed, the posteroventral margin of the list is angular, and the rib ends at or near the vertex of the angle; when the length of this rib is more or less reduced or when this rib is absent, the posteroventral margin of the list is rounded (*P. giganteum*, Figure 14: 1) or almost straight (*P. praetextum*, Plate 4, fig. 6). When compared to the depth of the body, the maximum length of the fission rib and the posterior main rib is about 0.22: 1 and 0.55: 1 (*P. circumsutum*, Figure 23: 6). The minimum length of the fission rib, expressed in the same manner, is about 0.07: 1 (*P. argus*, Figure 8: 1). The main ribs always are unbranched, straight or but slightly curved, and usually of moderate strength, and tapering distally. The fission rib frequently (always?) is double, *i.e.*, there is one rib on either side of the suture (*P. porosum*, Plate 1, fig. 3, 6); and it may be T-shaped, in which case it is divided distally in two branches, which form a marginal rib along the anterior half of the list (*P. circumcinctum*, Plate 1, fig. 5). The posterior main rib, which sometimes is more or less club-shaped distally (*P. doryphorum*, Figure 23: 1; *P. hindmarchi*, Figure 18: 3), generally has a posterior inclination of about 45° and may be directed straight back (*P. striatum*, Plate 2, fig. 8). In all the primitive and in many of the more or less highly differentiated species this list appears to lack structural differentiation except for the main ribs; in others it may have a number of short, secondary ribs (*P. favus*, Plate 2, fig. 7), or a more or less developed reticulation (*P. striatum*, Plate 2, fig. 8; *P. hindmarchi*, Figure 18: 3). It also should be mentioned that in *P. limbatum* (Plate 3, fig. 5) and *P. pulchrum* (Jörgensen, 1923, fig. 18) this list has a fine rib just behind the posterior main rib that extends to the margin of the list. The left sulcal list of *P. turbineum* (Plate 2, fig. 3) is of an exceptional type; its length is, as previously mentioned, only 0.38–0.39 the length of the hypotheca; and its greatest width is 0.12–0.13 the greatest depth of the body; its free margin is gently and evenly convex; it has a weak cross-rib somewhat in front of its middle and a submarginal rib along its entire length; with the exception of these two ribs, this list appears to lack structural differentiation. With regard to this list in *P. fimbriatum*, see p. 192. In most species this list ends a very short distance behind the posterior rib, but in some (*P. favus*, Figure 14:4, 5) it is more or less decurrent. The last condition is, in a sense, an initial step in the development of a parasagittal list (see *P. cuneolus*, Figure 22:1–3).

The primitive species have no lists except the cingular and sulcal lists. On the other hand, in many of the more or less highly evolved forms, *accessory lists* are developed. As an example of a highly differentiated and, if we may say so, almost schematical system of accessory lists, these lists in *Phalacroma limbatum* (Plate 3, fig. 3, 5) may first be described. In this species two lists, the *parasagittal lists* (*par. l.*, Figure 29), encircle the body, one on either side of the sagittal suture; however, in the transverse furrow parasagittal lists never are developed, and the left list ends at or near the posterior end of the longitudinal furrow. The left parasagittal list is of subuniform width throughout its entire length, has a maximum width which is subequal to or somewhat less than the width of the transverse furrow, and is furnished with a moderate number of simple, free or anastomosing, incomplete riblets. The right parasagittal list, which directly continues the left sulcal list, resembles the left, but forms on the antapex an acute, wedge-shaped process, the *posterior sail* (*post. s.*, Figure 29), directed posteriorly. When fully developed, the posterior sail is 0.15–0.27 the greatest depth of the body in length and has a central rib, the proximal half of which might form a more or less complex reticulum; the angle at its tip is 35°–50°. Of this fundamental system there are a great number of variants, the most important of which will now be described. In *P. fimbriatum* (Plate 4, fig. 4; Plate 2, fig. 1) the two parasagittal lists also encircle the whole body. On the epitheca both lists are of about the same width and structure; from the apex, where their width about equals 0.09 the greatest depth of the body, they slightly decrease in width toward the girdle; each of them has about twenty almost equidistant ribs, a few of which are branched. On the hypotheca the left list is very narrow, at most about half as wide as the transverse furrow. The right is much wider than the left, lacks a posterior sail, and merges so completely in the left sulcal list that the boundary between these two lists cannot be established with certainty. From the posterior main rib of the left sulcal list to the antapex, the right parasagittal list is of nearly subuniform width, about 0.14–0.20 the greatest depth of the body; anterodorsally to the antapex this list gradually becomes narrower, and its average width on the dorsal side of the hypotheca is only about 0.07 the greatest depth of the body. The right parasagittal list of the hypotheca has about twenty-six fairly strong and almost equidistant ribs, most of which are simple and almost straight, a few irregular or irregular and branched. The structure of the left list is unknown. As a last example of a species with the two parasagittal lists extending around the whole body, *P. turbineum* (Plate 2, fig. 3; Plate 4, fig. 1, 2) may be mentioned. In this species the right parasagittal list forms a direct continuation of the left sulcal list and lacks a posterior sail. On the average both the parasagittal lists are about twice as wide on the posterior half of the body as on the anterior half, and their maximum width is about 0.08–0.09 the greatest depth of the body. Each of them has a moderate number of short, simple ribs, approximately six on the epitheca and eighteen on the hypotheca. In most species the parasagittal lists are less developed than in the examples mentioned above. Generally speaking, the phylogenetic development of these lists appears to have proceeded from the posterior end of the body to the anterior, and the development of the right list seems to have preceded that of the left. In order to illustrate this statement, a few examples will be given. *P. pulchrum* (Plate 3, fig. 6) has two parasagittal lists on the hypotheca, but none on the epitheca. The left one of these two lists extends, on the dorsal side of the body, from the posterior cingular list to the antapex; it is very narrow, its maximum width being less than the width of the transverse furrow; and it is furnished with a few cross-ribs; in some specimens it may even be absent. The right parasagittal list forms a direct continuation of the left sulcal list and either extends to the posterior cingular list or is absent from the dorsal side of the hypotheca; dorsally it is of about the same type as the left list; posteriorly and posteroventrally of about the same type as the corresponding list in *P. limbatum*, only, as a rule, somewhat wider and with a slightly different structural differentiation. In *P. bipartitum* (Figure 21:2) only the right parasagittal list is present; it is restricted to the posterior half of the hypotheca, but still is connected with the left sulcal list. A peculiar feature of this species is that there are two posterior sails of about the same type as the corresponding structures in *P. limbatum*, one on each side of the antapex. In a fairly great number of species (*P. doryphorum*, Figure 23) only the posterior sail of the right parasagittal list is developed. This sail is subtriangular or wedge-shaped and is either situated on the antapex and directed posteriorly or slightly displaced ventrally and inclined posteroventrally. When fully developed, its length usually is about 0.20–0.40 the greatest depth of the body, and it is about as wide at the base as it is long or more or less decidedly narrower (*P. pugiunculus*, Jörgensen, 1923, fig. 19). Sometimes this sail has a central rib, sometimes it is more or less reticulated, especially in its central portion; sometimes both the central rib and the reticulation are developed; sometimes no structure can be distinguished. Only in a few of these species (*P. circumsutum*, Figure 23: 6; *P. cuneolus*, Figure 22: 1, 2) a connection is developed between the posterior sail and the left sulcal list.

The *flagellar pore* (*f. p.*, Figure 29) is a fairly large opening, located in the longitudinal furrow, *i.e.*, on the right valve, and just behind or about a girdle width behind the posterior cingular list. Its shape usually is subcircular or slightly elongated, in exceptional cases subtriangular (*Phalacroma porosum*, Plate 1, fig. 3) or slightly irregular. It is variable in size, but its greatest diameter appears never to exceed the width of the transverse furrow. Other pores to be mentioned in this connection are as follows: — in *P. praetextum* (Plate 4, fig. 7) there is a fairly small pore on the ventral side of the left valve, near the sagittal suture, and just behind the anterior cingular list. In *P. pulchrum*, *P. giganteum*, and *P. striatum* (Plate 3, fig. 1, 2; Plate 2, fig. 5) there are one to three fairly small pores on the ventral side of the left valve, near the sagittal suture, and just in front of the anterior cingular list. Although pores of the last-mentioned kind have been observed only in a comparatively small number of species, it is not impossible that they are characteristic of the genus as a whole. Their significance is not apparent.

Both *flagella* arise in the flagellar pore and are well developed. The transverse flagellum (Schütt, 1895, pl. 2, fig. 11: 2) lies in the girdle and encircles the body from the left around to the right. The longitudinal flagellum (Schütt, 1895, pl. 2, fig. 13: 6), which is about as long as the body or slightly longer or shorter, passes posteriorly between the sulcal lists.

The structure of the *thecal wall* is very different in the various species and affords important systematic characteristics. In most species there is a varying number of pores and poroids (Schütt, 1895, p. 21, 22) more or less uniformly scattered all over the theca. Sometimes (*Phalacroma fimbriatum*, Plate 4, fig. 4) these structures are numerous, sometimes (*P. turbineum*, Plate 4, fig. 1, 2) they are few, sometimes (*P. praetextum*, Plate 4, fig. 6, 7) they appear even to be absent. In *P. turbineum* they seem to be restricted to the transverse furrow and only about fifteen in number. In some species the theca appears to lack structural differentiation except for the pores and poroids, but usually it is characterized either by areolation or by reticulation. The areoles, which are small, rounded pits and usually more or less closely set (*P. circumcinctum*, Plate 1, fig. 5), resemble the poroids, with which they are connected by transitional structures (Schütt, 1895, p. 22). The meshes of the reticulation usually are fairly uniform in size within the species, but show a wide range of variation within the genus as a whole. In *P. striatum* (Plate 2, fig. 8), which is characterized by meshes of moderate size, twenty-five to thirty-five meshes on each valve border the posterior margin of the transverse furrow; in *P. favus* (Plate 2, fig. 7) the corresponding value is twenty to twenty-five; in *P. praetextum* (Plate 4, fig. 6), about fifteen; in *P. fimbriatum* (Plate 4, fig. 4), about ten; and in *P. turbineum* (Plate 2, fig. 3), five. In the last species the meshes are relatively larger than in any other known species. The ridges between the meshes sometimes are so fine that the reticulation hardly can be distinguished, sometimes (*P. fimbriatum*, Plate 4, fig. 4) they are rather heavy. It should be remembered in this connection that the degree of structural differentiation varies with age. The new valve of a recently divided specimen is thin and almost without structure; in old specimens the thecal wall is more or less heavy and its structural peculiarities are well developed. In most species the areolation or reticulation covers the whole thecal surface, in others (*P. limbatum*, Plate 3, fig. 4, 5) the regions nearest to the sagittal suture remain more or less undifferentiated. In *P. cuneus* (Figure 12) and related species a spine-like process projects into the cytoplasm from a point near the middle of the right sulcal list. *P. praetextum* (Plate 4, fig. 6, 7) is especially characterized by a dumbbell-shaped area, located on the ventral side of the hypotheca, just to the left of the sulcus, and extending on both sides of the sagittal suture from the posterior cingular list to the antapex. This area, which has a maximum width of about 0.33 the dorsoventral diameter of the body, is characterized by a structure quite different from that of the remaining portion of the theca. It has a faint reticulum of very small meshes, and in the middle of each or at any rate of most of these meshes there is an exceedingly fine pore. In other words, this area has the structure of a cribriform plate. Presumably it is a permanent structure; *i.e.*, it appears not to correspond to the intercalary zones of megacytic specimens (see p. 189).

With regard to the shape and structure of the *intercalary zones* of the megacytic specimens, see p. 51.

The *sagittal suture* of the two valves appears always to be finely serrated (Plate 2, fig. 1, 4). The three plates, epithecal, cingular, and hypothecal, of each valve very seldom are found separated. In one specimen of *Phalacroma giganteum*, the epithecal was detached from the cingular by means of the pressure of the cover-glass.

The *protoplasmic contents* are coarsely alveolar and hyaline, or may be of a pale rose or brownish color. The *nucleus*, which usually is located on the dorsal side of the hypotheca (Schütt, 1895, pl. 2, fig. 11: 1, 2; 13: 3, 6), is rather large, ellipsoidal, ovoidal, or spherical, and has a moniliform chromatin reticulum. Probably in all species there are one or two, usually two, large *pusules*, which open by short and slender canals into the flagellar pore (Schütt, 1895, pl. 2, fig. 11: 2). In many species *chromatophores* are absent; when present, these structures appear usually to be small, rod-shaped, and yellowish (Schütt, 1895, p. 64, pl. 3, fig. 16: 4; 17: 2). A characteristic feature of many species is the presence of rod-like or thread-like *rhabdosomes*, which in most cases are arranged radially (Schütt, 1895, pl. 2, fig. 11: 2; 13: 3). *Metaplasmic inclusions* of different kinds, *e.g.*, globules of fats and oils, also have been found. See also Schütt (1895) and Bütschli (1885). The cell sometimes (*Phalacroma pulchella*, Lebour, 1922, p. 817) is "full of large refractive bodies."

The *length of the body* is very variable within the species as well as within the genus. For the genus as a whole the range of variation in length thus far established is from 21 μ (*Phalacroma pulchellum*) to 148 μ (*P. giganteum*).

Reproduction: — The only mode of reproduction known in Phalacroma is binary fission of the free-swimming individuals. The line of fission or, in other words, the sagittal suture lies in the sagittal plane except in the region of the sulcus. Probably in most species the whole flagellar pore and the entire longitudinal furrow belong to the right valve (Schütt, 1895, pl. 3, fig. 16: 3). It is possible, however, that sometimes the portion of the longitudinal furrow that is in front of this pore belongs to the left valve, as in the specimen of *Dinophysis jörgenseni* (Plate 5, fig. 3). Since in all species the flagellar pore is located near the junction of the sulcus and the cingulum, by far the larger portion of the longitudinal furrow always belongs to the right valve. The whole right sulcal list belongs to the right valve. The left sulcal list is divided at the fission rib, which probably is always double (Plate 1, fig. 6) although, when seen in lateral view, it usually appears to be single. The portion of this list which is in front of the fission rib belongs to the left valve, the portion behind this rib to the right valve. The right parasagittal list and the posterior sail or sails belong exclusively to the right valve, the left parasagittal list exclusively to the left valve.

Neither the cingular and sulcal lists nor the parasagittal lists and the posterior sails are resorbed in binary fission (Schütt, 1895, pl. 2, fig. 10). Whether or not the flagella (of the right valve) are shed is not known. The flagella of the left valve are fairly well developed before the detachment of the two schizonts (Schütt, 1895, pl. 3, fig. 16: 4), and so the dividing specimens probably continue their active swimming during the fission processes.

The growth of the cingular and sulcal lists and the development of the thecal wall in the new halves of the two schizonts probably take place fairly rapidly. This is indicated by the fact that one rather seldom finds specimens in which these structures are not completely developed. Furthermore, judging by Schütt's figure (1895, pl. 3, fig. 16: 3), the cingular lists are fairly well developed even before the schizonts separate; see, however, Meunier (1910, p. 59). On the other hand, the development of the parasagittal lists and of the posterior sails, which presumably are phylogenetically rather young structures, appears to be rather slow. In any case, the posterior sails of the specimens of *Phalacroma doryphorum*, etc., examined were found to be very variable in size, and in species with parasagittal lists many specimens lacked these structures or had them very incompletely developed. For a better understanding of the value of the last-mentioned structures in the differentiation of species, their post-fission development should be submitted to a careful study.

Double specimens or groups of specimens resulting from fission or repeated fissions, such as have been found in *Dinophysis caudata* and *D. miles*, are unknown in Phalacroma.

A phenomenon that possibly may be characteristic of the genus as a whole (Pavillard, 1916, p. 47) is the pronounced increase in size that precedes binary fission and that is accompanied by the development of the so-called intercalary bands (Stein, 1883, p. 23) along the sagittal margins of the two valves. Specimens with intercalary zones or, according to Pavillard's (1915a) terminology, megacytic specimens, have been found in twenty-one of the forty-seven presumably valid species of this genus, viz., *Phalacroma acutum* (by Pavillard, 1916), *P. argus* (by Jörgensen, 1923), *P. cuneolus* (by us), *P. cuneus* (by Pavillard, 1915a, 1916; and by us), *P. doryphorum* (by Pavillard, 1915a, 1916; Jörgensen, 1913; and by us), *P. favus* (by Jörgensen, 1923), *P. fimbriatum* (by us), *P. giganteum* (by us), *P. globulus* (by Schütt, 1895), *P. hindmarchi* (by us), *P. mitra* (by Pavillard, 1915a, 1916), *P. mucronatum* (by us), *P. ovum* (by us), *P. paulseni* (by Paulsen, 1911b), *P. porodictyum* (by Stein, 1883; Schütt, 1895), *P. porosum* (by us), *P. pulchellum* (by Lebour, 1922), *P. rapa* (by Stein, 1883; Pavillard, 1915a, 1916), *P. rotundatum* (by Meunier, 1910), *P. rudgei* (by Murray and Whitting, 1899), and *P. vastum* (by Schütt, 1895); see also p. 198.

The intercalary zone, which appears to be of varying width in the different species, is relatively wide on the dorsal side of the body and decreases gradually in width toward the ventral side; in the region of the sulcus it appears usually to be very narrow or not developed at all. Sometimes, as in *Phalacroma mitra*

(Pavillard, 1916, p. 49), it has about the same structure as the thecal valves. In most cases, however, its structure is strikingly faint. In some species, *e.g.*, in *P. doryphorum* (Pavillard, 1916, fig. 12), this zone under low magnification appears to have closely set fine transverse striation; under higher magnifications each of the striae proves to be a row of closely set minute areoles.

The intercalary bands are transitory structures. When the new valve is formed in binary fission its sagittal margin is attached to the premegacytic sagittal margin of the old valve, and the intercalary band soon disappears; presumably it is resorbed. For further discussion of this interesting phenomenon, see Pavillard (1915a, 1916), who was the first to submit it to a careful study.

Finally, it may be mentioned that Bergh (1881b, p. 226) recorded a specimen of *Dinophysis laevis* [= *Phalacroma rotundatum* (Clap. and Lach.) var. *laevis* (Claparède and Lachmann) Jörgensen] in a resting condition ("im Ruhezustand, zu einer Kugel innerhalb der Schale zusammengezogen"). The significance of this observation must be regarded as uncertain (see Bütschli, 1885, p. 1020), since encystment has not been investigated or definitely known to occur in the Dinophysoidae.

Distribution: — The rather extensive data on the distribution of Phalacroma published at the present writing show that this genus is marine, almost exclusively eupelagic, of general oceanic distribution, but that the great majority of its species are limited to waters of tropical, subtropical, or warm-temperate nature or origin. The great difficulties implied in the determination of several of the species of this genus, the broad concept of species held by many of the investigators in this field, and the fact that but relatively few of the data are accompanied by figures or descriptions by means of which the determinations of species may be checked (see p. 58) make the general distribution of many of the species rather uncertain. The distribution of the genus as a whole, on the other hand, may be regarded as fairly well established.

Phalacroma rotundatum, *P. ovatum*, *P. paulseni*, *P. rotundatum* var. *laevis*, *P. minutum*, and *P. rudgei* are known to occur in the cold waters of the far north. *Phalacroma rotundatum* has been found along the whole coast of Norway, off Greenland, and in the Arctic Ocean; *P. ovatum*, on the west coast of Norway and off Greenland; *P. paulseni*, off Greenland; *P. rotundatum* var. *laevis*, on the west coast of Norway; and *P. minutum* and *P. rudgei*, in the Atlantic Ocean between lat. 58° N. and lat. 60° N. Of these species, *P. rotundatum*, *P. ovatum*, *P. paulseni*, and *P. rotundatum* var. *laevis* are endogenetic in the northern waters, while *P. minutum* and *P. rudgei* are probably southern forms, occasionally carried to the far north by the Gulf Stream. In the Antarctic Ocean *P. rotundatum* var. *laevis* has been found by Karsten (1905) as far to the south as lat. 63° S. It is a striking fact that all these species are small, rotund, and simply organized. The more or less luxuriant species appear to be restricted to warm-water regions (Schütt, 1893, p. 269). The only species of this genus known to be endogenetic in brackish waters is *P. rotundatum*, which has been recorded repeatedly from the less saline regions of the Baltic Sea.

Phalacroma is found in surface waters, but its optimum habitat seems to be the deeper levels of photosynthesis (Karsten, 1907, p. 442, 444). Some species, possibly saprozoic, have been found almost if not quite below the photic zone. It should be remembered, however, that the vertical distribution of this genus is very incompletely known, since but few records based on catches made with closing nets are available. The following from Karsten's (1905, 1906, 1907) reports on the phytoplankton of the Valdivia Expedition are the only published records. *Phalacroma rotundatum* var. *laevis* was found at Station 132, 400–300 m.; Station 151, 200–100 m.; *P. operculatum* at Station 170, 200–100 m.; Station 229, 200–20 m.; and Station 268, 63–46 m. *Phalacroma doryphorum* was taken at the following stations: — Station 227, 1000–800 m.; Station 228, 420–350 m.; Station 229, 1600–1400 m.; Station 239, 120–105 m.; Station 268, 105–88 m. and 63–46 m. All the specimens recorded were reported as "living." The specimens of *P. doryphorum* taken at great depths were found to be without chromatophores.

Although many of the species are widely distributed, none of them has been found to be abundant or even common. Indeed, most of these species appear to be rare, some even very rare.

Representatives of Phalacroma were found at 100 (78.7%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These 100 stations are distributed over the whole area covered by the Expedition as shown in the following table and Plate **24**: —

	Number of Stations and Occurrences		Number and % of Occurrences	%
California Current	4571, 4574, 4580, 4583	*4*	*4*	100
Mexican Current	4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4607, 4545, 4546	*13*	*13*	100
Panamic Area	4609, 4611, 4613, 4615, 4617, 4619, 4621, 4631, 4634, 4635, 4637, 4638, 4640, 4644	*14*	*17*	82.3
Peruvian Current	4646, 4647, 4648, 4650, 4651, 4652, 4655, 4657, 4659, 4660, 4661, 4662, 4663, 4664, 4665, 4666, 4667, 4668, 4669, 4670, 4671, 4673, 4675, 4676, 4678	*25*	*27*	92.6
Easter Island Eddy	4689, 4691, 4692, 4695, 4697, 4699	*6*	*10*	60
Galapagos Eddy	4713, 4715	*2*	*4*	50

	Number of Stations and Occurrences	Number and % of Occurrences		%
South Equatorial Drift	4679, 4680, 4681, 4683, 4685, 4687, 4701, 4705, 4706, 4707, 4709, 4711, 4717, 4719, 4720, 4721, 4722, 4724, 4725, 4728, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4739, 4740, 4741.	*30*	*45*	66.6
South Equatorial Current	4540, 4742, 4743	*3*	*3*	100
Equatorial Counter Current	4541, 4542	*2*	*2*	100
North Equatorial Current	4543	*1*	*2*	50

At sixty-seven of these 100 stations Phalacroma was taken in vertical hauls and at forty-five in surface hauls. Most of the records from vertical hauls are from 300–0 fathoms, some are from 800, 400, 150, 100–0 fathoms. Vertical hauls were made at sixty-eight out of the 127 stations. The genus thus was found at not less than 98.5% of the stations at which vertical hauls were made; it was absent from one station only, 4574 in the California Current, at which it was found in a surface haul.

Surface catches and Salpa stomachs of specimens taken in surface waters (eighty-one surface catches and twenty-four samples of Salpa stomachs) were examined from eighty-two stations. The genus, as previously mentioned, was taken in surface hauls at forty-five stations, *i.e.*, at 54.9% of all the surface stations. Taking into consideration the surface stations only, these forty-five record stations are distributed in the following manner:—

	Number of Stations and Occurrences	Number and % of Occurrences		%
California Current	4574, 4583	*2*	*4*	50
Mexican Current	4588, 4590, 4592, 4596, 4600, 4604, 4607, 4545, 4546	*9*	*9*	100
Panamic Area	4611, 4615, 4617, 4619, 4624, 4631, 4635, 4640, 4644	*9*	*13*	69.2
Peruvian Current	4648, 4650, 4657, 4660, 4661, 4664, 4666, 4669, 4675, 4676, 4678	*11*	*20*	55
Easter Island Eddy	4692	*1*	*5*	20
Galapagos Eddy	——	*0*	*2*	0
South Equatorial Drift	4680, 4706, 4709, 4720, 4725, 4731, 4733, 4741	*8*	*23*	34.7
South Equatorial Current	4743, 4540	*2*	*2*	100
Equatorial Counter Current	4541, 4542	*2*	*2*	100
North Equatorial Current	4543	*1*	*2*	50

On account of the prevalence of Phalacroma in deeper waters, the distribution and the frequency of the record stations at which *vertical* hauls were made should be used as an indicator of the horizontal distribution of this genus in the area investigated by the Expedition. These records show that the genus is almost evenly distributed throughout this area; indeed, it was found at not less than 98.5% of the stations at which vertical hauls were made. Furthermore, the even distribution of this genus is also evident when the distribution and frequency of the records of species are considered (Plate **24**). The only region in which Phalacroma was found to be represented rather sparingly was the California Current; north of Point San Lucas there were only four records of species, viz., three records of *P. parvulum* and one record of *P. rapa*. This scarcity possibly may be due to the fact that the California Current comes from the north, in other words, from a region where this genus is less abundant than within the tropics and subtropics. Of the eight most frequent species, *P. argus*, *P. cuneus*, *P. doryphorum*, *P. porodictyum*, and *P. rapa* (Figure 9, 13, 24, 7, 17) were found to be almost evenly distributed throughout the area investigated; *P. reticulatum* (Figure 26) was not found north of the equator; *P. striatum* (Figure 15) was not found in the California, Mexican, and Peruvian Currents; and *P. hindmarchi* (Figure 19) was restricted to the southwestern portion of this area, in other words, it had the same peculiar distribution as *Amphisolenia schauinslandi* (Figure 51) and *A. thrinax* (Figure 59).

The surface record-stations of Phalacroma are very unevenly distributed. While this genus was found at twenty-nine (69.0%) out of the forty-two surface stations in the Mexican Current, the Panamic Area, and the Peruvian Current, it did not occur at more than nine (30.0%) out of the thirty surface stations in the South Equatorial Drift, the Easter Island Eddy, and the Galapagos Eddy. The causes of this uneven distribution may lie in the greater influence of vertical circulation in the regions nearer to the western shores of the continents. It should also be mentioned that there is no surface species of this genus prevalent in the coastal regions as in the case of Dinophysis (*D. caudata*).

There are 309 records of species of Phalacroma from vertical catches. Out of these 309 records 1(0.3%; Station 4664) showed a frequency of 40%; 1(0.3%; Station 4663) 10%; 2(0.6%; Stations 4613, 4666) 6%; 2(0.6%; Stations 4663, 4709) 5%; 2(0.6%; Stations 4590, 4662) 4%; 8(2.5%; Stations 4598, 4664, 4667, 4671, 4695, 4713, 4715, 4742) 3%; 11(3.6%; Stations 4609, 4634, 4638, 4675, 4681, 4689 [2 records], 4697, 4699, 4713, 4740) 2%; 62(20.1%; Stations 4580, 4590, 4594, 4598 [2 records], 4605, 4613 [2 records], 4617, 4634 [2 records], 4637, 4638 [2 records], 4647, 4648 [3 records], 4650, 4651 [2 records], 4655, 4657 [2 records], 4665, 4667, 4671, 4676 [2 records], 4679 [2 records], 4681 [3 records], 4689 [3 records], 4691 [2 records], 4695, 4697, 4699 [3 records], 4701 [3 records], 4705, 4719 [2 records], 4721 [2 records], 4722, 4730, 4732 [2 records], 4734, 4737, 4739 [3 records], 4742) 1%; 220(71.2%) showed a frequency of less than 1%.

There are seventy-four records of species of this genus from surface catches. Out of these seventy-four records 1(1.4%; Station 4546) showed a frequency of 7%; 1(1.4%; Station 4619) 5%; 1(1.4%; Station 4669) 4%; 3(4.1%; Stations

4604, 4542, 4545) 3%; 6(8.1%; Stations 4615, 4624, 4650, 4669, 4675 [2 records]) 2%; 19(25.7%; Stations 4574, 4600 [2 records], 4604, 4617, 4619 [2 records], 4635, 4657, 4664, 4666, 4720, 4731, 4743, 4540, 4541, 4542, 4543, 4545) 1%; 43(58.2%) a frequency of less than 1% or did not have the frequency established.

Coincident occurrence of different species of Phalacroma in catches from 300 (800, 400, 150, 100)–0 fathoms is recorded at the following of the sixty-seven stations mentioned above:— 15 species occurred coincidently at 1 station (1.5%; Station 4730); 12 species at 1 station (1.5%; Station 4681); 11 species at 1 station (1.5%; Station 4734); 10 species at 2 stations (3.0%; Stations 4699, 4701); 9 species at 1 station (1.5%; Station 4740); 8 species at 3 stations (4.5%; Stations, 4713, 4732, 4737); 7 species at 6 stations (9.0%; Stations 4679, 4697, 4705, 4711, 4734, 4742); 6 species at 7 stations (10.4%; Stations 4587, 4637, 4691, 4695, 4709, 4721, 4739); 5 species at 6 stations (9.0%; Stations 4590, 4613, 4634, 4689, 4719, 4722); 4 species at 12 stations (17.9%; Stations 4594, 4598, 4605, 4617, 4638, 4655, 4662, 4664, 4665, 4676, 4683, 4717); 3 species at 9 stations (13.4%; Stations 4583, 4609, 4648, 4650, 4667, 4671, 4707, 4715, 4736); 2 species at 11 stations (16.4%; Stations 4580, 4647, 4651, 4652, 4657, 4661, 4663, 4666, 4675, 4685, 4728).

Coincident occurrence of different species in surface catches is recorded at the following of the forty-five surface stations mentioned above:— 3 species occurred coincidently at 7 stations (15.6%; Stations 4604, 4617, 4619, 4743, 4540, 4542, 4545); 2 species at 15 stations (33.3%; Stations 4592, 4596, 4600, 4635, 4644, 4660, 4664, 4669, 4675, 4676, 4678, 4720, 4731, 4741, 4541).

At the forty-five surface stations just mentioned, there are records of only nine of the thirty-one species found in the material of the Expedition. The number of surface records of each of these nine species is as follows: *Phalacroma doryphorum*, 26 records, 4 of which are from Salpa stomachs; *P. rapa*, 22 records, 2 of which are from Salpa stomachs; *P. cuneus*, 13 records, 2 of which are from Salpa stomachs; *P. favus*, 6 records, 1 of which is from a Salpa stomach; *P. argus*, 2 records, 1 of which is from a Salpa stomach; *P. parvulum*, 2 records; *P. hindmarchi*, 1 record; *P. expulsum*, 1 record (Salpa stomach); *P. lativelatum*, 1 record (Salpa stomach). Thus not less than sixty-one (82.5%) out of the seventy-four surface records refer to three species only. These three species are evenly distributed over the whole area investigated by the Expedition (see p. 55, on the distribution of the surface stations). It may also be mentioned that *P. porodictyum* was taken in a surface haul in Acapulco Harbor, a station not included in the 127 discussed above.

The fact that Phalacroma was found to be evenly distributed throughout the area investigated makes it highly plausible that this genus is fairly evenly distributed throughout all the tropical and subtropical seas. Finally, it may be mentioned that not less than sixteen out of the forty-seven presumably valid species have not been found except in the material of the Expedition.

Historical Discussion and Systematics

Stein (1883, p. 23), who established Phalacroma, gave no diagnoses but confined himself to a few words of comparisons and to the figuring of six new species, viz., *P. nasutum*, *P. operculatum*, *P. porodictyum*, *P. argus*, *P. doryphorum*, and *P. rapa*. Diagnoses of this genus have been published by Bütschli (1885, p. 1009), Delage and Hérouard (1896, p. 385), Schütt (1896, p. 26), Paulsen (1908, p. 19), and Lebour (1925, p. 75). Of these diagnoses the one by Schütt (1896) is by far the most nearly complete and satisfactory. No extensive description and discussion of this genus have been published.

Besides the six specific names established by Stein (1883), the following specific and subspecific names are to be found in the literature:

P. armatum Hensen (1895)
P. hastatum Hensen (1895)
P. operculoides Schütt (1895)
P. globulus Schütt (1895)
P. porodictyum Stein var. *parvula* Schütt (1895)
P. cuneus Schütt (1895)
P. vastum Schütt (1895)
P. vastum var. *acuta* Schütt (1895)
P. mitra Schütt (1895)
P. jourdani (Gourret) Schütt (1895)
P. ovum Schütt (1895)
P. blackmani Murray & Whitting (1899)
P. hindmarchi Murray & Whitting (1899)
P. dolichopterygium Murray & Whitting (1899)
P. rudgei Murray & Whitting (1899)
P. minutum Cleve (1900c)
P. ceratocorys Entz (1902a)
P. ceratocorys var. *tridentata* (Daday) Entz (1902a)
P. acuminatum (Claparède & Lachmann) Zacharias (1906)
P. sphaericum (Stein) Zacharias (1906)
P. lenticula Kofoid (1907a)
P. reticulatum Kofoid (1907a)
P. striatum Kofoid (1907a)
P. ultimum Kofoid (1907a)
P. circumsutum Karsten (1907)
P. hastatum Pavillard (1909)
P. cuneus Stüwe (1909)
P. circumcinctum Kofoid & Michener (1911)
P. favus Kofoid & Michener (1911)
P. fimbriatum Kofoid & Michener (1911)
P. giganteum Kofoid & Michener (1911)
P. limbatum Kofoid & Michener (1911)
P. porosum Kofoid & Michener (1911)
P. praetextum Kofoid & Michener (1911)
P. pulchrum Kofoid & Michener (1911)
P. rotundatum (Claparède & Lachmann) Kofoid & Michener (1911)
P. turbineum Kofoid & Michener (1911)
P. arcuatum Hensen (1911)
P. argo Hensen (1911)
P. cuter Hensen (1911)
P. obliquum Hensen (1911)
P. propulsans Hensen (1911)
P. rotundatum Hensen (1911)
P. acutum (Schütt) Pavillard (1916)
P. pulchellum Lebour (1922)
P. kofoidi Herdman (1923)
P. rotundatum (Claparède & Lachmann) var. *laevis* (Claparède & Lachmann) Jörgensen (1923)
P. ovatum (Claparède & Lachmann) Jörgensen (1923)
P. parvulum (Schütt) Jörgensen (1923)
P. elongatum Jörgensen (1923)
P. stenopterygium Jörgensen (1923)
P. simulans Jörgensen (1923)
P. pugiunculus Jörgensen (1923)
P. ebriola Herdman (1924)
P. irregulare Lebour (1925)

In the present paper the following new specific names have been established: — *P. apicatum*, *P. bipartitum*, *P. contractum*, *P. cuneolus*, *P. laticlatum*, *P. lens*, *P. mucronatum*, *P. paulseni*, *P. protuberans*, and *P. pyriforme;* and two previously described species, *Dinophysis galea* Pouchet (1883) and *D. expulsa* Kofoid and Michener (1911), have been transferred to this genus.

Several of the species mentioned in the last two paragraphs have been transferred to other genera. Schütt's (1895) transfer of *Dinophysis jourdani* Gourret to Phalacroma and Entz's (1902a) allocation, under the name of *Phalacroma ceratocorys,* are incorrect. This species belongs to Ceratocorys of the tribe Peridinioidae, as has been shown by Kofoid (1910a, p. 183) and by Jörgensen (1911, p. 147). *Ceratocorys tridentata* Daday (1888), which was treated by Entz (1902a) under the name of *Phalacroma ceratocorys* var. *tridentata* (Daday), is so inadequately described and figured that its generic allocation must be considered as uncertain. Zacharias's (1906, p. 536, 530) use of Phalacroma for Dinophysis in designating *Dinophysis acuminata* Claparède and Lachmann and *D. sphaerica* Stein was probably due to slips of the pen, since at the remaining several places in his paper he maintained the original generic allocation of these two species. In any case, it is erroneous; both these species are typical representatives of Dinophysis. Herdman's (1923, p. 34) transfer of *Amphidinium kofoidi* var. *petasatum* Herdman (1922) to Phalacroma, under the name of *P. kofoidi,* is incorrect, since this species has a very small epitheca and since its transverse and longitudinal furrows are very deep and without distinct lists (see the Dinophysidae, p. 32). It may also be mentioned that if this variety is given the status of a species, then its name must be *petasatum* and not *kofoidi*. For the same reasons *Phalacroma ebriola* Herdman (1924) does not belong to this genus; (see the family Dinophysidae, p. 32). The transfer to the genus Phalacroma of *Dinophysis rotundata* Claparède and Lachmann (by Kofoid and Michener, 1911), of *D. ovata* Claparède and Lachmann (by Jörgensen, 1923), and of *D. laevis* Claparède and Lachmann (by Jörgensen, 1923) probably is justified. These primitive forms are on the borderland between Phalacroma and Dinophysis, but they appear to be somewhat more closely related to the former than to the latter. It should be remembered, however, that these two genera merge into each other, and that their separation is almost arbitrary. As to whether *Dinophysis laevis* should be treated as a distinct species or as a variety of *Phalacroma rotundatum* is a question of its own that cannot be settled as yet. *Phalacroma hastatum* Pavillard (1909), although fairly highly differentiated, is of uncertain generic assignment. In the present paper we have followed Jörgensen's (1923,

p. 31) suggestion and have referred it to *Dinophysis hastata* Stein (see p. 269). Apparently with full justification, Jörgensen (1923, p. 3) has made *Phalacroma nasutum* Stein (1883) the type of a new genus, Pseudophalacroma. *Phalacroma ultimum* Kofoid (1907a) has in the present paper been made the type of another new genus, Dinofurcula.

The elevation to the rank of species of *Phalacroma porodictyum* Stein var. *parvula* Schütt (1895) (by Jörgensen, 1923) and of *P. vastum* var. *acuta* Schütt (1895) (by Pavillard, 1916) probably is justified.

Phalacroma arcuatum, P. argo, P. armatum, P. euter, P. hastatum, P. obliquum P. propulsans, and *P. rotundatum* Hensen (1895, 1911) are *nomina nuda.* The identity in the arrangement of the species in the two tables given by Hensen (1911, p. 166, 167) and the great similarity in the names indicate that the new names *P. arcuatum* and *P. argo* were intended for *P. armatum* and *P. argus. Phalacrama rotundatum* Hensen (1911) does not refer to *P. rotundatum* (Claparède and Lachmann), since Hensen (1895, 1911) records the latter as *Dinophysis rotundata. P. cuncus* Stüwe (1909), which also is a *namen nudum*, evidently is due to a typographical error and stands for *P. cuneus.*

Phalacroma simulans Jörgensen (1923) is a synonym of *P. favus* Kofoid and Michener (1911); and *P. stenopterygium* Jörgensen (1923) is a synonym of *P. expulsum* (Kofoid and Michener, 1911). Jörgensen (1923, p. 5) suggests that *P. rudgei* Murray and Whitting (1899) "is perhaps only a thick megacytical stage of *Phalacroma rotundatum* var. *laevis.*" However, on account of our scant knowledge of the small and rotund species of this genus, it is advisable to treat *P. rudgei*, preliminarily, as a valid species. With regard to *P. ovum* Schütt (1895) and *P. operculoides* Schütt (1895) see p. 118. With regard to *P. galea* (Pouchet, 1883) see p. 121. *Phalacroma irregulare* Lebour (1925) is based exclusively on fission stages with incomplete lists and with the intercalary border not yet absorbed. It must be regarded as too insufficiently known for certainty of specific identification. Finally, Paulsen (1911b, p. 305, fig. 2) figured a specimen, under the name of *Dinophysis rotundata*, which is referable to Phalacroma but not to any of the species known at the present time. For this form we suggest the name *Phalacroma paulseni*, sp. nov.

Under the designation of Phalacroma sp., four specimens have been figured, viz., by van Breemen (1906, pl. 1, fig. 4a, b), by Okamura (1907, pl. 4, fig. 26 and pl. 5, fig. 42), and by Lindemann (1923, fig. 13). P. sp. van Breemen (1906) possibly may be referable to *P. rudgei*, as suggested by Paulsen (1908, p. 19). P. sp. Okamura (1907, pl. 4, fig. 26) has been allocated to *P. apicatum* (p. 111).

P. sp. Okamura (1907, pl. 5, fig. 42) probably belongs to *P. mitra* Schütt (see Okamura, 1912, p. 18), and not to *P. elongatum* as suggested by Jörgensen (1923, p. 11). P. sp. Lindemann (1923) cannot be identified at the present time.

As will be seen from the previous paragraphs, there are at present forty-seven presumably valid species and one variety of Phalacroma, as follows:—

P. acutum (Schütt) Pavillard (1916)
P. apicatum, sp. nov.
P. argus Stein (1883)
P. bipartitum, sp. nov.
P. blackmani Murray & Whitting (1899)
P. circumcinctum Kofoid & Michener (1911)
P. circumsutum Karsten (1907)
P. contractum, sp. nov.
P. cuneolus, sp. nov.
P. cuneus Schütt (1895)
P. dolichopterygium Murray & Whitting (1899)
P. doryphorum Stein (1883)
P. elongatum Jörgensen (1923)
P. expulsum (Kofoid & Michener) nobis
P. favus Kofoid & Michener (1911)
P. fimbriatum Kofoid & Michener (1911)
P. giganteum Kofoid & Michener (1911)
P. globulus Schütt (1895)
P. hindmarchi Murray & Whitting (1899)
P. lativelatum, sp. nov.
P. lens, sp. nov.
P. lenticula Kofoid (1907a)
P. limbatum Kofoid & Michener (1911)
P. minutum Cleve (1900c)
P. mitra Schütt (1895)
P. mucronatum, sp. nov.
P. operculatum Stein (1883)
P. operculoides Schütt (1895)
P. ovatum (Claparède & Lachmann) Jörgensen (1923)
P. ovum Schütt (1895)
P. parvulum (Schütt) Jörgensen (1923)
P. paulseni, sp. nov.
P. porodictyum Stein (1883)
P. porosum Kofoid & Michener (1911)
P. praetextum Kofoid & Michener (1911)
P. protuberans, sp. nov.
P. pugiunculus Jörgensen (1923)
P. pulchellum Lebour (1922)
P. pulchrum Kofoid & Michener (1911)
P. pyriforme, sp. nov.
P. rapa Stein (1883)
P. reticulatum Kofoid (1907a)
P. rotundatum (Claparède & Lachmann) Kofoid and Michener (1911)
P. rotundatum (Claparède & Lachmann) var. laevis (Claparède & Lachmann)
P. rudgei Murray & Whitting (1899)
P. striatum Kofoid (1907a)
P. turbineum Kofoid & Michener (1911)
P. vastum Schütt (1895)

Besides these forty-seven valid species, we have *Phalacroma galea* (Pouchet, 1883), which may be identical with either *P. doryphorum* or *P. circumsutum*, and *P. irregulare*.

All the published descriptions of the species are short and incomplete and have no or but few data of variation for consideration. The descriptions of Kofoid (1907a) and of Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper. Some of the forty-seven species mentioned above, *e.g.*, *Phalacroma globulus* Schütt and *P. minutum* Cleve, are so incompletely known that their certain specific identification will cause considerable difficulty. Furthermore, the synonymies of some of these species, *e.g.*, those of *P. rotundatum* (Claparède and Lachmann) and of the other species occurring in northern European waters, are so exceedingly complicated that it appears more than doubtful whether anybody will be capable of unravelling them in a satisfactory way. Finally, a few of these species, as conceived in the present paper, are so variable that there are reasons to believe that future investigators with adequate material at their disposal will find it necessary and feasible to undertake a further systematic subdivision.

The first investigator to attempt a subdivision of Phalacroma (Jörgensen, 1923) divides the genus into six sections, viz., Paradinophysis, Euphalacroma, Cuneus, Argus, Podophalacroma, and Urophalacroma. The species included in these sections are as follows:— Paradinophysis:— *P. rotundatum*, *P. rotundatum* var. *laevis*, *P. rudgei*, *P. ovatum*, and *P. parvulum*. Euphalacroma:— *P. ovum*, *P. porodictyum*, *P. operculatum*, *P. acutum*, and *P. elongatum*. Cuneus:— *P. expulsum*, *P. cuneus*, *P. blackmani*, and *P. striatum*. Argus:— *P. argus*. Podophalacroma:— *P. rapa*, *P. dolichopterygium*, *P. mitra*, *P. favus*, and *P. hindmarchi*. Urophalacroma:— *P. doryphorum*, *P. circumsutum*, *P. pugiunculus*, and *P. pulchrum*. Using Jörgensen's system as a basis, Pavillard (1923a) suggested a division of the genus into two subgenera, Euphalacroma and Paradinophysis. To the first of these he referred four of Jörgensen's sections, viz., Oblongata (nom. nov.), Cuneus, Argus, Podophalacroma. To the second subgenus he referred the remaining two of Jörgensen's sections, viz., Rotundati (nom. nov.) and Urophalacroma.

The situation of the sulcal lists relative to the thecal valves was unknown even to Stein (1883, p. 23). This problem was settled by studies on the closely related genus Dinophysis (see p. 224). Bütschli (1885) and Schütt (1895, 1899) have given fairly extensive accounts of the structure and organization of the thecal wall and of the cell contents.

With regard to the morphological changes that take place in the theca preceding binary fission, it may be mentioned that megacytic specimens were figured by several investigators, *e.g.*, by Stein (1883), Schütt (1895), Murray and Whitting (1899), and Meunier (1910) before Pavillard (1915a, 1916) discussed at length and correctly interpreted this phenomenon. Schütt (1895, p. 148) misunderstood the significance of the intercalary zones, while Meunier (1910, p. 59) gave a short but correct account of these structures. It may also be mentioned in this connection that Pouchet (1894) interpreted megacytic specimens in the genus Dinophysis as prefission stages.

Contributions to our knowledge of the distribution of Phalacroma are to be found in the following papers, not specifying those previously mentioned in this section:— Cleve (1899c, 1900b, 1901a, c, 1902b, 1903b), Daday (1888), Entz (1902b, 1904, 1905), Forti (1922), Gräf (1909), Gran (1912b, 1915), Karsten (1905, 1906, 1907), Lemmermann (1899a, 1901a, 1904, 1905a), Lindemann (1924, 1925), Lloyd (1925), Lohmann (1902, 1908a, 1920), Mangin (1912, 1915), Nathansohn

(1908, 1909, 1910a), Ostenfeld (1898a, 1906, 1915, 1916b), Ostenfeld and Paulsen (1904), Ostenfeld and Schmidt (1901), Paulsen (1904), Pavillard (1905, 1912), Rauschenplat (1900), Schiller (1911a, b, c, 1912), Schmidt (1901), Schröder (1900a, 1906a, 1911), Stüwe (1909), and Whitelegge (1891). None of these papers contains original figures by means of which the correctness of the determinations may be checked. Forti (1922) gives reproductions of previously published figures of the species recorded. Due to the great difficulties implied in the determination of several of the species of Phalacroma and to the broad concept of species held by many of the investigators, much of the data on the distribution of this genus should be accepted tentatively.

References to Phalacroma or minor contributions to our knowledge of this genus are found also in Balbiani (1884c), Bergh (1884), Calkins (1902), Chun (1903), Doflein (1909, 1911, 1916), Forti and Issel (1923, 1924), Hensen (1891), Kofoid (1906c), Lindemann (1923a), Nathansohn (1910b), Oltmanns (1922), Schütt (1893, 1900a), Steuer (1910, 1911), Walther (1893), and Willey and Hickson (1909). Pavillard (1923a) gives a critical review of Jörgensen's (1923) important paper on this group.

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

Although Phalacroma is limited largely to tropical, subtropical, and warm-temperate waters of relatively low buoyancy, it is characterized by the fact that the body (theca) is simple in shape, viz., subspheroidal (Schütt, 1895, pl. 2, fig. 12: 1), lenticular (Plate **3**, fig. 3, 5), cuneate (Plate **2**, fig. 5, 8), inversed fig-shaped (Plate **2**, fig. 7), subbiconical (Plate **4**, fig. 1–7), or bilaterally flattened ellipsoidal (Figure 3: 6) and subobovoidal (Figure 11). In no species does the body show adaptations to flotation in the form of pronounced elongation or protuberances as in Amphisolenia, Triposolenia, and certain species of Dinophysis; they maintain themselves in their optimum habitat, *i.e.*, in the upper strata of the sea mainly as follows:— (*1*) they are fairly active swimmers; (*2*) most of them are relatively small; (*3*) their protoplasm contains large pusules (Schütt, 1895, pl. 4, fig. 19: 2) and inclusions of low specific gravity, such as fats and oils (Schütt, 1895, p. 82–86), and they thus have a specific gravity approaching that of the surrounding medium; (*4*) in many of them the surface friction is increased by structural differentiations of the outer surface of the theca (Plate **4**, fig. 1–7); (*5*) some of them have relatively large cingular, sulcal, or parasagittal lists (Plate 2, fig. 8; Plate 1, fig. 6; Plate 4, fig. 4; Plate 3, fig. 5; Figure 23:6).

The most important of these five points probably is the third one, *i.e.*, the lowering of the specific gravity of the body. Without stressing the first point, it is known that the species of Phalacroma are fairly active swimmers, but, on the other hand, there are no data as yet on the question as to how their swimming capacity compares with that of the members of such genera as Amphisolenia and Triposolenia in which the body is highly adapted for flotation. As to the second point, *i.e.*, the relatively small size of the body, it may be mentioned that the largest of all the known species of Phalacroma, *P. giganteum*, is characterized by its thin and fragile theca, while its close relative, the comparatively small *P. cuneus*, has a rather heavy theca. The reduced thickness of the thecal wall in *P. giganteum* may be interpreted as an adaptation to flotation; the decrease in the weight of the theca at least to some extent counterbalances the reduction in the relative surface of resistance caused by the increase in the volume of the body. When the adaptive value of the lists is considered, it should be remembered that these structures are relatively small in all the species of the genus occurring in cold waters (viz., *P. rotundatum* and its variety *laevis*, *P. ovatum*, *P. paulseni*, *P. minutum*, and *P. rudgei*), and that they reach their highest development in waters of low buoyancy. A thorough understanding of the functions of each of the three different kinds of lists present in this genus, viz., the cingular, sulcal, and parasagittal lists, will require a careful analysis from the viewpoints of mechanics and hydrodynamics. Such an analysis is outside the scope of the present paper. The following summary statements must suffice.

The cingular lists, although small, undoubtedly act as parachutes when the body is suspended with the apex uppermost. The nearly symmetrically developed parasagittal lists of some species, *e.g.*, of *P. limbatum* and *P. fimbriatum* (Plate 3, fig. 5; Plate 4, fig. 4), act as parachutes when the organism is turned upon one of its lateral faces. The asymmetrical parasagittal lists of some species, *e.g.*, of *P. pulchrum* (Plate 3, fig. 6), and the asymmetrical left sulcal list increase the surface of resistance and cause the organism to sink in a descending zigzag or spiral path whenever it rests on one of its lateral faces. They also function as keels and rudders, thus stabilizing the progressive spiral swimming characteristic of Phalacroma (*cf.* Kofoid, 1906c, p. 129). Noteworthy in this connection are the small size of the right sulcal list, when compared to the left, and the fact that the left sulcal list is somewhat oblique in position, passing from the left valve to the right, and often somewhat spiral-shaped (Plate 2, fig. 1, of *Phala-*

croma fimbriatum; Plate 5, fig. 3, of *Dinophysis jörgenseni*). Finally, it may be added that the inclination of the longitudinal axis of the body found in several species of Phalacroma may be connected with the spiral mode of swimming. With regard to the significance of the spiral swimming, see Jennings (1901).

Although in the present paper all the external characters have been taken into account in the establishment and characterization of species, some of the specific separations in Phalacroma should be regarded as tentative. This is due partly to the simple organization of many of these species and partly to the fact that all the species characters are subject to variations of the fluctuating kind, in varying degree of amplitude. The characters which are most variable within the species are the size and shape of the body (theca), the relative height of the epitheca, the shape of the left sulcal list, and the development and structure of the accessory lists and sails. These are also the characters which have been most profoundly modified within the genus as a whole, and it is largely upon them that the subdivisions of the genus have been founded. The variations in the development of the parasagittal lists appear at least in part to be due to the comparatively slow formation of these structures following binary fission.

When not otherwise stated, the following principles have been applied in the *descriptions* of species of this genus:—

(*1*) All characteristics refer to specimens in lateral view.

(*2*) Diagnoses and descriptions refer to premegacytic specimens only; when only megacytic specimens were available, descriptions and measurements were made from valves exclusive of the intercalary zone.

(*3*) The terms length and depth of body, and symmetrical and asymmetrical species refer to body (theca) exclusive of lists.

(*4*) When the cingular lists have only the two ribs near the dorsal sagittal suture, they are said to be without ribs.

(*5*) The right sulcal list is without structural differentiations.

If not otherwise stated in the *diagnosis*, the species is characterized by the following features:—

(*1*) The body is subsymmetrical, and its longitudinal axis is perpendicular to the girdle.

(*2*) The thecal wall has scattered pores.

(*3*) In the case of the species figured with the body viewed dorsoventrally, the flagellar pore is located about a girdle-width behind the posterior cingular list.

(*4*) The epitheca is visible above the anterior cingular list.

(*5*) The cingular lists are ribbed, subequal, about as wide as the transverse furrow, subhorizontal or with but slight anterior inclination, and run in an almost straight line across the body. Their ribs are complete or almost so, *i.e.*, they reach the free edge of the list, equidistant, straight, and simple or almost so.

(*6*) The right sulcal list is subtriangular, and extends to R_2 or to R_3 of the left sulcal list or to a point somewhere between these two ribs.

(*7*) Left sulcal list: the ventral and posterior margins, which are straight or but slightly convex, concave, or sigmoid, form together a distinct angle. The three main ribs are present, of moderate strength, almost straight, and not club-shaped or otherwise modified; and the list has no structural differentiation besides the main ribs.

(*8*) Accessory lists and sails are absent, or, when present, they lack structural differentiations.

The methods of measuring lengths, angles, and proportions utilized are shown in Figure 29.

Subdivisions. Relationships among the Species

Although Phalacroma is one of the most primitive genera of Dinophysoidae, it exhibits a marked structural diversity. Of all the known species, *P. pulchellum* is considered to be, on the whole, structurally the most primitive, resembling the simple ancestors from which this genus originated. This assumption is based on the small size (length, 21 μ) of this species, on its approach to the fundamental spherical form, its large and high epitheca (the posterior cingular list is located about 0.40 the length of the body from the apex), the slight development of its cingular and sulcal lists, its lack of accessory lists and sails, and on the areolation and porulation of its thecal wall. A fundamental feature of the structural differentiation within the genus is that it nearly always has been accompanied by an increase in size. Although the body shows a great variety of shapes, it is never characterized by extreme elongation or by processes; on the other hand, bilateral compression is a nearly universal phenomenon. The girdle is supposed to have been originally nearly equatorial in position (see p. 30). From the equatorial position, which still is found in some of the primitive as well as in some of the advanced species (*P. lenticula*, Figure 3: 7; *P. limbatum*, Plate 3, fig. 5), the girdle has migrated anteriorly; or a reduction in the height of the epitheca has taken place. The cingular lists show increase in size and structural complexity, but remain comparatively small and simple. A somewhat greater diversity in size and structure is exhibited by the left sulcal list. Just as in Ornithocercus and Histioneis, it is largely the portion of this list behind the fission rib that has increased in size and structural complexity. The phylogenetic development of the accessory lists and sails appears to have proceeded from the posterior end of the left sulcal list anteriorly along the dorsal side of the body, and from the right valve to the left. The structure of the thecal wall seems to have developed in most cases from areolation to reticulation; and there seems to have been an inherent tendency for the meshes of the reticulum to become progressively larger. Sometimes, however, a differentiation of the thecal structure appears to have taken place (*e.g.*, *P. giganteum*).

In most cases the progress within the several groups, which have been established in speciation, is from the less to the greater diversity and specialization in structural detail. This increase in complexity is expressed in several, though not often in all the characters, of the individual species. It is interesting to note how the structural features utilized in speciation in this genus seem to be pervaded by the aspect of factors such as those with which the geneticist deals. In some groups the speciation might be conceived as a series, partially realized, of permutations of factors with intergradations due to multiple factors giving results which simulate seriation. In other groups we find more or less clearly defined orthogenetic series of intermediate and progressively differentiated species. The factorial analyses of genetics do not compel the assumptions that the individual links in these series have originated chronologically, *i.e.*, that they are genetically sequential, although the conventional conception of the evolutionary process inclines us to this interpretation. Nuclear reorganizations equivalent, or related to those which ensue in gametogenesis or endomixis would appear to be an essential cytological basis for the distribution of genes which the kind of speciation outlined above seems to suggest. However, such reorganizations are as yet unknown in this genus.

1. CONTRACTUM group: —
   P. contractum, sp. nov. Figure 3: 1.

2. ROTUNDATUM group: —
   P. pulchellum Lebour (1922, fig. 1–4).
   P. parvulum (Schütt) Jörgensen. Figure 3: 4–6.
   P. globulus Schütt (1895, pl. 2, fig. 12).
   P. operculoides Schütt (1895, pl. 2, fig. 11: 1).
   P. rudgei Murray & Whitting (1899, pl. 31, fig. 6).
   P. rotundatum (Claparède & Lachmann) Jorgensen (1923, fig. 2).
   P. rotundatum (Claparède & Lachmann) var. *laevis* (Claparède & Lachmann) (1858, pl. 20, fig. 13).
   P. irregulare Lebour (1925, pl. 11, fig. 4).
   P. latirelatum, sp. nov. Figure 3: 2, 3.
   P. paulseni, sp. nov. Paulsen (1911b, fig. 2).
   P. ovatum (Claparède & Lachmann). Jörgensen (1923, fig. 3).
   P. lens, sp. nov. Figure 4: 1–3.
   P. porosum Kofoid & Michener. Figure 5.
   P. lenticula Kofoid. Figure 3: 7.

3. Argus group: —

P. porodictyum Stein. Figure 6.
P. vastum Schütt (1895, pl. 3, fig. 16: 3).
P. argus Stein. Figure 8: 1, 2.
P. apicatum, sp. nov. Figure 10.
P. operculatum Stein *s. str.* (1883, pl. 18, fig. 8).
P. circumcinctum Kofoid & Michener. Figure 8: 3.
P. ovum Schütt. Figure 11.
P. elongatum Jörgensen (1923, fig. 9).
P. pyriforme, sp. nov. Figure 4: 4, 5.

4. Cuneus group: —

P. cuneus Schütt. Figure 12.
P. blackmani Murray & Whitting (1899, pl. 31, fig. 4).
P. striatum Kofoid. Figure 14: 3.
P. giganteum Kofoid & Michener. Figure 14: 1.

5. Rapa group: —

P. acutum (Schütt) Pavillard. Schütt (1895, pl. 3, fig. 17: 7).
P. minutum Cleve (1900c, pl. 8, fig. 10, 11).
P. dolichopterygium Murray & Whitting (1899, pl. 31, fig. 8).
P. mitra Schütt (1895, pl. 4, fig. 18).
P. rapa Stein. Figure 16.
P. favus Kofoid & Michener. Figure 14: 2, 4, 5.
P. hindmarchi Murray & Whitting. Figure 18.

6. Expulsum group: —

P. protuberans, sp. nov. Figure 20: 1–5.
P. expulsum (Kofoid & Michener). Figure 20: 6–9.

7. Limbatum group: —

P. limbatum Kofoid & Michener. Figure 21: 1.
P. bipartitum, sp. nov. Figure 21: 2.
P. pulchrum Kofoid & Michener. Figure 21: 3.

8. Doryphorum group: —

P. mucronatum, sp. nov. Figure 22: 4, 6, 8.
P. doryphorum Stein. Figure 23: 1–5.
P. circumsutum Karsten. Figure 23: 6.
P. cuneolus, sp. nov. Figure 23: 1–3, 5, 7.
P. pugiunculus Jörgensen (1923, fig. 19).

9. Praetextum group: —

P. praetextum Kofoid & Michener. Figure 25: 4, 5.

10. Reticulum group: —

P. fimbriatum Kofoid & Michener. Figure 25: 1.
P. reticulatum Kofoid. Figure 25: 2.
P. turbineum Kofoid & Michener. Figure 25: 3.

Discussion of Species Groups

1. Contractum group (Figure 3: 1). The sole member of this group is of uncertain generic assignment. The small size and subrotund shape of the body, the fairly large size of the epitheca, the small size and the shape of the cingular and sulcal lists, and the lack of ribs in the left sulcal list affiliate it with *Pseudophalacroma nasutum.* The latter species is characterized especially by an anterior prolongation of the longitudinal furrow, extending two thirds the distance from the girdle to the apex. This prolongation, which presumably is a primitive feature of great taxonomic significance, is not indicated in our drawing of *Phalacroma contractum* but may have been overlooked. The small size and simple structure of the cingular and sulcal lists indicate that this species is on a lower evolutionary level than the members of the Rotundatum group.

2. ROTUNDATUM group (Lebour, 1922, fig. 1–4; Figure 3: 4–6; Schütt, 1895, pl. 2, fig. 12, 11: 1; Murray & Whitting, 1899, pl. 31, fig. 6; Jörgensen, 1923,

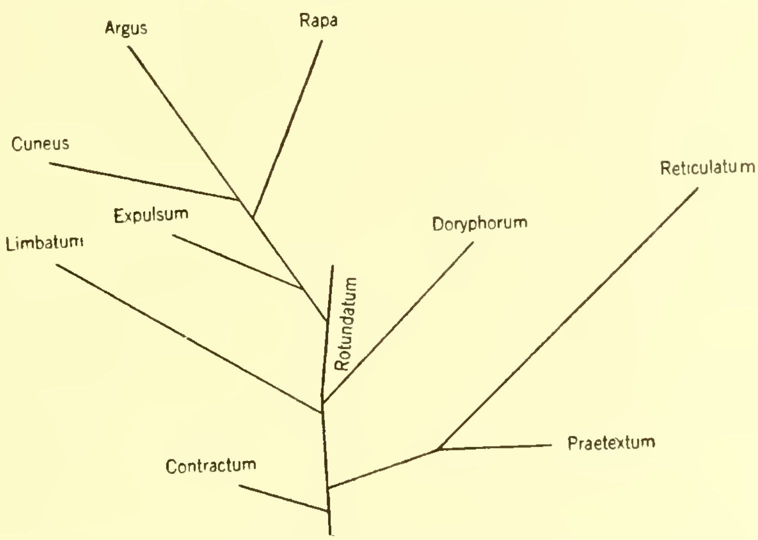

FIGURE 2.— Graphical representation of the relationships of the groups of species in Phalacroma.

fig. 2; Claparède & Lachmann, 1858, pl. 20, fig. 13; Lebour, 1925, pl. 11, fig. 4; Figure 3: 2, 3; Paulsen, 1911b, fig. 2; Jörgensen, 1923, fig. 3; Figure 4: 1–3; 5: 1–3; 3: 7). Body circular, subcircular, or ellipsoidal in lateral outline; length: depth, 0.95–1.30: 1. Epitheca large to fairly small, depending on position of girdle, which is quite variable; posterior cingular list located 0.16–0.58 the length of body from apex. Longitudinal axis usually perpendicular or nearly so, but it may be somewhat inclined posteroventrally. In dorsoventral view the body is subrotund to more or less narrowly lens-shaped. The cingular lists, which are somewhat wider to somewhat narrower than the transverse furrow and usually without structural differentiation, are either subhorizontal or characterized by a more or less pronounced anterior inclination. Free margin of right sulcal list either almost evenly convex, or nearly straight anteriorly and convex posteriorly. Left sulcal list, which is very unsatisfactorily represented in some of the members of this group, is probably always furnished with three main ribs and angular at posterior main rib. Accessory lists and sails absent. Thecal wall usually porulate and areolate, but areolation may be lacking or is replaced by a fine-meshed reticulation. Most of the species are small; length, 21–82 μ.

All the members of this group are very simple in shape and structure; and since several of them have overlapping ranges of variation, the present delimitation of species should be regarded as partly tentative; compare, for instance, *Phalacroma parvulum*, *P. lativelatum*, and *P. operculoides* (Figure 3: 2, 3, 4–6; Schütt, 1895, pl. 2, fig. 11: 1). No distinct orthogenetic lines can be distinguished; and the degree of interrelationship among the various members cannot be established, due to the simplicity of their organization. The following evolutionary tendencies are inherent in this group: — increase in the size and bilateral compression of the body, anterior displacement of the girdle and consequent reduction of the size of the epitheca, increase in the size of the cingular and left sulcal lists, decrease in the size of the right sulcal list, and the change of the structure of the thecal wall from areolation to reticulation. Furthermore, in some members the cingular lists tend to become inclined anteriorly. A striking feature of these tendencies is their independence, as will be illustrated by the following examples: — *Phalacroma lenticula* (Figure 3: 7) is advanced in size of body (being the largest member of the group), in having the left sulcal list relatively large, and in having the thecal wall reticulated; on the other hand, its girdle has maintained the primitive subequatorial position and its cingular lists are unusually narrow. *Phalacroma porosum* (Figure 5) is large, its girdle is located anteriorly, and its theca is reticulated; its right sulcal list, on the other hand, is still relatively large. *Phalacroma lativelatum* (Figure 3: 2, 3) is primitive in the size of the body, in the relative size of the right sulcal list, and in the structure of the thecal wall; it is advanced in having the epitheca reduced in size and in the unusually large size of the left sulcal list. The bilateral compression of the body has advanced in this group as far as in any other group of this genus (see, for instance, *P. lens*, Figure 4: 2, and *P. irregulare*, Lebour, 1925, pl. 11, fig. 4e). The tendency of the cingular lists to become subhorizontal in some species and inclined anteriorly in others indicates that this group is close not only to the ancestral forms of Phalacroma but also to those of the closely related genus Dinophysis.

The Rotundatum group (a name previously used by Pavillard, 1916, p. 60, and by Jörgensen, 1923, p. 5) corresponds largely to Jörgensen's (1923) Sectio Paradinophysis, the only difference being that Jörgensen does not include *Phala-*

croma operculoides. This difference, however, is apparent only, and due to the fact that *P. operculoides* Schütt of Jörgensen is identical with *P. ovum* Schütt, nobis (see p. 121).

3. Argus group (Figure 6; Schütt, 1895, pl. 3, fig. 16: 3; Figure 8: 1, 2, and 10; Stein, 1883, pl. 18, fig. 8; Figure 8: 3; and 11; Jörgensen, 1923, fig. 9; Figure 4: 4, 5). Body obovate to subovate in lateral outline; length: depth, 1.11–1.65: 1. Epitheca rounded dome-shaped to conical; large, about as wide as hypotheca or but slightly narrower, and usually rather high; distance from posterior cingular list to apex is 0.25–0.53 the length of body. Hypotheca without ventral corner. Longitudinal axis perpendicular or somewhat inclined posteroventrally; very seldom inclined slightly posterodorsally. In dorsoventral view the body usually is obovate, but it may be biconical or pear-shaped. Cingular lists subhorizontal and subequal, about as wide as or somewhat wider than transverse furrow, with or without ribs. Free margin of right sulcal list often angular, concave anteriorly and convex to straight posteriorly; or it is more or less evenly convex. Left sulcal list with three main ribs; its free margin either angular or rounded at posterior main rib. Parasagittal lists usually absent; triangular posterior sail never developed. Thecal wall either areolate or faintly reticulate; when reticulate, 15–30 meshes border girdle posteriorly. Small to large species, 48–111 μ in length.

Among the members of this group, *Phalacroma porodictyum* (Figure 6) is in several respects the most primitive. The body of this species, which usually is regularly obovate in lateral outline, is in some specimens nearly subcircular; the left sulcal list has the fundamental subrectangular shape and its ribs are simple, well developed, and nearly straight; the thecal wall is finely areolate. On the other hand, this species is advanced in having the free margin of the right sulcal list angular, concave anteriorly and concave to straight posteriorly, a character of the greatest taxonomic importance, since it is found in but few species of the genus. From an ancestral form structurally very close to *P. porodictyum* evolved *P. vastum*, *P. argus*, *P. apicatum*, and *P. operculatum s. str.*, all of which are structurally very similar. *Phalacroma vastum* (Schütt, 1895, pl. 3, fig. 16: 3), the sulcal lists of which are of unknown shape and structure, differs from *P. porodictyum* especially in having the thecal wall finely reticulate instead of areolate. *Phalacroma argus* (Figure 8: 1, 2) is more advanced than *P. porodictyum* in having the free margin of the left sulcal list rounded instead of angular posteriorly, the posterior main rib of this list reduced in size, and the thecal wall reticulate. *Phalacroma apicatum* (Figure 10), which resembles *P. argus* in these characteristics, differs from this species, as well as from *P. porodictyum* and *P. rastum*, in the conical shape of its epitheca. *Phalacroma operculatum s. str.* (Stein, 1883, pl. 18, fig. 8), which is very similar to *P. apicatum* in a great many respects, *e.g.*, in the cone-like shape of the epitheca, differs from *P. rastum*, *P. argus*, and *P. apicatum* in having retained the primitive areolate structure of the thecal wall. (Unfortunately, the right sulcal list is omitted in Stein's figure of the type specimen of this species.)

The four remaining species of this group, viz., *Phalacroma circumcinctum*, *P. ovum*, *P. elongatum*, and *P. pyriforme*, are of somewhat less certain allocation. *Phalacroma circumcinctum* (Figure 8:3) is structurally closest to *P. apicatum*, which it resembles in the fairly elongate and, in dorsoventral view, subbiconical shape of the body; in the subequatorial position of the girdle; and in the sub-horizontal position and the width of the cingular lists. It differs from this species especially in the following respects: — it has retained the primitive, areolate structure of the thecal wall; it has a parasagittal list, a unique feature in this group; the free margin of the right sulcal list is gently sigmoid and that of the left sulcal list is angular posteriorly; and the fission rib of the latter list is T-shaped. The last peculiar character of *P. circumcinctum* recalls *P. ovum* (Figure 11) and may be taken as an indication of the close relationship between these two species. *Phalacroma ovum* is primitive in having the thecal wall finely areolate and the free margin of the right sulcal list gently convex. It is advanced in the anterior displacement of the girdle and in having the fission rib of the left sulcal list T-shaped and the posterior main rib of this list club-shaped. *Phalacroma elongatum* (Jörgensen, 1923, fig. 9) differs from the other members of this group in the pronounced elongation of the body. Its systematic position is uncertain largely because of the fact that its right sulcal list is unknown and of its left sulcal list only the anterior half is known. *Phalacroma pyriforme* (Figure 4:4, 5) resembles *P. argus* strikingly in the shape of the body in lateral view, in the position of the girdle, and in the rounded shape of the posterior portion of the free margin of the left sulcal list. It differs from all the other members of this group in the pyriform shape of the body in dorsoventral view, a character wherein it approaches the Cuneus group, to which the Argus group undoubtedly is very closely related.

The following tendencies appear to be inherent in the Argus group:— the epitheca and the hypotheca, either both or separately, tend to become conical, the girdle to move anteriorly, the longitudinal axis to become deflected postero-ventrally, the theca to become reticulate, the free margin of the right sulcal list to become angular, that of the left sulcal list to become rounded posteriorly.

Furthermore, the epitheca as well as the hypotheca tends to develop parasagittal lists, but this tendency is expressed morphologically in one species only, viz., *Phalacroma circumcinctum*. An increase in size can be recorded, although most of the members are of subequal size (compare the size of *P. pyriforme* and that of *P. apicatum*).

This group differs fundamentally from the section Argus established by Jörgensen (1923). The latter group includes but one species, viz., *Phalacroma argus*. *P. porodictyum*, *P. operculatum* s. str., *P. ovum* (= *P. operculoides*, Jörgensen, 1923), and *P. elongatum* are referred by Jörgensen to his section Euphalacroma, a group including, besides these four species, *P. acutum*, which in the present paper has been assigned to the Rapa group.

4. Cuneus group (Figure 12; Murray and Whitting, 1899, pl. 31, fig. 4; Figure 14: 3, and 1). Body cuneate in lateral outline, about as deep as long, and deepest at girdle. Epitheca large but relatively low; very broadly rounded. Posterior cingular list 0.20–0.28 the length of body from apex. Hypotheca more or less cuneate and slightly deflected posteroventrally; its posterior portion fairly broadly to rather narrowly rounded; its dorsal margin straight, slightly convex or concave, or slightly sigmoid, concave anteriorly and convex posteriorly; its postmargin evenly convex and confluent with the dorsal and ventral margins; its ventral margin not angular. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of hypotheca narrowly rounded to acute. Cingular lists subhorizontal and subequal, about as wide as transverse furrow, ribbed or reticulate. Free margin of right sulcal list angular, sigmoid, or gently convex. Left sulcal list with the three main ribs developed; its free margin gently convex at posterior main rib and not angular as in most species of this genus; main ribs, especially the posterior, usually more or less weak. Parasagittal lists may be present, but triangular posterior sail never developed. Thecal wall with a reticulum of medium-sized polygons, each of which has a central pore; about twenty-five to thirty-five polygons border girdle posteriorly; reticulation sometimes faint or, perhaps, even absent. Medium-sized to very large species, 72–148 μ in length.

This is the most uniform group within the genus. Its evolutionary differentiation is characterized by the independence of the individual features; in other words, it gives the impression of permutation of characters rather than of orthogenesis. The following facts illustrate this statement. There is a progressive increase in size, but this increase is not paralleled by any other character: *Phalacroma cuneus* is 72–88 μ, *P. striatum* 102–136 μ, *P. blackmani* 125 μ, and *P.*

giganteum 148 μ long. The reticulation of the theca in *P. cuneus*, *P. striatum*, and *P. blackmani* is rather heavy and decidedly better developed than in any of the members of the Argus group, a group from which the Cuneus group presumably originated. In *P. giganteum*, on the other hand, which in regard to size is at the top of its group, the theca lacks reticulation or nearly so. The size of the left sulcal list and the direction of the posterior main rib of this list are about the same in *P. cuneus*, *P. blackmani*, and *P. giganteum* as in *P. argus;* while in *P. striatum*, a species of intermediate size, this list is unusually large and its posterior main rib is directed posteriorly. The right sulcal list has about the same shape, structure, and relative size in *P. striatum* as in *P. argus*. On the other hand, in the small *P. cuneus* this list is long and narrow and its ventral margin is gently convex; and in the large *P. giganteum* it is comparatively small, and its ventral margin is sigmoid instead of angular as in *P. argus*. The parasagittal lists reach their highest development in *P. blackmani*, a species of intermediate size.

The tendencies to be found in this group are as follows: — the body and the left sulcal list tend to increase in size; the reticulation of the thecal wall and the accessory ribbing of the left sulcal list tend to become heavier; the posterior main rib of the left sulcal list tends to become more deflected posteriorly; the free margin of the right sulcal list tends to become angular, concave anteriorly and convex posteriorly; and parasagittal lists tend to develop.

This group corresponds largely to the section Cuneus established by Jörgensen (1923), the main difference being that Jörgensen includes *Phalacroma stenopterygium* (= *expulsum*), a species assigned by us to the Expulsum group. *Phalacroma expulsum* resembles the members of the Cuneus group in having the hypotheca cuneate in dorsoventral view and the free margin of the left sulcal list rounded instead of angular posteriorly. On the other hand, it differs very strikingly in the small size of the epitheca, in the shoulder-like constriction of the body on the dorsal side of the girdle, and in not having the hypotheca cuneate in lateral outline. Although the members of the Expulsum group embody tendencies that affiliate them with the Cuneus group, they undoubtedly represent a different evolutionary line, and their assignment to the Cuneus group would decidedly decrease the present homogeneity of this unit.

5. Rapa group (Schütt, 1895, pl. 3, fig. 17: 1; Cleve, 1900c, pl. 8, fig. 10, 11; Murray and Whitting, 1899, pl. 31, fig. 8; Schütt, 1895, pl. 4, fig. 18; Figure 16; 14: 2, 4, 5; and 18). Body subobovate to subcuneate or fig-shaped in lateral outline; length: depth, 1.00–1.34: 1. Longitudinal axis perpendicular or somewhat inclined posteroventrally. Epitheca about as deep as hypotheca or slightly less;

either high and dome-shaped, or more or less flattened. Distance from posterior cingular list to apex 0.10–0.44 the length of body. Hypotheca tapering posteriorly, with a more or less developed corner near middle of ventral side; posterior portion of ventral side (*i.e.*, behind posterior main rib of left sulcal list) almost straight or more or less concave. In dorsoventral view the body is usually cuneate, sometimes fig-shaped, with the posterior portion of hypotheca narrowly rounded to subacute. Cingular lists subhorizontal and subequal, about as wide as transverse furrow, ribbed or reticulate. Free margin of right sulcal list gently convex or this list is of subuniform width throughout the greater part of its length and more or less strongly convex posteriorly. Left sulcal list with three well-developed main ribs; its free margin angular at posterior main rib. Parasagittal lists absent or exceedingly narrow. Thecal wall sometimes areolate but usually reticulate; when reticulate, about twenty to twenty-five meshes border girdle posteriorly. Fairly small to rather large species, 50–98 μ in length.

Phalacroma acutum (Schütt, 1895, pl. 3, fig. 17: 1) is, on the whole, the most primitive member of this group. It is characterized especially by the comparatively high and dome-shaped epitheca and by having the posterior portion of the ventral side of the hypotheca nearly straight; the dorsal margin of the hypotheca is gently and evenly convex; and the thecal wall is finely reticulate. Very closely related to, and possibly identical with, this species is *P. minutum* Cleve (1900c, pl. 8, fig. 10, 11), of which our knowledge, unfortunately, is very fragmentary. Another very close relative is *P. dolichopterygium* Jörgensen (1923, fig. 15), which differs from *P. acutum* mainly in having the epitheca somewhat lower. Since this character is fairly variable within several of the members of Phalacroma, this form too might be specifically identical with *P. acutum*. *Phalacroma dolichopterygium* Murray and Whitting (1899, pl. 31, fig. 8) probably evolved from an ancestral form of about the same shape and structure as *P. dolichopterygium* Jörgensen (1923). These two forms differ from each other mainly in the length of the left sulcal list, which in the specimen figured by Murray and Whitting (1899) extends to the antapex of the body, while in Jörgensen's (1923) it ends just behind the ventral corner of the hypotheca, just as in most of the other members of this group. *Phalacroma dolichopterygium* Jörgensen (1923) also may be considered very similar to the ancestral form from which *P. mitra*, *P. favus*, and *P. rapa* evolved. The most primitive of the three last species presumably is *P. mitra* (Schütt, 1895, pl. 4, fig. 18), which differs from *P. dolichopterygium* Jörgensen (1923) mainly in having the posterior half of the ventral margin of the hypotheca strikingly concave. *Phalacroma rapa* (Figure 16) represents an extreme development of the *mitra* type, being characterized especially by the very pronounced angularity of the ventral margin of the hypotheca; the dorsal margin, on the other hand, is still evenly convex, at least in many specimens. *Phalacroma favus* (Figure 14: 4, 5) also may be regarded as an extreme derivative of the *mitra* type; in this species the posterior portion of the body is more or less strongly constricted and thus mammilliform, and the dorsal margin of the hypotheca is undulating. The remaining member of this group, *P. hindmarchi* (Figure 18), must be considered a highly differentiated representative of an evolutionary branch that split off very early, even below the level of *P. acutum*. It has remained primitive in some respects, viz., in the relatively great height of the epitheca and in the structure of the thecal wall, which is areolate; in the latter feature it is even more primitive than *P. acutum*. On the other hand, the posterior portion of its body is as strikingly constricted and mammilliform as in *P. favus*.

Five evolutionary series in this group can be distinguished:—

1. Ancestral form — *P. acutum* — *P. minutum*.

2. Ancestral form — *P. acutum* — *P. dolichopterygium* Jörgensen (1923) — *P. dolichopterygium* Murray and Whitting.

3. Ancestral form — *P. acutum* — *P. dolichopterygium* Jörgensen (1923) — *P. mitra* — *P. rapa*.

4. Ancestral form — *P. acutum* — *P. dolichopterygium* Jörgensen (1923) — *P. mitra* — *P. favus*.

5. Ancestral form — *P. hindmarchi*.

In the four first the epitheca tends to become progressively lower and the posterior portion of the hypotheca to become constricted, mammilliform; the structure of the thecal wall, on the other hand, which is reticulate even in the most primitive known member, viz., *Phalacroma acutum*, does not show any progressive tendencies. In the evolutionary line that led to the development of *P. hindmarchi* the structure of the theca did not even reach the stage characteristic of the four first series but remained areolate, and the tendency to reduce the height of the epitheca was but slightly materialized; on the other hand, the tendency to constrict the posterior portion of the hypotheca was carried to an extreme. It should also be noted that in this group the left sulcal list tends to become decurrent, and its posterior main rib tends to become club-shaped; these tendencies, however, are but seldom materialized (*P. dolichopterygium*, *P. favus*, *P. hindmarchi*). Increase in size is also to be recorded.

This group differs from section Podophalacroma, established by Jörgensen

(1923), only in so far as it does include *Phalacroma acutum* and *P. minutum*, two species assigned by Jörgensen (1923) to his section Euphalacroma. That these two species are more closely related to the members of our RAPA group than to those of our ARGUS group (to which we have referred most of the species assigned by Jörgensen, 1923, to his section Euphalacroma) is strongly indicated by the comparatively heavy reticulation of their thecal wall and by the angularity of the ventral margin of their hypotheca. It should be remembered, however, that we are dealing with very simple organisms, the genetic relationships of which are exceedingly difficult to establish.

6. EXPULSUM group (Figure 20: 1–9). Body sac-like, subobovate, or subcircular in lateral outline, with a dorsal shoulder-like constriction at girdle; length: depth, 1.02–1.24: 1. Longitudinal axis perpendicular or deflected posteroventrally at 1°–10°. Epitheca 0.54–0.76 as deep as hypotheca, low, gently rounded to flat. Posterior cingular list 0.11–0.26 the length of body from apex. In dorsoventral view the body is wedge-shaped, with undulating side contours, and narrowly rounded to acute posteriorly. Cingular lists somewhat narrower to 2.3 times wider than transverse furrow, subhorizontal to inclined anteriorly at 45°, ribbed or without structural differentiation. Right sulcal list subtriangular, its free margin gently convex. Left sulcal list with anterior main rib and fission rib well developed and with posterior main rib vestigial or absent; its free margin rounded posteriorly. Accessory sails and lists absent. Thecal wall with or without reticulation; when reticulation is present it is confined to central portions of valves and 17–20 meshes border girdle posteriorly. Medium-sized species, 53.0–67.4 μ long.

Of the two species included in this group, *Phalacroma expulsum* (Figure 20: 1–5) is the farther advanced, being characterized by a narrower and lower epitheca and by cingular lists of pronounced anterior inclination, two characteristics that affiliate this species with Dinophysis. The structure of the thecal wall shows retrogressive instead of progressive tendencies in this group.

Phalacroma expulsum was assigned by Jörgensen (1923) to the CUNEUS group under the name of *P. stenopterygium*. For a discussion of our attitude on this point, see above, our treatment of the CUNEUS group.

7. LIMBATUM group (Figure 21: 1, 2, 3). Body subcircular in lateral outline; length: depth, 0.99–1.10: 1. Longitudinal axis perpendicular. Epitheca 0.70–0.87 as deep as hypotheca, sometimes high and dome-shaped, sometimes more or less low. Posterior cingular list 0.19–0.50 the length of body from apex. Body strongly compressed bilaterally, ellipsoidal to lens-shaped in outline. Cingular

lists subhorizontal or somewhat inclined anteriorly, subequal, about as wide as transverse furrow, and with or without ribs. Free margin of right sulcal list usually gently convex. Left sulcal list with the three main ribs well developed; its free margin angular at posterior main rib. With posterior triangular sail (or sails) connected with left sulcal list by a well-developed list. Parasagittal lists often present on dorsal side of hypotheca and sometimes on epitheca as well. Thecal wall finely reticulate; reticulation often restricted to central portions of valves. Rather small to medium-sized species, 51–77 μ long.

Of the three members of this group *Phalacroma limbatum* (Plate 3, fig. 5; Figure 21: 1) is the most primitive in regard to the position of the girdle, which is subequatorial. On the other hand, it is the most advanced in the extension of the parasagittal lists, which encircle not only the hypotheca but also the epitheca. *Phalacroma bipartitum* (Figure 21: 2), which is intermediate with regard to the position of the girdle, is the farthest advanced in having two, instead of one, posterior sails. *Phalacroma pulchrum* (Figure 21: 3), which is the smallest member of the group and thus in this respect presumably the most primitive, is farthest advanced in the following respects:— the girdle is located anteriorly and the epitheca is flattened, disk-like; the cingular lists have a fairly pronounced anterior inclination; the list connecting the posterior sail with the left sulcal list is unusually wide.

While the size and shape of the body have been subject to but slight evolutionary changes in this group, there is a pronounced tendency in the girdle to move anteriorly and in the parasagittal lists to increase in size and complexity. Indeed, in no species, except in *Phalacroma fimbriatum*, are the parasagittal lists so large and highly differentiated as in *P. limbatum*. The structure of the thecal wall shows retrogressive rather than progressive tendencies.

The only member of this group included in Jörgensen's (1923) subdivisions of Phalacroma is *P. pulchrum*. This was assigned under the name of *P. circumsutum* Karsten to section Urophalacroma of Jörgensen, a section corresponding largely to our Doryphorum group. It should be noted that *P. circumsutum* Jörgensen (1923) comprises *P. circumsutum* Karsten as well as *P. pulchrum* Kofoid and Michener, and that *P. circumsutum* Karsten is assigned by us to the Doryphorum group. The Limbatum and Doryphorum groups undoubtedly are genetically very closely related, but they should, according to our opinion, be kept separate, since they appear to represent different evolutionary lines. For a discussion of the characters showing a close relationship between *P. pulchrum* and *P. limbatum* see p. 164.

8. DORYPHORUM group (Figure 22: 4, 6, 8; 23: 1–5; 23: 6; and 22: 1–3, 5, 7; Jörgensen, 1923, fig. 19). Body sometimes subrotund but usually obovate to subobovate in lateral outline; length: depth, 1.05–1.28: 1. Longitudinal axis usually perpendicular but sometimes slightly deflected posteroventrally. Epitheca large, slightly narrower than hypotheca, and moderately high to rather low. Distance from posterior cingular list to apex is 0.17–0.41 the length of body. In dorsoventral view the body is either ellipsoidal to obovate or wedge-shaped. Cingular lists usually subhorizontal, but sometimes somewhat inclined anteriorly, subequal, about as wide as the transverse furrow, and ribbed or without structural differentiation. Free margin of right sulcal list gently convex. Left sulcal list with three well-developed main ribs; its margin angular at posterior main rib. With triangular or wedge-shaped posterior sail, which may be connected with left sulcal list by a narrow list. Parasagittal list usually not developed on dorsal side of hypotheca. Thecal wall finely areolate. Small to medium-sized species, 35.0–86.0 μ long.

Phalacroma mucronatum (Figure 22: 4, 6, 8) is the most primitive member of the DORYPHORUM group, and it presumably has about the same habitus as the ancestral forms from which this group originated. The following of its features are more or less primitive: — its small size, the subrotund shape of its body in lateral view, the relatively great height of its epitheca, the fact that its left sulcal list is relatively long and not unusually wide posteriorly, and that the posterior main rib of this list is not club-shaped. Its structurally and probably also genetically closest relative is *Phalacroma doryphorum* (Figure 23: 1–5). This species has advanced in the following respects: — it has increased in size, the body has become obovate, the girdle has been displaced anteriorly, the left sulcal list has increased in width posteriorly and its posterior main rib has become club-shaped, and the posterior sail has increased in size and structural complexity. *Phalacroma circumsutum* (Figure 23: 6) has advanced beyond the *doryphorum* stage mainly in developing a connecting list between the posterior sail and the left sulcal list. *Phalacroma mucronatum* — *P. doryphorum* — *P. circumsutum* may be regarded as an orthogenetic series. *Phalacroma cuneolus* and *P. pugiunculus* (Figure 22: 1–3, 5, 7; Jörgensen, 1923, fig. 19) differ from these species in having the lateral outline of the body somewhat less regular and the posterior sail relatively narrower. *Phalacroma cuneolus* is especially characterized by having the body cuneate in dorsoventral outline, a peculiarity not found in any of the first three species; in *P. pugiunculus* this character is unknown.

The tendencies inherent in the DORYPHORUM group are as follows: — increase in the size of the body, decrease in the height of the epitheca, *i.e.*, anterior displacement of the girdle, increase in the posterior width of the left sulcal list, and in the size and complexity of the posterior sail, development of a connecting list between the posterior sail and the left sulcal list. On the other hand, while in some of the other groups the thecal structure has been subject to evolutionary processes, this feature does not exhibit any tendency to change in the present group. As to the presence of a parasagittal list on the dorsal side of the hypotheca in *Phalacroma circumsutum*, see p. 184.

The Doryphorum group corresponds to Jörgensen's (1923) section Urophalacroma with the exception that it does not include *Phalacroma pulchrum*. With regard to this exception see p. 161.

9. Praetextum group (Figure 25: 4, 5). Body rounded biconical in lateral outline, about 1.12 times longer than deep. Longitudinal axis perpendicular. Epitheca large, about as deep as hypotheca; posterior cingular list 0.51–0.53 the length of body from apex. In dorsoventral view the body is biconical, with rounded apices. Cingular lists subhorizontal, subequal, narrower than transverse furrow, and reticulate. Free margin of right sulcal list gently sigmoid, convex anteriorly and concave posteriorly. Left sulcal list subtriangular, gradually decreasing in width posteriorly; posterior main rib absent. Accessory lists and sails absent. Thecal wall with heavy reticulation; meshes of moderate and subuniform sizes, and about fifteen of them border girdle posteriorly on each valve. The most characteristic feature of this group is a large dumbbell-shaped area or plate on the ventral side of the hypotheca. This plate is cribriform; it has a faint reticulum of very small polygons, each with a fine central pore. The single member of this group is small, 61–62 μ long.

10. Reticulatum group (Figure 25: 1, 2, 3). Body biconical in lateral outline; length: depth, 1.25–1.84: 1. Longitudinal axis perpendicular, or it has a slight posteroventral deflection. Epitheca large, about as deep as hypotheca; posterior cingular list 0.23–0.45 the length of body from apex. In dorsoventral view the body is biconical, with narrowly rounded to acute apices. Cingular lists subhorizontal, subequal, somewhat wider to somewhat narrower than transverse furrow, ribbed or without structural differentiation. Free margin of right sulcal list gently convex to angular. Left sulcal list merges posteriorly into right parasagittal list; its main ribs not of the type characteristic of most groups of this genus. Parasagittal lists present but without triangular posterior sail. Thecal wall with unusually heavy and large-meshed reticulation; from five to ten polygons border girdle posteriorly. Rather small to large species, 69.5–118.0 μ long.

Of the three species referred to this group, *Phalacroma reticulatum* (Figure

25: 2) and *P. turbineum* (Figure 25: 3) are structurally quite close to each other, while *P. fimbriatum* (Figure 25: 1) occupies a rather isolated position. The first two species are characterized especially by the pronounced biconical shape of the body, by the unusually wide-meshed thecal reticulation (five to eight polygons border girdle posteriorly) and by the narrowness of their parasagittal lists. Peculiarly enough, *P. turbineum*, although smaller, is structurally farther advanced than *P. reticulatum*. Its hypotheca is more elongated, the distance from the apex to the posterior cingular list being 0.23 as compared with 0.40–0.45 the length of the body; the number of polygons along the posterior border of the girdle is only five as compared with seven or eight; and parasagittal lists are present not only on the hypotheca, but also on the epitheca. *Phalacroma fimbriatum*, although the largest member of the group, is characterized by the subequatorial position of the girdle, by the less extreme size of the meshes of the thecal reticulation (about ten of them border the girdle posteriorly), and by the more broadly rounded apices in lateral view. It is farthest advanced not only in the size of the body but also in the size and structural differentiation of the parasagittal lists.

The inherent tendencies to be found in this group are as follows:— increase in the size of the body, anterior displacement of the girdle, development of an extreme biconical, top-like shape, development of large parasagittal lists without a differentiation of triangular posterior sails, increase in the size of the meshes of the thecal reticulation. On the other hand, the left sulcal list tends to remain very small, and its ribs do not show tendencies to develop in the same manner as in most of the other groups of the genus.

In Jörgensen's (1923) subdivisions of the genus Phalacroma no members of the Praetextum and Reticulatum groups were included.

The relationships of these ten groups are represented graphically by Figure 2. As will be seen from this figure, the Rotundatum group is regarded on the whole, as the most primitive; and among its members *Phalacroma pulchellum* is considered as the one most closely approaching the ancestral type from which this genus evolved (see p. 67). The Contractum group represents a small side branch, that originated at a very low level, probably even before the left sulcal list had developed the rectangular shape and the three main ribs characteristic of most of the members of this genus. The Praetextum and Reticulatum groups presumably also branched off before the left sulcal list had developed its typical shape and structure. Of these two groups, both of which are characterized by unusually heavy and wide-meshed thecal reticulation and by the tendency toward a biconical shape of body, the Praetextum group remained relatively primitive in most respects, *e.g.*, in the size and shape of the body, in the position of the girdle, and in the size of the meshes of the thecal reticulation, while the Reticulatum group was subjected to profound evolutionary changes. The development of the cribriform plate in the Praetextum group, however, put this unit in a quite isolated position.

The remaining groups did not branch off until the left sulcal list had developed the shape and structure typical of the Rotundatum group. The Doryphorum and the Limbatum groups, both of which are characterized by a triangular posterior sail, originated from small ancestral forms of the Rotundatum group, subcircular in lateral outline and with the girdle subequatorial. *Phalacroma mucronatum* (Figure 22: 4, 6, 8) of the Doryphorum group is structurally not far removed from these ancestral forms. The Argus group appears also to have evolved directly from the Rotundatum group. Indeed, some of its members are structurally fairly close to some of the species of the latter group. From the line that led to the evolution of the top members of the Argus group, the Cuneus, Rapa, and Expulsum groups presumably branched off. That the Cuneus group is very closely related to the Argus group is indicated by the following striking similarities between *P. striatum* (Plate 2, fig. 8) and *P. argus* (Figure 8: 1): — (*1*) the longitudinal axis of the body is deflected posteroventrally; (*2*) the free margin of the right sulcal list is concave anteriorly, convex posteriorly, and angular near the middle; its concave anterior portion is strengthened by a marginal rib; (*3*) the left sulcal list has a delicate reticulation, and its free margin is rounded posteriorly, and not angular at the posterior main rib as in most of the species of this genus; (*4*) the thecal wall has a polygonate reticulation, and the polygons are of moderate and subequal size and furnished with a central pore. The Rapa group presumably evolved from an ancestral form fairly similar to *P. vastum* (Schütt, 1895, pl. 3, fig. 16: 3) and *P. porodictyum* (Figure 6) (see p. 67). Of its recent members *P. acutum* (Schütt, 1895, pl. 3, fig. 17: 1) is structurally closest to the ancestral type. *Phalacroma expulsum* (Figure 20: 1–5) shows distinct affiliation with the Cuneus group in the cuneate shape of the hypotheca in dorsoventral view and in having the posterior portion of the left sulcal list rounded instead of angular as it is in most of the other groups of Phalacroma.

Pavillard (1923a, p. 878) divided Phalacroma into two subgenera as follows:

Euphalacroma	section Oblongata, nom. nov.
	" Cuneus Jörgensen
	" Argus Jörgensen
	" Podophalacroma Jörgensen
Paradinophysis	section Rotundati, nom. nov.
	" Urophalacroma Jörgensen

Sections Oblongata and Rotundati of Pavillard correspond to Jörgensen's (1923) sections Euphalacroma and Paradinophysis, respectively. The adoption of this subdivision is inadvisable since it does not express the evolutionary processes that lead to the development of the various groups. The ROTUNDATUM group is probably just as closely related to the ARGUS group as it is to the DORYPHORUM group (= Urophalacroma). It is probably best, at least for the time being, to keep the groups apart. At the same time it should be pointed out that Pavillard's subgenus Euphalacroma corresponds to our ARGUS, CUNEUS, RAPA, and EXPULSUM groups, all of which are very closely related and evolved from a common ancestral form (Figure 2). If this evolutionary branch is given the status of a subgenus, then subgeneric status must also be given to the CONTRACTUM, PRAETEXTUM, RETICULATUM, ROTUNDATUM, LIMBATUM, and DORYPHORUM groups, and knowledge of the genus Phalacroma does not commend this.

1. CONTRACTUM GROUP. Only one species, *Phalacroma contractum*, belongs to this group.

PHALACROMA CONTRACTUM, sp. nov.

Figure 3: 1

Diagnosis: — Body subcircular in lateral outline, strikingly constricted at girdle, deepest just in front of the middle; length: depth, 1.11:1. Posterior cingular list 0.33 the length of body from apex. Cingular lists weak, about half as wide as transverse furrow or less. Left sulcal list about 0.44 the length of body; its anterior half of subuniform width and slightly wider than transverse furrow; posteriorly it decreases gradually in width; its margin not angular posteriorly but evenly convex; apparently without ribs or other structural differentiations. Length, 35 μ.

Eastern tropical Pacific.

Description: — A small species, the body of which is subcircular in lateral outline, strikingly constricted at the girdle, and deepest just in front of the middle. The ratio between the length and the depth is about 1.11 : 1. The longitudinal axis of the body is about perpendicular to the girdle.

The epitheca is about 0.79 as deep as the hypotheca, strongly and evenly convex, highest in the center, and rather prominent above the anterior cingular list. The transverse furrow is rather strikingly concave, and its width is about 0.43 the greatest height of the epitheca. The posterior cingular list is about 0.33 the length of the body from the apex. The dorsal and posterior margins of the hypotheca are subsemicircular; the dorsal margin is somewhat bulging just behind the girdle. The ventral margin of the hypotheca is flattened but confluent with the posterior margin. The posterior portion of the body is strikingly wider than the anterior.

The cingular lists are weak, subhorizontal, subequal, about half as wide as the transverse furrow or even somewhat narrower; their structure is unknown. The right sulcal list is unknown. The left sulcal list is about 0.44 the length of the body; its anterior half is of subuniform width and slightly wider than the transverse furrow; posteriorly it decreases gradually in width, and its free margin is not angular posteriorly but evenly convex; according to the available drawing, it is without ribs and other structural differentiations, and the middle portion of its free margin is reflexed in about the same manner as in *Dinophysis lenticula* Pavillard (1916, pl. 3, fig. 6). There are no accessory lists or sails. The structure of the thecal wall is unknown.

Megacytic specimens have not been recorded as yet.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 35.0 μ. Greatest depth of body, 31.4 μ.

Comparisons: — This species is established on a single outline drawing of a specimen in lateral view, and the description given above thus is incomplete in several respects. The following important characters are unknown: — the shape of the body in dorsoventral view, the structure of the thecal wall, the structure of the cingular lists and of the left sulcal list, and the shape and structure of the right sulcal list.

The discussion of the relationships of *Phalacroma contractum* must be postponed until further data about the structure of this species are available. However, it may be pointed out that the size of the body, the position and development of the girdle, and the shape and size of the left sulcal list suggest a rather close relationship to *Pseudophalacroma nasutum* (Stein) Jörgensen. The latter species is characterized especially by an anterior prolongation of the longitudinal furrow which extends about two thirds of the distance from the girdle to the apex, is somewhat dilated anteriorly, and bordered by a rather low and narrow ridge. This prolongation, which probably is a primitive feature of great systematic significance, is not indicated in Figure 3: 1 and it is impossible to decide whether this absence is real or due to an omission. The small size, subcircular shape of body in lateral view, relatively high epitheca, and weak development of lists affiliate this species with the most primitive members of the Dinophysidae.

Occurrence: — *Phalacroma contractum* is recorded at only one of the 127 stations. This station (4711), the type locality, is on the fourth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 75°, and the frequency less than 1% (one specimen).

2. Rotundatum Group. Of the thirteen members of this group only five were found in the material of the Expedition, and these have been arranged in the following order, suggestive of probable evolutionary sequence: — *Phalacroma parvulum*, *P. lativelatum*, *P. lens*, *P. porosum*, and *P. lenticula*.

Phalacroma parvulum (Schütt) Jörgensen

Figure 3: 4, 5, 6

Phalacroma porodictyum Stein var. *parvula* Schütt, 1895, pl. 2, fig. 13: 6. Lemmermann, 1899a, p. 371; 1901a, p. 373. Ostenfeld & Schmidt, 1901, p. 176. Entz, 1902b, p. 94; 1905, p. 111.
Phalacroma parvulum Jörgensen, 1923, p. 7, 8, 9, 45, fig. 4.

Diagnosis: — Body subcircular or subellipsoidal in lateral outline, deepest near the middle; length: depth, 1.05–1.16: 1. Posterior cingular list 0.26–0.43 the length of body from apex. Cingular lists without structure. Left sulcal list 0.45–0.55 as long as body; distance between R_1 and R_3 is 0.33–0.42 the length of body; R_2 is 0.11–0.21, R_3 is 0.24–0.31 the greatest depth of body; margin forms angle of 80°–110° at R_3; R_3 inclined posteriorly at 0°–30°. Theca finely and closely areolate. Length, 34.8–57.5 μ.

Probably of world-wide distribution in tropical, subtropical, and warm-temperate seas.

Description: — A small species, the body of which is subcircular or subellipsoidal in lateral outline, deepest near the middle. The ratio between the length and the depth is 1.05–1.16: 1. In the specimen, Figure 3: 4, this ratio is 1.05: 1; in the specimens, Figure 3: 5, 6, and Schütt, 1895, pl. 2, fig. 13: 6, and Jörgensen, 1923, fig. 4, it is 1.13–1.16: 1. The longitudinal axis of the body is about perpendicular to the girdle.

The epitheca is well and evenly convex, highest in the center, moderately elevated or rather prominent above the anterior cingular list, and about 0.73–0.90 as deep as the hypotheca; in our specimens this ratio is 0.79 (0.73–0.87): 1; in Schütt's (1895) and Jörgensen's (1923) it is 0.87–0.90: 1. The transverse furrow is flat or slightly convex; and its width is 0.40–1.00 the greatest height of the epitheca. In the specimens, Figure 3: 5, 6, the width of the transverse furrow and the height of the epitheca are subequal; in another specimen (Figure 3: 4) and in the specimens figured by Schütt (1895) and Jörgensen (1923) this ratio is 0.40–0.60: 1. The posterior cingular list is 0.26–0.43 the length of the body from the apex; in one of our specimens and in Schütt's (1895) specimen this ratio is 0.41–0.43: 1; in two specimens (Figure 3: 5, 6) and in Jörgensen's (1923) specimen it is 0.26–0.32: 1. The hypotheca is symmetrical or almost so, subsemicircular or subellipsoidal; its margins are evenly convex and confluent. The anterior and posterior ends of the body are either of about the same width, or either end is slightly wider or narrower than the other.

The cingular lists are subhorizontal, subequal, about as wide as or slightly wider or narrower than the transverse furrow, and without structural differentiation. The right sulcal list ends at a point about midway between the fission rib and the posterior main rib of the left sulcal list (Schütt, 1895, pl. 2, fig. 13: 6), or it extends as far as to the last-mentioned rib (Figure 3: 5); its anterior half is of subuniform width and about as wide as or slightly narrower than the transverse

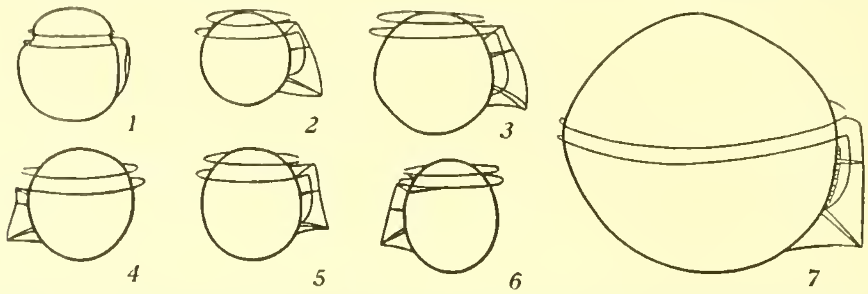

FIGURE 3.— 1, *Phalacroma contractum*, sp. nov., right lateral view of type specimen, Station 4711 (300–0 fathoms). × 430. 2, 3, *Phalacrama lativelatum*, sp. nov., right lateral view. 2, from type specimen, Station 4619, Salpa stomach. × 430. 4–6, *Phalacrama parvulum* (Schütt) Jörgensen. 4, 6, in left lateral view; 5, in right lateral view. × 130. 4, from Station 4724 (300–0 fathoms); 5, from Station 4580 (300–0 fathoms); 6, from Station 4571 (300–0 fathoms); 7, *Phalacroma lenticula* Kofoid, right lateral view of type specimen, Station 4740 (300–0 fathoms). × 430.

furrow; posteriorly it decreases gradually in width. The left sulcal list is 0.50 (0.45–0.55) as long as the body, and the distance between the anterior and posterior main ribs is 0.36 (0.33–0.42) the length of the body. The anterior main rib is 0.16 (0.13–0.22), the fission rib 0.15 (0.11–0.21), and the posterior main rib 0.28 (0.24–0.31) the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is rather strikingly sigmoid, concave anteriorly and convex posteriorly (Figure 3: 4; Schütt, 1895, pl. 2, fig. 13: 6); or it is almost straight, or gently concave or convex (Figure 3: 5, 6; Jörgensen, 1923, fig. 4); at the posterior main rib it forms an angle of 90° (85°–110°); behind the last-mentioned rib it is straight or slightly concave or convex. The main ribs of this list are of moderate strength, and not club-shaped or otherwise modified; either all of them are straight or nearly so or the posterior is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.40 (0.30–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 18°(0°–30°). Except for the main ribs this list appears to lack structure. There are no accessory lists or sails.

The thecal wall is finely and closely areolate, and has scattered pores; the areoles are of about the same size as the pores.

Megacytic specimens have not been recorded.

The dimensions of three of our specimens and of the specimens figured by Schütt (1895) and Jorgensen (1923) were measured.

Dimensions:— Length of body, 34.8–35.6 μ (average, 35.1 μ). Greatest depth of body, 29.5–33.0 μ.

Schütt (1895, pl. 2, fig. 13: 6) does not give the magnification of his figure of the type specimen; however, it probably is 640 times, since this is the magnification of most of his figures of the species of this genus. According to this magnification the type specimen was 48.8 μ long and 42.2 μ deep. Jörgensen's (1923) specimens were 55–56 μ long and 51 μ deep; his specimen figured was 57.5 μ long and 51.0 μ deep.

Variations:— The size of the body, the ratio between the length and the depth of the body, the size of the epitheca, the size of the right sulcal list, and the shape of the left sulcal list are the most variable characters of this species.

Comparisons: — One of the specimens (Figure 3: 4) assigned to *Phalacroma parvulum* agrees very closely with the type specimen of this species as drawn by Schütt (1895, pl. 2, fig. 13: 6). The remaining specimens (Figure 3: 5, 6) show a close agreement with *P. parvulum* Jörgensen (1923, fig. 4). They differ from the type specimen in the relatively lower epitheca and in the almost straight ventral margin of the left sulcal list. We cannot decide as to whether or not Jörgensen's (1923) conception of this species is correct. However, it appears most advisable to accept, preliminarily, his decision in this matter.

Phalacroma parvulum probably is closely related to *P. rotundatum* (Claparède and Lachmann). Indeed, these two species are so similar that their specific separation must be regarded as tentative. Intermediate specimens have been found (Stein, 1883, pl. 19, fig. 9, 10), the specific assignment of which is almost arbitrary. Generally speaking, *P. parvulum* seems to be slightly larger (Jörgensen, 1923, fig. 2, 4), its epitheca seems to be somewhat higher relatively, its anterior cingular list of less anterior inclination, and its left sulcal list relatively wider posteriorly.

It may be mentioned that our present conception of *Phalacroma rotundatum* is very confused. As a consequence, the synonymy is so complicated that it probably will be impossible to unravel it in an adequate manner. *Dinophysis michaelis* Ehrenberg and *D. laevis* Claparède and Lachmann have been considered as identical with *Phalacroma rotundatum*, and some investigators have changed from one position to another in their choice between these three names, without giving any reasons for doing so. Jörgensen (1923, p. 5) writes about *Phalacroma rotundatum:* "By the above name I designate a variable species, or perhaps a group of species. . . . " A thorough-going revision of this species, as well as of *Dinophysis michaelis* and *D. laevis*, is highly desirable and should be based on material from the Bay of Kiel, the Danish Straits, the Skager Rak, the North Sea, and the west coast of Norway. It should be mentioned that in the original figures of *Phalacroma rotundatum* and *Dinophysis laevis* the left sulcal list is rounded posteriorly, of moderate width, and not wider posteriorly than anteriorly. Later investigators (*e.g.*, Stein, 1883, pl. 19, fig. 9, 10, 11) have assigned to *P. rotundatum* specimens in which the left sulcal list is angular at the posterior main rib and much wider posteriorly than anteriorly. With regard to *Dinophysis michaelis* see p. 240.

Another close relative of *Phalacroma parvulum* is *P. operculoides s. str.* (Schütt, 1895, pl. 2, fig. 11: 1). These two forms also are so similar that their specific separation must be regarded as tentative. The only characteristic in which the last species differs from the first is the shape of the left sulcal list, and this feature is very variable in many species of this genus. However, the data are not sufficient to solve this question.

Phalacroma ovatum (Claparède and Lachmann), *P. lativelatum* nob., and *Dinophysis exigua*, nob. are probably rather closely related to *Phalacroma parvulum*. *Phalacroma ovatum* has about the same habitus as *P. rotundatum*, but it is smaller and has a small antapical spine-like projection (Jörgensen, 1923, p. 6, fig. 3). *Phalacroma lativelatum* differs from *P. parvulum* in the greater width of its left sulcal list; however, it is rather probable that the ranges of variation of these two species overlap. *Dinophysis exigua* is easily distinguished from *Phalacroma parvulum* by the shape of the posterior portion of its left sulcal list and by the posterior inclination of the posterior main rib of this list; another distinctive characteristic is the inclination of the anterior cingular list.

On the other hand, *Phalacroma parvulum* is probably not very closely related to *P. porodictyum*, to which Schütt (1895) referred it as a variety.

Synonymy: — If this species is identical with *P. operculoides* Schütt *s. str.* (see p. 121), then *P. parvulum* becomes a synonym of *P. operculoides*.

Occurrence: — *Phalacroma parvulum* is recorded at seven of the 127 stations. There are 3, 3, 0, 0, 1, and 0 stations on the six lines of the Expedition. Of these seven stations three (4571, 4574, 4580) are in the California Current; one (4635) is in the Panamic Area; two (4648, 4651) are in the Peruvian Current; one (4724) is in the South Equatorial Drift. At two stations (4574, 4635) the species was taken in surface hauls; at one station (4651) in a haul from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these seven stations at the surface was 66°–79°; the average was 73.0°.

At five stations (4574, 4580, 4635, 4648, 4651) the frequency is 1%; at the two remaining stations it is less.

Schütt (1895), who was the first to figure a specimen of this species, did not give any information as to the localities of his material; however, this probably was taken either at Naples, or in the Atlantic. Entz (1902b, 1905) found this species in the Adriatic. Jörgensen (1923, p. 8) writes that it "appears to be frequent throughout the entire Mediterranean." Ostenfeld and Schmidt (1901) recorded it at one station in the Gulf of Aden. Entz, and Ostenfeld and Schmidt do not give any figures or descriptions by means of which their determinations of this species may be checked.

The species probably is eupelagic and of world-wide distribution in tropical, subtropical, and warm-temperate seas. On account of its small size it is but seldom taken with silk nets of the mesh customarily used.

Phalacroma lativelatum, sp. nov.

Figure 3: 2, 3

Diagnosis: — Body subcircular in lateral outline, deepest near the middle; length: depth, 1.04–1.06: 1. Posterior cingular list 0.22–0.33 the length of body from apex. Cingular lists without structure. Left sulcal list 0.57–0.58 as long as body; distance between R_1 and R_3 is 0.43–0.45 the length of body; R_2 is 0.22–0.24, and R_3 is 0.32–0.44 the greatest depth of body; margin forms angle of 80°–90° at R_3; R_3 inclined posteriorly at 20°–30°, sometimes club-shaped. Theca finely and closely areolate. Length, 29.6–37.9 μ.

Eastern tropical Pacific.

Description: — A small species, subcircular in lateral outline, deepest near the middle. The ratio between the length and the depth is 1.04–1.06: 1. The longitudinal axis of the body is about perpendicular to the girdle.

The epitheca is 0.64–0.70 as deep as the hypotheca; it forms almost an arc of a circle, is highest in the center, and is rather slightly elevated, but visible, above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width about equals or slightly exceeds the greatest height of the epitheca. The posterior cingular list is 0.22–0.33 the length of the body from the apex. The hypotheca is regularly (Figure 3: 2) or slightly irregularly (Figure 3: 3) subcircular. The anterior and posterior ends of the body are of subequal width.

The cingular lists are subhorizontal, subequal, about as wide as or slightly wider than the transverse furrow, and without structure. The right sulcal list extends to or even slightly beyond the posterior main rib of the left sulcal list; it is of subequal width throughout the greater part of its length and rounded posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is 0.57–0.58 as long as the body, and the distance between the anterior and posterior main ribs is 0.43–0.45 the length of body. The anterior main rib is about 0.20, the fission rib 0.22–0.24, and the posterior main rib 0.32–0.44 the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently convex or gently sigmoid, concave anteriorly and convex posteriorly; at the posterior main rib it forms an angle of 80°–90°; behind the last-mentioned rib it is straight, or gently convex or concave. The main ribs of this list are of moderate strength; either all of them are straight or nearly so, or the posterior is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.33 the distance between the anterior and posterior main ribs. The posterior main rib, which may be club-shaped (Figure 3: 3), has a posterior inclination of 20°–30°. Except for the main ribs this list appears to lack structure. There are no accessory lists or sails.

The thecal wall is finely and closely areolate, and has scattered pores; the areoles are of about the same size as the pores.

Megacytic specimens have not been recorded.

The proportions of two specimens of the Expedition were measured.

Dimensions:— Length of body, 29.6–37.9 μ (type, 29.6 μ). Greatest depth of body, 27.9–36.6 μ (type, 27.9 μ).

Variations: — The size of the body, the relative size of the left sulcal list, and the shape and structure of the posterior main rib of this list appear to be the most variable characters.

Comparisons: — This species is established on outline drawings of two specimens in lateral view.

Phalacroma lativelatum is closely related to *P. parvulum*. These two forms probably have overlapping ranges of variation, and their specific separation should be regarded as tentative. They differ from each other in the relative size of the left sulcal list. *Dinophysis laevis* [= *Phalacroma rotundatum* (Claparède and Lachmann) var. *laevis* (Claparède and Lachmann) Jörgensen] as conceived by Bergh (1881b, pl. 15, fig. 55) also is closely related to *Phalacroma lativelatum;* the most important difference between these two forms, *i.e.*, the relative size of the left sulcal list, may be due to regulatory changes dependent on the viscosity of the medium. (See p. 87.)

Occurrence: — *Phalacroma lativelatum* is recorded at only one of the 127 stations. This station (4619), the type locality, is on the first line of the Expedition and in the Panamic Area. Two specimens were found in the stomach of a Salpa taken in a surface haul at a temperature of 79°. The frequency was 1%.

Phalacroma lens, sp. nov.

Figure 4: 1, 2, 3.

Diagnosis: — Body subrotund in lateral outline, somewhat constricted at girdle; deepest just behind posterior cingular list or in the middle; length: depth, 1.05–1.11: 1. In dorsal view lens-shaped, widest in the middle, constricted anteriorly, 2.38–2.66 times longer than wide. Posterior cingular list 0.30–0.37 the length of body from apex. Cingular lists sometimes with slight anterior inclination; structure unknown. Left sulcal list 0.45–0.55 the length of body; distance between R_1 and R_3 is 0.32–0.45 the length of body; R_2 is 0.09–0.11, and R_3 is 0.17–0.20 the greatest depth of body; margin forms angle of 90°–100° at R_3; R_3 inclined posteriorly at 10°–25°. Theca finely and closely areolate. Length, 49.0–56.4 μ.

Eastern tropical Pacific.

Description: — A rather small species, with body subrotund in lateral outline, somewhat constricted at the girdle, and deepest just behind the posterior cingular list or in the middle. The ratio between the length and the depth is 1.09 (1.05–1.11): 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is 0.85 (0.80–0.89) as deep as the hypotheca, moderately elevated above the anterior cingular list, moderately and almost evenly convex, and highest in the center. The transverse furrow is somewhat concave, and its width is 0.45–0.75 the greatest height of the epitheca. The posterior cingular list is 0.33 (0.30–0.37) the length of the body from the apex. The dorsal margin of the hypotheca is evenly, and gently or moderately convex, and confluent with the postmargin, which is broadly and evenly convex. The ventral margin of the hypotheca either is of about the same convexity as the dorsal margin, or it is more or less flat, or again somewhat irregular as in the specimen represented (Figure 4: 3); it is confluent with the postmargin. The anterior and posterior ends of the body either are of about the same width, or the anterior is somewhat wider than the posterior. In dorsoventral view the outline of the body is lens-shaped, widest in the middle, somewhat constricted in front of the posterior cingular list, and 2.38–2.66 times longer than wide; the side contours of the hypotheca are evenly convex.

The cingular lists are subequal, about as wide as the transverse furrow, and either subhorizontal or with a slight anterior inclination; their structure is unknown. The right sulcal list ends at or somewhat in front of or behind a point midway between the fission rib and the posterior main rib of the left sulcal list; in some specimens it is subtriangular, decreasing gradually in width posteriorly; in other specimens it is subequal in width throughout its anterior half or even throughout the greater portion of its length; anteriorly it is about as wide as or somewhat narrower than the transverse furrow. The left sulcal list is 0.50 (0.45–0.55) as long as the body, and the distance between the anterior and posterior main ribs is 0.40 (0.32–0.45) the length of the body. The anterior main rib is 0.14 (0.09–0.17), the fission rib 0.10 (0.09–0.11), and the posterior main rib 0.18 (0.17–0.20) the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently concave or nearly straight; at the posterior main rib it forms an angle of 97° (90°–100°); behind the last-mentioned rib it is straight or slightly concave or convex. The main ribs of this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.25–0.37 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 10°–35°. Structure of list besides the three main ribs unknown. There are no accessory lists or sails.

The thecal wall is finely and closely areolate and has scattered pores; the areoles are of about the same size as the pores.

Megacytic specimens were not found.

The proportions of three specimens were measured.

Dimensions: — Length of body, 49.0–56.4 μ (average, 52.3 μ; type, 56.4 μ). Greatest depth of body, 46.6–50.8 μ (average, 48.1 μ; type, 50.8 μ).

Variations: — Judging by the specimens examined, this species is rather constant. The shape of the hypotheca in lateral view and the size of the right sulcal list are the most variable characters.

Comparisons: — The species is established on outline drawings of three specimens found in the material of the Expedition.

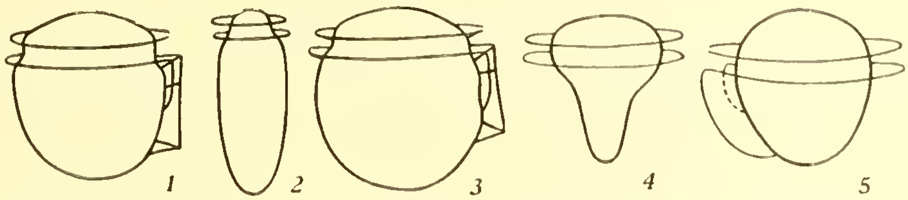

FIGURE 4.— 1, 2, 3, *Phalacroma lens*, sp. nov. 1, 3, in right lateral view; 2, in dorsal view. 2, 3, from type specimen. × 430. 1, from Station 4713 (300–0 fathoms); 2, 3, from Station 4717 (300–0 fathoms). 4, 5, *Phalacroma pyriforme*, sp. nov., type specimen. 4, in dorsal view; 5, in left lateral view, Station 4713 (300–0 fathoms). × 430.

Phalacroma lens probably is rather closely related to *Phalacroma rudgei*, *P. rotundatum*, *P. porosum*, *P. pulchellum*, and to the other subrotund and simple species of this genus. It differs from *P. rudgei* mainly in size (49.0–56.4 μ, as compared with 74 μ), in the anterior constriction of its body in dorsoventral view, and in the areolate structure of its thecal wall. From *P. rotundatum* it may be distinguished by the constriction at the girdle in lateral and dorsoventral views. In *P. porosum* the girdle is gently sigmoid and the sulcal lists are larger than in *P. lens;* and *P. pulchellum* is much smaller (21–33 μ in length), broader in dorsoventral view, and has a smaller left sulcal list. On account of the simplicity of these species, their interrelationships cannot be traced with any high degree of probability.

Occurrence: — *Phalacroma lens* is recorded at three of the 127 stations. There are 0, 0, 0, 1, 2, and 0 stations on the six lines of the Expedition. Of these stations one (4713) is in the Galapagos Eddy, and two (4717, 4730) are in the South Equatorial Drift. Station 4717 is the type locality. All records refer to hauls from 300–0 fathoms.

The temperature range of these three stations at the surface was 73°–79°; the average was 75.9°.

The frequency is less than 1% in all the cases.

PHALACROMA POROSUM Kofoid and Michener

Plate 1, fig. 3, 6. Figure 5

Phalacroma porosa KOFOID & MICHENER, 1911, p. 290.

Diagnosis: — Body subrotund in lateral outline, sometimes subtruncate anteriorly; somewhat deeper anteriorly than posteriorly, deepest at or somewhat behind girdle; length: depth, 0.99–1.12: 1. In ventral view narrowly obovate. Posterior cingular list 0.20–0.26 the length of body from apex. Girdle crosses lateral faces of body in a sigmoid curve. Cingular lists sometimes slightly inclined anteriorly, without ribs. Left sulcal list 0.52–0.65 the length of body; distance between R_1 and R_3 is 0.36–0.50 the length of body; R_2 is 0.10–0.24, and R_3 is 0.16–0.28 the greatest depth of body; margin forms angle of 90°–110° at R_3; R_3 inclined posteriorly at 10°–35°. Hypotheca with fine reticulation; twenty-five to thirty polygons border girdle posteriorly. Length, 47.9–73.8 μ.

Eastern tropical Pacific.

Description: — A rather small or medium-sized species, the body of which is subrotund in lateral outline, sometimes subtruncate anteriorly, somewhat deeper anteriorly than posteriorly, and deepest at or somewhat behind the girdle. The ratio between the length and the depth is 1.07 (0.99–1.12): 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is 0.87 (0.78–0.95) as deep as the hypotheca, and moderately or but slightly elevated above the anterior cingular list; sometimes (Figure 5: 1) it is rather strongly convex, sometimes (Figure 5: 2) more or less flattened; in most cases it is highest in the center, but in some specimens somewhat dorsally to the center. The transverse furrow is flat or slightly convex or concave, and its width is 0.66–1.33 the greatest height of the epitheca. The posterior cingular list is 0.23 (0.20–0.26) the length of the body from the apex. The dorsal margin of the hypotheca is evenly and gently convex, and confluent with the postmargin, which is broadly and evenly convex. The ventral margin of the hypotheca either is of about the same convexity as the dorsal margin (Figure 5: 3), or it is somewhat irregular as in Figure 5: 1, 2; it is confluent with the postmargin. In dorsoventral view the outline of the body is narrowly obovate, widest in or just in front of the middle, and with rather narrowly rounded apices; the anterior and the posterior ends are almost of the same width.

The girdle crosses the lateral faces of the body in a sigmoid curve. The cingular lists are subequal, about as wide as the transverse furrow, and either subhorizontal or with a slight anterior inclination; they have, on each valve, only two ribs, one of which is dorsal, the other ventral. The sulcus is about 0.63 as long as the hypotheca. The flagellar pore is located at a distance about equaling its own diameter behind the junction of the cingulum and the sulcus. The right sulcal list ends at, or just in front of or behind the posterior main rib of the left sulcal list; its greatest width about equals or slightly exceeds the width of the transverse furrow; in some specimens it is widest anteriorly, and decreases gradually in width posteriorly; in others, *e.g.*, in the type specimen, it is widest near the middle, and decreases in width anteriorly and posteriorly. The left sulcal list is 0.58 (0.52–0.65) as long as the body, and the distance between the anterior and posterior main ribs is 0.46 (0.36–0.50) the length of the body. The anterior main rib, when present, is 0.14 (0.12–0.18), the fission rib 0.16 (0.10–0.24), and the posterior main rib 0.22 (0.16–0.28) the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list sometimes is almost straight, sometimes gently sigmoid, convex anteriorly and concave posteriorly, and sometimes slightly concave or almost straight anteriorly and posteriorly, and more or less convex or angular at the fission rib (Figure 5: 1; Plate 1, fig. 6); at the posterior main rib it forms an angle of 100° (95°–110°); behind the last-mentioned rib it is straight, or gently concave or convex. The main ribs of

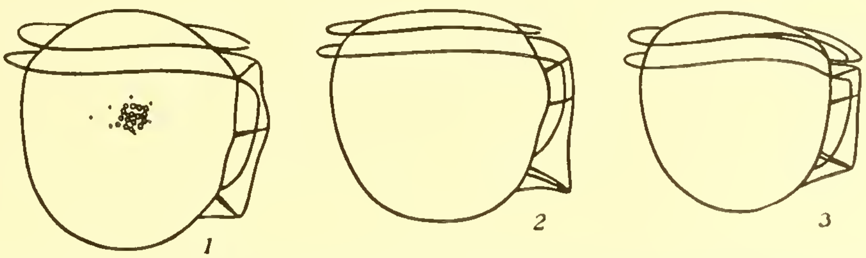

FIGURE 5.— 1–3, *Phalacroma porosum* Kofoid & Michener, right lateral view; structure of surface indicated only on small portion of theca in 1. × 430. 1, from Station 4721 (300–0 fathoms); 2, from Station 4709 (300–0 fathoms); 3, from Station 4681 (300–0 fathoms).

this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35 (0.27–0.48) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 25° (10°–35°). With the exception of the main ribs, the left sulcal list lacks structural differentiation. There are no accessory lists or sails.

Except along the dorsal, posterior, and ventral margins, the thecal wall of the hypotheca has a fine reticulum of subequal polygonate meshes; the posterior margin of the girdle is bordered by from twenty-five to thirty polygons. No reticulation has been observed in the epitheca and in the transverse furrow. The whole thecal wall has scattered pores. In the transverse furrow there are two rows of pores, each row with eleven or twelve pores on each valve. The pores are large and prominent and located centrally in relatively heavier polygons.

A megacytic specimen (the type) was recorded.

The proportions of five specimens were measured.

Dimensions: — Length of body, 47.9–73.8 μ (average, 63.0 μ; type, 47.9 μ). Greatest depth of body, 43.5–65.9 μ (average, 59.2 μ; type specimen, 43.5 μ). The type specimen is megacytic; for the sake of comparison, its dimensions and proportions exclusive of the intercalary zone are given. The measurements in the original description of this specimen (Kofoid and Michener, 1911, p. 290) include this zone.

Variations: — Judging by the specimens examined, this species appears to be rather constant. The size of the body, the shape and relative height of the epitheca, the shape of the ventral margin of the hypotheca, and the shape of the ventral edge of the left sulcal list are the most variable characters.

Comparisons: — The description and figures are from the type material.

Phalacroma porosum is probably rather closely related to *P. lens*, *P. rudgei*, *P. rotundatum*, *P. pulchellum*, and to the other small, rotund, and simple species of Phalacroma. However, the distinguishing characteristics of these species are so simple that they afford but little foundation for an estimate of the structural interrelationships. Distinguishing characteristics of *P. porosum* are the size of the body and the shape of the girdle.

Occurrence: — *Phalacroma porosum* is recorded at seven of the 127 stations. There are 0, 0, 1, 1, 4, and 1 stations on the six lines of the Expedition. All these stations (4681, 4709, 4721, 4730, 4732, 4734, 4740) are in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these seven stations at the surface was 68°–81°; the average was 76.4°.

At one station (4721) the frequency is 1 %; at the remaining stations it is less.

The species has been found only in the material of the Expedition. It was first recorded at Station 4721, the type locality. Its absence from surface catches and the fact that all the record stations are located in the South Equatorial Drift are the most noteworthy peculiarities of its distribution in the Eastern Pacific.

Phalacroma lenticula Kofoid

Figure 3:7

Phalacroma lenticula Kofoid, 1907a, p. 194, pl. 12, fig. 69.

Diagnosis: — Body subcircular in lateral outline, deepest at girdle; length: depth, 0.95:1. In dorsal view lens-shaped, with subacute apices, widest at girdle, about twice as long as wide. Posterior cingular list 0.58 the length of body from apex. Cingular lists narrow, about half as wide as transverse furrow. Left sulcal list 0.50 the length of body; distance between R_1 and R_3 is 0.27 the length of body; R_2 is 0.10, R_3 is 0.18 the greatest depth of body; margin forms angle of 90° at R_3; R_3 inclined posteriorly at 45°. Theca finely reticulate. Length, 81.3 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, with the body subcircular in lateral outline, deepest at the girdle, and about as deep as long or even slightly deeper than long. In the type specimen the ratio between the length and the depth is 0.95: 1. The longitudinal axis of the body is deflected posteroventrally at 2°–5°.

The epitheca is about as deep as the hypotheca, highest in or slightly dorsally to the center, subsemicircular or rounded conical, and very prominent above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 0.12–0.13 the greatest height of the epitheca. The posterior cingular list is about 0.58 the length of the body from the apex. The hypotheca is semicircular, with evenly convex margins. Posteriorly the body is somewhat wider than anteriorly. In dorsoventral view the body has a regularly lens-shaped outline, with subacute apices, widest at the girdle, and about twice as long as wide.

The cingular lists are subhorizontal, subequal, and about half as wide as the transverse furrow; their structure is unknown. The right sulcal list extends to the posterior main rib of the left sulcal list; it is of subuniform width throughout the greater portion of its length and decreases gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow; it is reticulate along the base. The left sulcal list is about 0.50 the length of the body, and the distance between the anterior and posterior main ribs is 0.27 the length of the body. The anterior main rib, when present, and the fission rib are about 0.10, the posterior main rib is about 0.18 the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is nearly straight; at the posterior main rib it forms an angle of about 90°; behind the last-mentioned rib it is nearly straight or slightly concave. The main ribs of this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is about 0.33 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 45°. The structure of this list besides the main ribs is unknown. There are no accessory lists or sails.

The thecal wall has a fine reticulum of subequal polygonate meshes; the posterior margin of the girdle is bordered by thirty-five to forty polygons. Most of the polygons have a central pore; and in the transverse furrow there are two rows of pores, each row with forty to fifty pores on each valve.

Megacytic stages were not recorded.

The proportions of the type were measured.

Dimensions: — Length of body, 81.3 μ. Greatest depth of body, 86.0 μ.

Comparisons: — The description and drawing are based on the type material.

The species appears to occupy a somewhat isolated position. The subcircular shape of its body in lateral view, the subequatorial position of its girdle, and the narrowness of its cingular lists are characteristics that affiliate it with the most primitive members of this genus, *e.g.*, *Phalacroma globulus* Schütt. On the other hand, it is fairly advanced in size and in the structural differentiation of the thecal wall; and the shape of its body in dorsoventral view, lens-shaped, with subacute apices, widest at girdle, and about twice as long as wide, is unique among the known primitive species of this genus.

Occurrence: — *Phalacroma lenticula* is recorded at six of the 127 stations. There are 0, 2, 1, 1, 1, and 1 stations on the six lines of the Expedition. Of these six stations two (4662, 4664) are in the Peruvian Current; four (4679, 4701, 4724, 4740) are in the South Equatorial Drift. At one station (4662) the species is recorded from 800–0 fathoms. The remaining records refer to hauls from 300–0 fathoms.

The temperature range of these six stations at the surface was 68°–81°; the average was 73.0°.

The frequency is less than 1% in all the recorded cases.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) at Station 4740 (not Station 4749 as stated, Kofoid, 1907a, p. 194). Its absence from surface catches and from the California Current, Mexican Current, and Panamic Area is noteworthy.

3. Argus Group. Of the nine species assigned to this group the following were taken by the Expedition: — *Phalacroma porodictyum*, *P. argus*, *P. apicatum*, *P. circumcinctum*, *P. ovum*, and *P. pyriforme*.

Phalacroma porodictyum Stein

Figure 6, 7

Phalacroma porodictyum Stein, 1883, pl. 18, fig. 11–14. Bütschli, 1885, pl. 55, fig. 1. Schütt, 1895, p. 93, pl. 2, fig. 13:1–6. Ostenfeld, 1898a, p. 428; 1915, p. 9. Lemmermann, 1899a, p. 319, 371; 1901a, p. 373; 1905a, p. 35. Murray & Whitting, 1899, p. 330, tab. 3. Ostenfeld & Schmidt, 1901, p. 176. Lohmann, 1902, p. 53. Entz, 1902b, p. 94; 1904, p. 14; 1905, p. 111. Pavillard, 1905, p. 59, 81, 102; 1909, p. 283; 1916, p. 47, 48, 54. Karsten, 1906, p. 191. Stüwe, 1909, p. 244, 252, 287.

Hensen, 1911, p. 166. Forti, 1922, p. 106, 190, 208, pl. 7, fig. Jörgensen, 1923, p. 8, 9, 10, 13, 16, 24, fig. 6.

Phalacroma porodyctium Daday, 1888, p. 99 (*lapsu pennae*).

Phalacroma operculatum Schütt, 1895, p. 93, pl. 2, fig. 10: 1–3. Hensen, 1911, *partim*, p. 166, 167, tab. 15.

Phalacroma porodictum Schröder, 1900a, p. 9, 11, 19 (*lapsu pennae*); 1906a, p. 322, 325, 327; 1911, p. 21, 37.

?*Phalacroma porodictyum* Okamura, 1912 (*non* 1907, p. 134), p. 18, pl. 5, fig. 83.

Diagnosis: — Body obovate or subellipsoidal in lateral outline, deepest at or somewhat behind girdle, usually somewhat deeper anteriorly than posteriorly; length: depth, 1.11–1.23: 1; longitudinal axis deflected posteroventrally at 0°–20°. In dorsal view obovate, 1.60–1.80 times longer than wide. Posterior cingular list 0.37–0.50 the length of body from apex. Cingular lists without, or with but faintly indicated ribs. Right sulcal list with angular margin, concave anteriorly, and convex or straight posteriorly. Left sulcal list 0.37–0.53 the length of body; distance between R_1 and R_3 is 0.33–0.40 the length of body; R_2 is 0.09–0.13, and R_3 is 0.10–0.21 the greatest depth of body; margin forms angle of 75°–100° at R_3; R_3 inclined posteriorly at 15°–45°. Theca finely and closely areolate. Length, 72.5–81.5 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is obovate or subellipsoidal in lateral outline, deepest at or somewhat behind the girdle, and 1.11–1.23 times longer than deep. In the Expedition specimens the ratio between the length and the depth is 1.18 (1.14–1.23): 1; in Stein's (1883, pl. 18, fig. 11), 1.14: 1; in Schütt's (1895, pl. 2, fig. 10: 2; 13: 3), 1.11–1.15: 1; and in Jörgensen's (1923, fig. 6), 1.13: 1. The longitudinal axis of the body either is perpendicular to the transverse furrow, as in Stein's (1883) specimen and in some of the Expedition specimens, or it is deflected posteroventrally at an angle of 1°–20°; in the Expedition specimens this deflection does not exceed 8°; in Schütt's (1895, pl. 2, fig. 10_2) it is about 20°, and in Jörgensen's (1923) about 12°.

The epitheca is 0.97 (0.96–0.98) as deep as the hypotheca, strongly and almost evenly convex, in some specimens slightly flattened ventrally or both ventrally and dorsally (Figure 6: 1), dome-shaped, highest at or in some specimens slightly dorsal to the center, and very prominent above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 0.20–0.30 the greatest height of the epitheca. The posterior cingular list is 0.37–0.50 the length of the body from the apex; in the Expedition specimens this ratio is 0.47 (0.44–0.50): 1; in Stein's (1883), 0.37: 1; in Schütt's (1895, pl. 2, fig. 10: 2, and 13: 3), 0.38–0.50: 1; and in Jörgensen's (1923), 0.37: 1. The hypotheca is sometimes symmetrical, as in Stein's (1883) specimen and in Figure 6: 1, but usually it has a more or less pronounced posteroventral inclination (see p. 99). Its dorsal, posterior, and ventral margins are well and evenly convex and confluent. Its posterior portion, which is rather broad in some specimens and rather narrow in others, is nearly always somewhat narrower than the anterior portion of the body. In dorsoventral view (Stein, 1883, pl. 18, fig. 13) the body is regularly obovate, about 1.60–1.80 times longer than wide, and widest at or somewhat behind the girdle; its anterior portion is broadly, its posterior narrowly convex; and its side contours are evenly convex.

The cingular lists are subhorizontal and subequal; they are about as wide as, or slightly wider or narrower than, the transverse furrow, and are "without or with faintly indicated ribs" (Jörgensen, 1923, p. 9). The right sulcal list usually ends at or somewhat behind a point midway between the fission rib and the posterior main rib of the left sulcal list; sometimes it extends even to the last-mentioned rib; in some specimens its ventral margin, even in the widest region, does not quite extend to the ventral margin of the left sulcal list, but in most specimens it does. The anterior half to two thirds of the free margin of this list is more or less concave and sometimes strengthened by a marginal rib; the posterior portion of this margin, which forms a distinct angle with the anterior portion, is more or less convex or almost straight. The greatest width of this list is located just behind the concave portion. The left sulcal list is 0.37–0.53 as long as the body; in the Expedition specimens this ratio is 0.46 (0.44–0.53): 1; in Stein's (1883), 0.40: 1; in Schütt's (1895, pl. 2, fig. 13_3), 0.39: 1; in Jörgensen's (1923), 0.37: 1. The distance between the anterior and posterior main ribs is 0.36 (0.33–0.40) the length of the body. The anterior main rib, when present, is 0.10–0.17, the fission rib 0.08–0.13, and the posterior main rib 0.10–0.21 the greatest depth of the body; in the Expedition specimens these three ratios are 0.12 (0.10–0.13): 1, 0.10 (0.08–0.13): 1, and 0.17 (0.14–0.21): 1; behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list usually is slightly sigmoid, concave anteriorly and convex posteriorly; sometimes it is nearly straight, or gently concave or convex, or it may be slightly angular at the fission rib (Jörgensen, 1923, fig. 6); at the posterior main rib it forms an angle of 75°–100°; in the Expedition specimens this angle is 93° (90°–100°); in Stein's (1883) about 75°; behind the last-mentioned rib it is almost straight or slightly concave or convex. The main ribs of this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35 (0.25–0.45) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 30° (15°–45°). Sometimes this list has a faint reticulation (Stein, 1883; Jörgensen, 1923). There are no accessory lists or sails.

The thecal wall is finely, closely, and usually rather faintly areolate, and has scattered pores. In the transverse furrow there are two rows of pores.

Megacytic stages have been seen by Stein (1883) and Schütt (1895).

The proportions of eight of the Expedition specimens and of those figured by Stein (1883, pl. 18, fig. 11), Schütt (1895, pl. 2, fig. 10: 2, and 13: 3) and Jörgensen (1923, fig. 6) were measured.

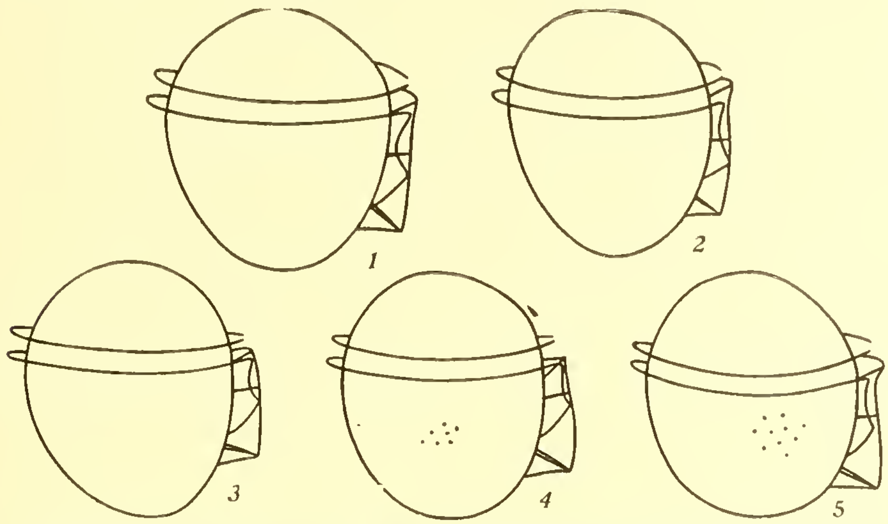

FIGURE 6.— 1–5, *Phalacroma porodictyum* Stein, right lateral view. Porulation indicated only on small portion of theca in 4 and 5. × 430. 1, 2, 3, 5, from Station 4737 (300–0 fathoms); 4, from Station 4739 (300–0 fathoms).

Dimensions: — Expedition specimens: Length of body, 74.8–8.15 μ (average, 77.5 μ). Greatest depth of body, 62.2–69.8 μ (average, 65.8 μ). The size of the type specimen (Stein, 1883, pl. 18, fig. 11) is unknown. According to Stein's (1883) information about the magnifications of his figures, this specimen was somewhere between 73 μ and 112 μ long. The specimens represented by Schütt (1895, pl. 2, fig. 10: 2, and 13: 3) are about 76–78 μ long. The length of Jörgensen's (1923, fig. 6) specimen is about 72 μ. According to Lohmann (1902, p. 53), the length varies between 58 μ and 76.5 μ. This statement, which implies a striking variability in size, has been disregarded in the present paper, since Lohmann does not give any figures or description by means of which his conception of the species might be checked.

Variations: — The variability of this species, as conceived here and by Jörgensen (1923), is rather striking. However, there seems to be but little doubt that we are dealing with a natural systematic unit. The different forms represented by Figure 6 and by the figures of previous investigators appear to be connected by continuous series of intermediate forms and are probably modifications. The size of the body, the inclination of the longitudinal axis of the body, the relative height and the shape of the epitheca and of the hypotheca, and the shape and size of the left sulcal list are the most variable characters.

Comparisons: — None of the specimens found in the material of the Expedition and determined as *Phalacroma porodictyum* agrees completely with the type specimen of this species as figured by Stein (1883, pl. 18, fig. 11). However, some of these specimens (Figure 6: 1) approach the type so closely that their assignment can be regarded as certain. They differ from the type mainly in having the epitheca somewhat higher relatively and the left sulcal list somewhat longer. Other specimens (Figure 6: 3) are rather similar to Schütt's (1895, fig. 10: 2) and to Jörgensen's (1923, fig. 6) but we have not seen any specimens that show a complete agreement with any of the figures of these two authors.

Phalacroma porodictyum is probably most closely related to *P. argus*. This relationship is indicated by the close resemblance in the size and shape of the body, and in the shape and structure of the right sulcal list. The first species differs from the last mainly in the angularity of its left sulcal list and in the areolate structure of its thecal wall. In both these characters it probably is the more primitive. For further discussion, see p. 107.

Phalacroma porodictyum is certainly specifically distinct from *P. parvulum*, a form which Schütt (1895) first figured as a variety of *P. porodictyum*, and which Jörgensen (1923, p. 7) established as a distinct species.

Synonymy: The specimens figured as *Phalacroma operculatum* Stein by Schütt (1895, pl. 2, fig. 10) probably are referable to *P. porodictyum*. The specimen represented by Okamura (1907, pl. 4, fig. 26) under the designation *P.* sp. . . . *Phalacroma porodictyum* Stein? undoubtedly belongs to *P. apicatum* nob. *Phalocroma porodictyum* Okamura (1912, fig. 83) is probably not identical with *P. porodictyum* Stein, since the specimen figured is very small, about 47 μ long, and has a left sulcal list which is more than twice as wide at the posterior main rib as it is anteriorly.

Hensen (1911, p. 166) writes that he has partly confused *Phalacroma porodictyum* and *P. operculatum*. These two species probably have been confused by several investigators, but the extent of this confusion cannot be established, since only a few authors give figures or descriptions. It may be mentioned in this connection that Cleve never recorded *P. porodictyum*, although he carried out extensive investigations on the plankton of the seas from which this species has been recorded repeatedly. On the other hand, Cleve has numerous records of *P. operculatum*.

Occurrence: — *Phalacroma porodictyum* is recorded at twenty-nine of the 127 stations. There are 5, 5, 6, 5, 8, and 0 stations on the six lines of the Expedition. Of these twenty-nine stations, four (4587, 4590, 4598, 4605) are in the Mexican Current; three (4613, 4634, 4637) in the Panamic Area; five (4648, 4662, 4666, 4673, 4676) in the Peruvian Current; four (4689, 4691, 4697, 4699) in the

Easter Island Eddy; one (4713) in the Galapagos Eddy; and twelve (4679, 4681, 4701, 4705, 4719, 4721, 4724, 4730, 4732, 4734, 4737, 4739) in the South Equatorial Drift. At one station (4713) the species is recorded from 150–0 fathoms; at two stations (4662, 4666) from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The species is also recorded from surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

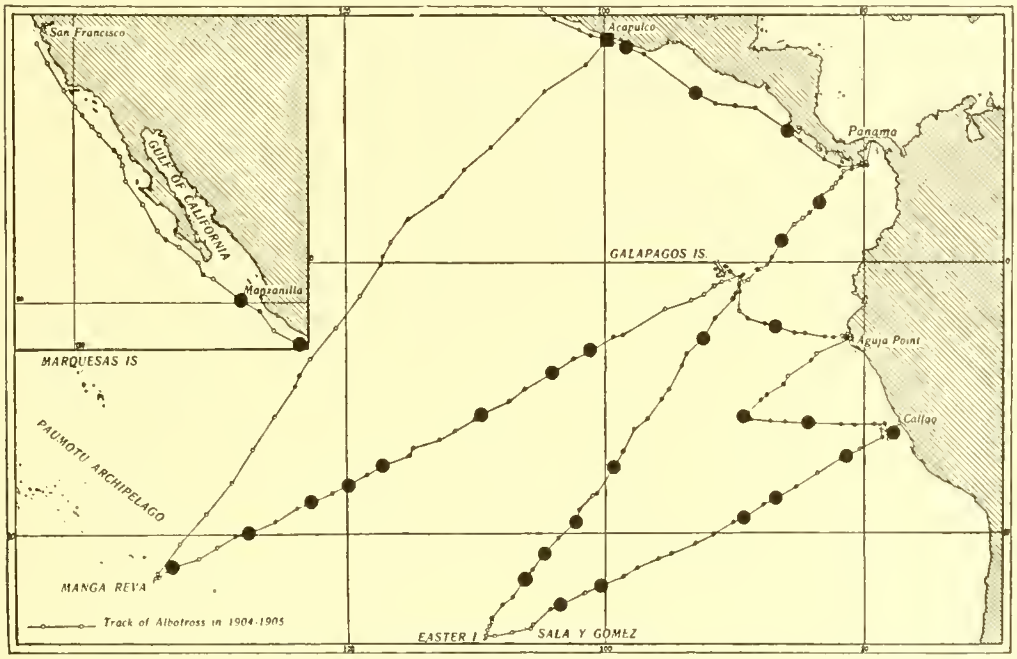

FIGURE 7.— Occurrence of *Phalacroma porodictyum* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

The temperature range of these twenty-nine stations at the surface was 67°–85°; the average was 75.5°. At Acapulco the surface temperature was 83°.

The frequency is 1% at seven stations (4634, 4648, 4679, 4681, 4689, 4699, 4719). At the remaining stations it is less than 1%.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." The specimens of this species drawn by Schütt (1895) probably were taken either at Naples, or in the tropical or subtropical regions of the Atlantic. In the Atlantic it was found by the following investigators:— Jörgensen (1923), in the Bay of Cadiz; Murray and Whitting (1899), at lat. 37° 44′ N., long. 30° 55′ W.; Ostenfeld (1898a), at lat. 35° 44′ N., long. 38° 03′ W.; Stüwe (1909), at lat. 28° 30′ N., long. 40° 16′ W.; Karsten (1906), at lat. 0° 9′ S., long. 8° 29′ W.; Hensen (1911), localities not specified. From the Mediterranean it is recorded by Pavillard (1905, 1916), in the Gulf of Lyons; Forti (1922), in the Ligurian Sea; Daday (1888) and Schröder (1900a), at Naples; Schröder (1906a), in the Ionian Sea; Entz (1902b, 1905) and Schröder (1911), in the Adriatic Sea; Jörgensen (1923), "throughout the entire Mediterranean." In the Red Sea it was found by Ostenfeld and Schmidt (1901); in the Gulf of Aden by Ostenfeld and Schmidt (1901) and Schröder (1906a); in the Arabian Sea by Ostenfeld and Schmidt (1901) and Schröder (1906a); off the coast of Celebes by Ostenfeld (1915); in the Peruvian Current by Lemmermann (1899a). With regard to Okamura's (1912) records from Japanese waters, see p. 102.

The species was found in waters of the following temperatures: — 74° (Murray and Whitting, 1899), 77.0°–80.3° (Ostenfeld and Schmidt, 1901), and 75.2° (Stüwe, 1909).

Of the investigators who have contributed to a knowledge of the distribution of this species only Stein (1883), Forti (1922), and Jörgensen (1923) give descriptions or drawings of this form by means of which their determinations may be checked.

Phalacroma porodictyum is eupelagic and evidently widely distributed in tropical, subtropical, and warm-temperate seas. In the area investigated by the Expedition it appears to be of almost uniform occurrence. Its optimum habitat according to the records is in deeper waters, within the levels of photosynthesis. It was found at the surface at only one Expedition station, viz., Acapulco.

Phalacroma argus Stein

Figure 8: 1, 2; 9

Phalacroma argus Stein, 1883, p. 18, fig. 15–17. Schütt, 1895, p. 13, 83, pl. 3, fig. 15: 1–3. Lemmermann, 1899, p. 372; 1901a, p. 372. Cleve, 1901a, p. 16. Ostenfeld & Schmidt, 1901, p. 175. Entz, 1902b, p. 94; 1905, p. 111. Schröder, 1906a, p. 324, 327. Karsten, 1907, p. 235. Pavillard, 1909, p. 283; 1916, p. 52. Hensen, 1911, p. 166, 167, tab. 15. Jörgensen, 1923, p. 13, fig. 13.
Phalacroma argo Hensen, 1911, p. 167 (*lapsu pennae*).

Diagnosis: — Body slightly obovate in lateral view, deepest at or somewhat behind girdle; length: depth, 1.15–1.48: 1; longitudinal axis deflected postero-ventrally at 0°–12°. In ventral view obovate, widest somewhat behind girdle; length: width, 1.75: 1. Posterior cingular list 0.28–0.45 the length of body from apex. Cingular lists usually without ribs. Right sulcal list with angular margin, concave anteriorly and convex posteriorly. Left sulcal list 0.45–0.59 the length of body; distance between R_1 and R_3 is 0.33–0.43 the length of body; R_2 is 0.07–0.14 and R_3 is 0.09–0.11 the greatest depth of body; margin gently sigmoid, concave anteriorly, convex posteriorly, seldom evenly convex throughout; R_3 inclined posteriorly at 25°–50°. Theca usually reticulate; 15–20 polygons border girdle posteriorly. Length, 83.5–110.5 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized or rather large species, the body of which is obovate in lateral view, deepest at or in most specimens somewhat behind the girdle and 1.15–1.48 times longer than deep. In the Expedition specimens the ratio between the length and the depth of the body is 1.17–1.25: 1; in Stein's (1883, pl. 18, fig. 15, 16), 1.32–1.48: 1; in Schütt's (1895, pl. 3, fig. 15: 1), 1.15: 1; and in Jörgensen's (1923, fig. 13), 1.21: 1. The longitudinal axis either is perpendicular to the transverse furrow, as in Stein's (1883) and in some of the Expedition specimens, or it is deflected posteroventrally at an angle of 1°–12°; in none of the Expedition specimens is it deflected more than at 4°; in those figured by Schütt (1895) and Jörgensen (1923) the deflection is 8°–12°.

The epitheca is 0.87–0.96 as deep as the hypotheca, strongly and almost evenly convex, dome-shaped, highest at or just dorsal to the center, and very prominent above the anterior cingular list. The transverse furrow is flat or slightly convex; and its width is 0.22–0.35 the greatest height of the epitheca. The posterior cingular list is 0.28–0.45 the length of the body from the apex; in the Expedition specimens the corresponding figures are 0.43–0.45; in Stein's (1883), 0.28–0.32; in Schütt's (1895), 0.32; and in Jörgensen's (1923), 0.37. The hypotheca is sometimes symmetrical, as in Stein's (1883) specimens and in Figure 8: 2; but usually it has a more or less pronounced posteroventral inclination (see above). Its dorsal, posterior, and ventral margins are well and evenly convex and confluent. The posterior end of the body is nearly always somewhat narrower than the anterior. In the specimens represented by Stein (1883, pl. 18, fig. 15) and Schütt (1895, pl. 3, fig. 15: 1) the anterior and the posterior portions of the body are of about the same width. In dorsoventral view (Stein, 1883, pl. 18, fig. 17) the body is regularly obovate, about 1.75 times longer than wide, and widest at or somewhat behind the girdle; its anterior end is broadly, its posterior end narrowly, convex; and its side contours are evenly convex.

The cingular lists are subhorizontal and subequal; their width usually about equals or slightly exceeds the width of the transverse furrow; occasionally it is somewhat less. In most specimens these lists appear to lack ribs, but in specimens of well-developed thecal reticulation, they have basally "irregular, coarse and short radial beams, finally anastomosing into an incomplete, wide-meshed reticulation" (Jörgensen, 1923, p. 13). The right sulcal list extends to or somewhat beyond a point midway between the fission rib and the posterior main rib of the left sulcal list; in some specimens its ventral margin, even in the widest region, does not quite extend to the ventral margin of the left sulcal list, but in others it does. The anterior half to two thirds of the free margin of this list is more or less concave and, at least in some specimens, is strengthened by a marginal rib; the posterior portion of this margin, which forms a distinct angle with the anterior portion, is more or less convex or, seldom, almost straight. The greatest width of this list is located just behind the concave portion. The left sulcal list is 0.45–0.59 as long as the body; in the Expedition specimens this ratio is 0.45–0.53: 1; in Stein's (1883), 0.51–0.59: 1; in Schütt's (1895), 0.54: 1; in Jörgensen's (1923), 0.45: 1. The distance between the anterior and the posterior main ribs is 0.33–0.43 the length of the body. The anterior main rib, when present, is 0.07–0.14, the fission rib 0.07–0.14, and the posterior main rib 0.09–0.11 the greatest depth of the body; in the Expedition specimens these three ratios are 0.09–0.14: 1; 0.08–0.09: 1; and 0.09–0.11: 1. The greatest width of this list, which in most specimens is located about midway between the fission rib and the posterior main rib, is 0.10–0.15 the greatest depth of the body. The free margin of this list is gently sigmoid, concave anteriorly and convex posteriorly, seldom gently and evenly convex throughout (Stein, 1883, pl. 18, fig. 15, 16); in other words, it is not angular posteriorly as in most species of the genus, but gently and evenly convex. The main ribs of this list are straight and comparatively weak, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.32–0.45 the distance from the anterior to the posterior main rib; in the Expedition specimens this ratio is 0.41–0.42: 1. The posterior main rib has a posterior inclination of 25°–50°; this angle in the Expedition specimens is 30°–35°; in Stein's (1883), 40°; in Schütt's (1895), 25°; and in Jörgensen's (1923), 50°. There are no ribs except the three main ribs, but sometimes the list appears to be delicately reticulate. There are no accessory lists or sails.

The thecal wall has a polygonate, sometimes but slightly developed, reticulation. There are fifteen to twenty polygons on each valve bordering the posterior margin of the girdle. Each polygon has a central pore. In the transverse furrow there are two rows of pores (and polygons, if present), each row with fifteen to twenty pores on each valve.

Megacytic stages have been found by Jörgensen (1923, p. 13).

The dimensions of two of the Expedition specimens and of the specimens drawn by Stein (1883, pl. 18, fig. 15, 16), Schütt (1895, pl. 3, fig. 15), and Jörgensen (1923, fig. 13) were measured.

Dimensions: — Expedition specimens: Length of body, 83.5–86.2 μ. Greatest depth of body, 66.9–73.5 μ. We do not know the size of the two specimens figured by Stein (1883, pl. 18, fig. 15, 16), one of which is the type. According to Stein's information about the magnifications of his figures, these specimens were somewhere between 80 μ and 145 μ long; the type specimen (Stein, 1883, pl. 18, fig. 16) was somewhere between 94 μ and 145 μ long. The specimen represented by Schütt (1895, pl. 3, fig. 15) is about 110.5 μ long and 96.1 μ deep; the one figure by Jörgensen (1923, fig. 13) is about 91.2 μ long and 75.7 μ deep; *i.e.*, these specimens are slightly larger than those found by the Expedition in the Pacific Ocean.

Variations: — *Phalacroma argus* is rather strikingly variable in the following characters: — the size of the body, the inclination of the longitudinal axis of the body, the relative depth of the body, the relative height of the epitheca, and the

FIGURE 8.— 1, 2, *Phalacroma argus* Stein, right lateral view. Surface markings, faint reticulation, and porulation, indicated only on small portion of theca in 1. × 430. 1, from Station 4730 (300–0 fathoms); 2, from Station 4724 (300–0 fathoms). 3, *Phalacroma circumcinctum* Kofoid and Michener, right lateral view of type specimen, slightly tilted. × 430. Station 4671 (300–0 fathoms).

shape of the sulcal lists. The variations in the inclination of the longitudinal axis of the body are probably exaggerated due to the tilting of some of the specimens examined.

Comparisons: — Stein (1883, pl. 18, fig. 15, 16) figures two specimens of *Phalacroma argus*, one relatively small and dorsoventrally narrow, the other relatively large and deep. The specimens in the material of the Expedition agree rather closely with the last-mentioned specimen (Stein, 1883, fig. 16). They differ mainly in the following respects: — (*1*) the epitheca is relatively higher; (*2*) the ventral margin of the left sulcal list is not evenly convex but sigmoid, being gently concave anteriorly and convex posteriorly. In most of the Expedition specimens the longitudinal axis of the body is deflected somewhat posteroventrally, while in Stein's specimen the body is symmetrical. The differences, however, are too small to be considered as specific. Moreover, it should be noted that the relative height of the epitheca, the shape of the ventral margin of the left sulcal list, and the inclination of the longitudinal axis of the body are characters subject to rather striking variability in the species of the ARGUS group (*P. apicatum*, Figure 10).

The specimens of *Phalacroma argus* figured by Schütt (1895, pl. 3, fig. 15) and by Jörgensen (1923, fig. 13) agree very closely with most of the ALBATROSS specimens of this species. They differ mainly in having the longitudinal axis of the body deflected somewhat more posteroventrally, at 8°–12° as compared with 1°–4°; they agree fairly closely with the specimen represented by Stein (1883, pl. 18, fig. 16). This specimen therefore should be regarded as the type of *Phalacroma argus*. The question as to whether or not the two forms represented by Stein (1883) under this name are different genetically cannot be settled as yet. Preliminarily, Jörgensen's (1923) broad conception of this species is adopted.

Judging by the great similarities in the shape and structure of the cingular and sulcal lists and in the structural differentiation of the thecal wall, *Phalacroma argus* is probably more closely related to *P. apicatum* than to any other known member of the genus. Indeed, these two forms are so similar that even their specific separation is questionable, and the solution suggested should be regarded as tentative. *Phalacroma argus* differs from *P. apicatum* mainly in having relatively lower, well-rounded, and dome-shaped epitheca.

Phalacroma porodictyum Stein, as conceived in the present paper and by Schütt (1895) and Jörgensen (1923), is probably, next to *P. apicatum*, the nearest-known relative of *P. argus*. This relationship is indicated by the close resemblance in the size and shape of the body and in the shape and structure of the right sulcal list. *Phalacroma porodictyum* is easily distinguished from *P. argus* and *P. apicatum* by the angularity of the posterior portion of its left sulcal list and by the structure of its thecal wall.

Probably another close relative of *Phalacroma argus* is *P. striatum*. This species, which is a member of the rather highly differentiated CUNEUS group, resembles *P. argus* in the following respects: — (*1*) The longitudinal axis of the body is deflected posteroventrally. (*2*) The free margin of the right sulcal list is concave anteriorly and convex posteriorly. Its concave anterior portion, which forms a distinct angle with the posterior portion, is strengthened by a marginal rib. (*3*) The left sulcal list is delicately reticulated. Its free margin is well rounded posteriorly, and not angular at the posterior main rib as in most of the species of this genus. (*4*) The thecal wall has a polygonate reticulation. The polygons are of moderate size and each of them has a central pore. *Phalacroma* *striatum* is easily distinguished from *P. argus* by its low epitheca, its broad, somewhat wedge-shaped hypotheca, and its exceptionally large left sulcal list. The Cuneus group probably originated from an ancestral form of about the same habitus as *P. argus*, just as this last species probably originated from a form resembling *P. porodictyum*.

From the comparatively simple structure of *Phalacroma argus*, it seems probable that its closest relatives, next to *P. apicatum*, *P. porodictyum*, and *P. striatum*, should be sought among those members of the genus which are pre-

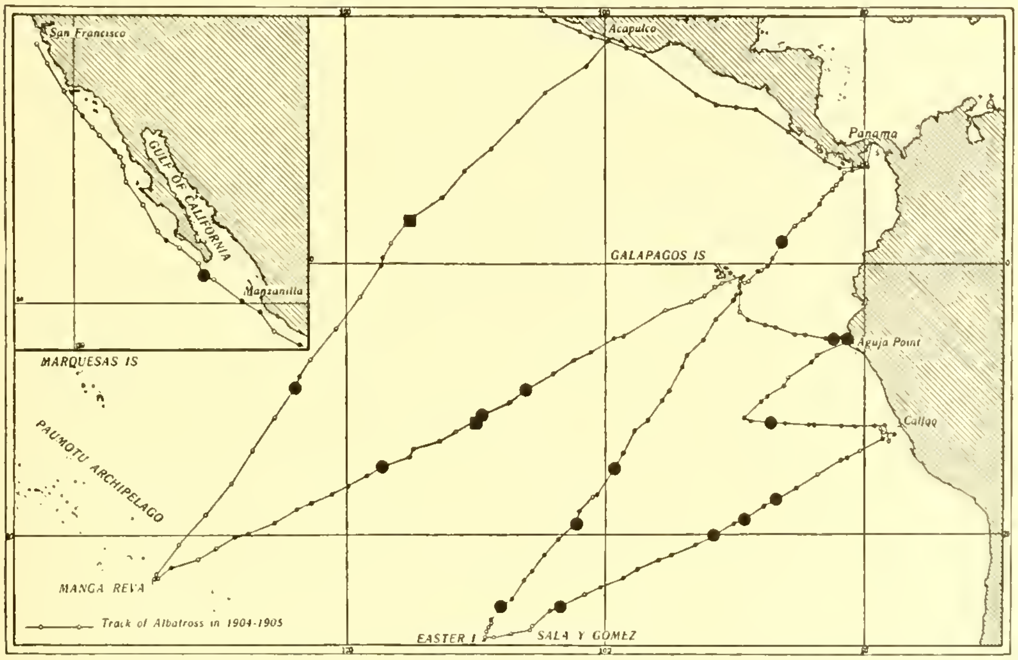

Figure 9.— Occurrence of *Phalacroma argus* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

sumably the most primitive. The following species are mentioned in this connection:— *P. operculatum* Stein *s. str.*, *P. ovum* Schütt, *P. operculoides* Schütt *s. str.* However, the degree of relationship between each of these simple species and *P. argus* is not known; in other words, which of them is more closely related to this species than the others. *Phalacroma argus* is readily distinguished from these species by the shape and structure of its sulcal lists. See also p. 113.

Occurrence: — *Phalacroma argus* is recorded at eighteen of the 127 stations. There are 1, 4, 4, 3, 4, and 2 stations on the six lines of the Expedition. Of these eighteen stations, one (4583) is in the California Current; one (4637) in the Panamic Area; three (4652, 4655, 4664) in the Peruvian Current; two (4691,

4695) in the Easter Island Eddy; ten (4679, 4681, 4683, 4701, 4705, 4722, 4724, 4725, 4730, 4740) in the South Equatorial Drift; one (4540) in the South Equatorial Current. At two stations (4725 [Salpa], 4540), the species was taken at the surface; at one station (4652) in a haul from 100–0 fathoms, and at one station (4701) in a haul from 800–0 fathoms as well as in a haul from 300–0 fathoms. All the other records refer to catches from 300–0 fathoms only.

The temperature range of these eighteen stations at the surface was 65°–83°; and the average was 73.7°. At Stations 4725 and 4540, where the species was taken at the surface, the surface temperature was 77° and 79°, respectively.

At one station (4681) the frequency is 2%; at two stations (4655, 4691) it is 1%; at the remaining stations it is less than 1%.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." Hensen (1911) found it at a very great number of stations throughout the tropical, subtropical, and warm-temperate regions of the Atlantic. "*P. argus* tritt schon im Floridastrom auf, ist im westlichen Teil der Sargossosee gut vertreten und kommt sonst ziemlich gleichmässig, aber lückenhaft vor" (Hensen, 1911, p. 167). The specimens drawn by Schütt (1895) were probably taken either in the tropical, subtropical, or warm-temperate regions of the Atlantic or in the Gulf of Naples. Jörgensen (1923, p. 13, 14), who states that this species is "known from many places in the warmer Atlantic, including the Florida Current," reports it from the Bay of Cadiz; Pavillard (1909, 1916) from the Gulf of Lyons; Entz (1902b, 1905) from the Adriatic Sea; Jörgensen (1923) from "throughout the whole of the Mediterranean (at fourteen out of thirty-seven stations), everywhere in single specimens." In the Red Sea it has been found by Schröder (1906a); in the Gulf of Aden by Ostenfeld and Schmidt (1901); in the Arabian Sea by Ostenfeld and Schmidt (1901), Cleve (1901a), and Schröder (1906a); in the Indian Ocean by Cleve (1901a) and Karsten (1907). Ostenfeld and Schmidt (1901) found it in surface waters and at a depth of twenty feet; Karsten (1907) in a catch from 100 meters. Most of the remaining records mentioned in this paragraph probably refer to surface catches.

Ostenfeld and Schmidt (1901) found the species in waters of 79.5° and 82.4°.

Only Stein (1883) and Jörgensen (1923) give drawings by means of which the accuracy of their determinations may be judged.

This is a eupelagic species occurring in tropical, subtropical, and warm-temperate regions of all seas. The Expedition records reveal an almost even distribution throughout the area investigated, with an optimum habitat in deeper rather than surface waters, within the levels of photosynthesis.

Phalacroma apicatum, sp. nov.

Figure 10

Phalacroma sp. Okamura, 1907, p. 134, pl. 4, fig. 26a and b.

Diagnosis: — Body irregularly obovate or sublozenge-shaped in lateral outline, with subconical epitheca; deepest at or just behind girdle; length: depth, 1.24–1.30: 1; longitudinal axis deflected posteroventrally at 0°–10°. In ventral view subbiconical, with rounded apices, widest at girdle, 1.40 times longer than wide. Posterior cingular list 0.49–0.53 the length of body from apex. Lists resemble those of *Phalacroma argus.* Of the main ribs of left sulcal list R_2 is

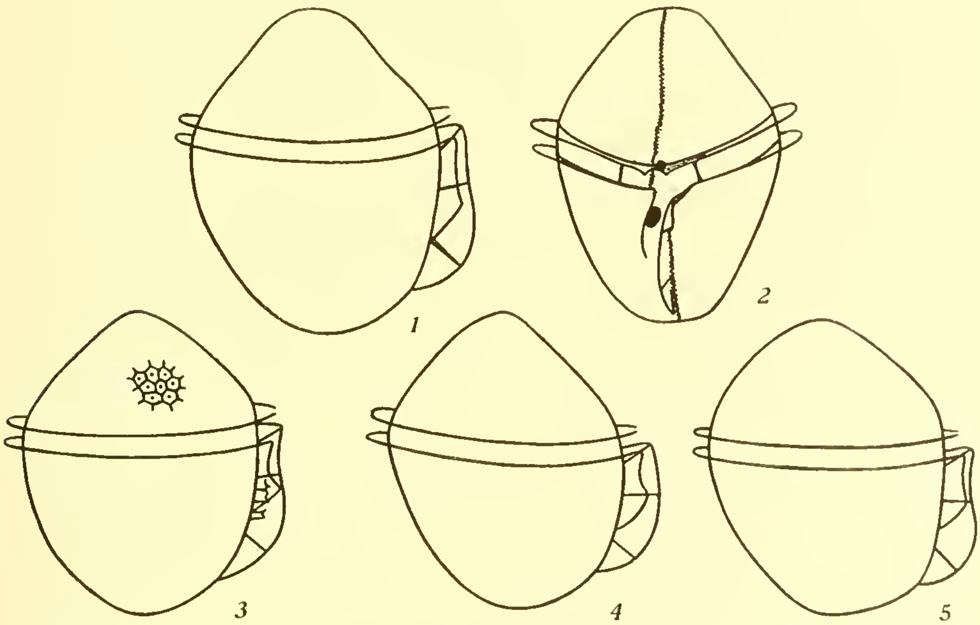

Figure 10.— *Phalacroma apicatum*, sp. nov. 1, 3, 4, 5, in right lateral view; 2, in ventral view. Left sulcal list with traces of reticulation in specimen represented by 3; surface markings indicated only on small portion of theca in 3. × 430. 1, 2, from type specimen, Station 4737 (300–0 fathoms); 3, from Station 4730 (300–0 fathoms); 4, from Station 4737 (300–0 fathoms); 5, from Station 4734 (300–0 fathoms).

0.09–0.17 and R_3 is 0.12–0.17 the greatest depth of body. Surface markings of theca as in *P. argus;* sometimes apparently absent. Length, 91.8–102.2 μ.

Tropical and subtropical Pacific.

Description: — A rather large species with the body irregularly obovate or sublozenge-shaped in lateral outline, with subconical epitheca, deepest at or just behind the girdle, and 1.27 (1.24–1.30) times longer than deep. The longitudinal axis of the body is either perpendicular to the transverse furrow (Figure 10: 3), or it is deflected posteroventrally at an angle of 1°–10°.

The epitheca is subconical, about as deep as the hypotheca, the ratio being 0.99 (0.95–1.00): 1, highest in or just dorsally to the center and very prominent above the anterior cingular list; it has gently convex, almost straight or even slightly concave side contours, which are nearly perpendicular to each other, and rounded apex. The transverse furrow is flat or somewhat convex; and its width is 0.16 (0.14–0.19) the greatest height of the epitheca. The posterior cingular list is 0.50 (0.49–0.53) the length of the body from the apex. The hypotheca is sometimes almost symmetrical (Figure 10: 3), but in most specimens it has a more or less pronounced posteroventral inclination (see above). It is somewhat irregularly, seldom regularly, ovoidal. The dorsal margin is evenly and gently convex. The ventral margin sometimes has about the same curvature as the dorsal, but in nearly all the specimens it is somewhat more strongly curved; in some, however, (Figure 10: 5) it forms a broadly rounded corner at the posterior end of the left sulcal list, in which case its anterior portion is but slightly convex. The posterior end of the body is broadly convex and always distinctly broader than the anterior. In ventral view (Figure 10: 2) the body is subbiconical, about 1.40 times longer than wide and widest at the transverse furrow; the side contours of the epitheca and of the hypotheca are slightly convex or almost straight; and the anterior and posterior ends are rounded, the anterior slightly narrower than the posterior.

The cingular lists are as in *Phalacroma argus*. The sulcus is about half as long as the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a small pore is found near the sagittal suture, just in front of the anterior cingular list. The right sulcal list resembles that of *P. argus*, but it sometimes (Figure 10: 1) extends to the posterior main rib of the left sulcal list. The left sulcal list also resembles that of *P. argus* but is, on the average, somewhat wider. The ratios between the main ribs of this list and the greatest depth of the body are as follows: — anterior main rib, 0.13 (0.10–0.15): 1; fission rib, 0.12 (0.09–0.17): 1; posterior main rib, 0.14 (0.12–0.17): 1. Sometimes (Figure 10: 3) this list has a faint and irregular reticulation; and in some specimens its free margin is evenly convex throughout the whole length (Figure 10: 4). The distance between the anterior main rib and the fission rib is 0.40 (0.33–0.50) the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of 42° (30°–50°). There are no accessory lists or sails.

The surface markings of the thecal wall are the same as in *Phalacroma argus;* sometimes the reticulation seems to be absent.

Megacytic stages have not been seen.

The proportions of five of the Expedition specimens and of that drawn by Okamura (1907, fig. 26b) were measured.

Dimensions: — Expedition specimens: Length of body, 91.8–102.2 μ (average, 96.2 μ; type, 101.5 μ). Greatest depth of body, 71.5–81.3 μ (average, 75.5 μ; type, 77.8 μ). Okamura's (1907, fig. 26b) specimen: Length of body, 101 μ. Greatest depth of body, 76 μ.

Variations: — This species is rather variable in the inclination of the longitudinal axis of the body, in the shape and relative height of the epitheca and of the hypotheca, in the shape of the right sulcal list, in the shape and structure of the left sulcal list, and in the surface markings of the thecal wall. The variations in the inclination of the longitudinal axis of the body and in the shape of the body probably are partly apparent and due to the tilting of some of the specimens examined. The epitheca generally is pronouncedly subconical, but sometimes specimens are found which in the shape of the epitheca approach, more or less, *Phalacroma argus* (Figure 10:5). The ventral margin of the left sulcal list is gently sigmoid in most specimens; in exceptional cases it is evenly convex (Figure 10:4).

Comparisons: — The structurally nearest species to *Phalacroma apicatum* is *P. argus*, from which it differs in its more contracted epitheca. For further discussion, see p. 107.

Phalacroma circumcinctum, which shows a rather striking resemblance to *P. apicatum* in the shape of the body, especially in dorsoventral view, differs in having the longitudinal axis of the body deflected posterodorsally, in having a parasagittal list, in the shape and structure of the sulcal lists, and in the surface markings of the thecal wall. The question as to whether or not these two species are closely related must be left open.

The distinguishing characteristic of *Phalacroma apicatum*, when compared with *P. argus*, *i.e.*, the subconical shape of the epitheca, is found also in *P. operculatum* Stein *s. str.* (Stein, 1883, pl. 18, fig. 8), in one of the two specimens figured by Schütt (1895, pl. 3, fig. 17:2) under the name of *P. rastum* var. *acuta*, in the rather highly differentiated *P. turbineum* (Plate 2, fig. 3) and in *P. reticulatum* (Plate 4, fig. 3). In the case of *P. operculatum* and *P. rastum* var. *acuta* (= *P. acutum* Pavillard), this similarity may be considered a sign of close relationship, *i.e.*, as an expression of an inherent "tendency." On the other hand, the relationships of *P. turbineum* and *P. reticulatum* to *P. apicatum* are uncertain. See also p. 191.

Synonymy: — Okamura (1907, p. 134, fig. 26) suggested that his *Phalacroma* sp. might represent *P. porodictyum* Stein. According to the size and the magnification of the drawing, this specimen was 101 μ long.

Occurrence: — *Phalacroma apicatum* is recorded at five of the 127 stations. There are 0, 0, 0, 1, 4, and 0 stations on the six lines of the Expedition. Of these five stations one (4697) is in the Easter Island Eddy, and four (4730, 4732, 4734, 4737, type locality) are in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these five stations at the surface was 75.0°–81.5°; the average was 79.1°.

The frequency in every case is less than 1%.

The species, which previously was known from Japanese waters, is probably eupelagic and widely distributed in tropical and subtropical seas. In the material of the Expedition it is limited to the Easter Island Eddy and the western portion of the South Equatorial Drift; in other words, it has about the same distribution as *Amphisolenia schauinslandi* and *A. thrinax* and several other warm-water forms. Its average temperature is exceptionally high, 79.1°.

Phalacroma circumcinctum Kofoid and Michener

Plate 1, fig. 4, 5. Figure 8: 3

Phalacroma circumcincta Kofoid & Michener, 1911, p. 288, 291.

Diagnosis: — Body subovate in lateral view, deepest at girdle; length: depth, 1.25: 1; epitheca with slight ventral inclination, hypotheca almost symmetrical. In ventral view subbiconical, 1.54 times longer than wide, widest at girdle, with narrowly rounded apices. Posterior cingular list 0.46 the length of body from apex. Cingular lists without ribs. Right sulcal list reticulate. Left sulcal list: distance between posterior cingular list and R_3 is 0.38 the length of body; R_2 is 0.07 and R_3 is 0.15 the greatest depth of body; at R_3 margin forms rounded corner at 90°; R_1 is absent; R_2 is T-shaped; R_3 inclined posteriorly at 80°–85°. On right valve of epitheca and hypotheca there is an apparently structureless parasagittal list forming a direct continuation of left sulcal list; its maximum width but slightly exceeds half the width of transverse furrow. Theca densely areolate; 30–35 areoles border girdle posteriorly. Length 86.5 μ.

Eastern subtropical Pacific.

Description: — A medium-sized species, with body subovate in lateral outline, deepest at the girdle, and about 1.25 times longer than deep. The longitudinal axis of the body is deflected anteroventrally at an angle of about 2°, due to the ventral inclination of the epitheca.

The epitheca is about as deep as the hypotheca and very prominent above the anterior cingular list; it is inclined slightly ventrally; in other words, it is highest slightly ventrally to the center. Its ventral, anterior, and dorsal margins are confluent; the ventral and anterior are rather strongly convex; the dorsal is gently convex, somewhat flattened. The transverse furrow is slightly concave, and its width is about 0.26 the greatest height of the epitheca. The posterior cingular list is about 0.46 the length of the body from the apex. The hypotheca is almost symmetrical; its ventral, posterior, and dorsal margins are confluent; the posterior margin is somewhat more strongly convex than the ventral and the dorsal. The posterior end of the body is somewhat narrower than the anterior. In dorsoventral view the body is subbiconical, widest at the girdle, and about 1.54 times longer than wide; the side contours of the epitheca and of the hypotheca are gently concave or almost straight; the anterior and posterior ends of the body are narrowly rounded or subtruncate, and of about the same width.

The cingular lists are subhorizontal and subequal; their width about equals the width of the transverse furrow; and they appear to lack ribs. The sulcus is about half as long as the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a small pore is found a short distance from the sagittal suture and just in front of the anterior cingular list. The right sulcal list extends to a point somewhat behind the fission rib of the left sulcal list; even in the widest region its ventral margin does not extend to the ventral margin of the left sulcal list; it is of almost equal width throughout the greater portion of its length; its free margin is gently sigmoid, being concave anteriorly and convex posteriorly. The whole list is reticulated, with two longitudinal rows of meshes, 6–8 meshes in each row. The left sulcal list is comparatively long and narrow; the distance from the posterior cingular list to the posterior main rib is 0.38 the length of the body; at the place of the anterior main rib the width of the list is about 0.10 the greatest depth of the body; the fission rib is about 0.07, the posterior main rib about 0.15 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The ventral margin of this list is gently sigmoid, being concave anteriorly and convex posteriorly; at the posterior main rib the margin forms a rounded corner at an angle of about 90°. The posterior margin of this list is almost straight. The anterior main rib of this list was not developed in the type specimen. The fission rib is T-shaped, being divided distally into two branches which form a marginal rib along the anterior half of the list. The posterior main rib is gently concave posteriorly and not club-shaped; it has a posterior inclination of about 80°–85°. The distance from the posterior cingular list to the fission rib is about 0.33 the distance between the posterior cingular list and the posterior main rib. With the exception of the main ribs, the left sulcal list appears to lack structural differentiation. On the right valve there is an apparently structureless parasagittal list. This list extends from the left sulcal list, of which it is a direct continuation, to the girdle, and along the anterior and ventral margins of the epitheca. On the epitheca the width of this list is somewhat more than half the width of the transverse furrow; on the hypotheca the maximum width about equals half the width of the transverse furrow.

The thecal wall is areolate, and the areoles are of almost uniform size and evenly distributed. There are from thirty to thirty-five areoles on each valve bordering the posterior margin of the girdle. In the transverse furrow there are three irregular rows of areoles.

Megacytic stages have not been seen.

The proportions of the type were measured.

Dimensions: — Length of body, 86.5 μ. Greatest depth of body, 68.9 μ.

Comparisons: — The above description is made from the original drawings of the type specimen. The long, irregular, hyaline appendage of this specimen (Plate 1, fig. 5), apparently issuing from the sagittal suture near the posterior main rib of the left sulcal list, is of unknown nature and significance. Presumably it is a temporary structure, and it may be connected with reorganizing processes either independent of, or following binary fission; compare Kofoid (1908). This structure has not been considered of any systematic importance and thus has been omitted from the description of the species and disregarded in the discussion of the relationships of this form. The shape and the lack of structure of the parasagittal list also appear to indicate that this specimen was taken while still in a process of skeletal reorganization (see Plate 3, fig. 4).

This species has a somewhat uncertain position within the genus. It resembles *P. apicatum* in the somewhat elongate and, in dorsoventral view, subbiconical shape of its body. Other features in which these two species agree are the subequatorial position of the girdle and the width and inclination of the cingular list; however, since these species presumably are relatively primitive in these respects, these similarities are of less importance in this connection. *P. circumcinctum* is easily distinguished from *P. apicatum* by the following characters: — (*1*) the epitheca is inclined ventrally instead of dorsally; (*2*) the right sulcal list is reticulate, and its free margin is gently sigmoid and not angular; (*3*) the margin of the left sulcal list is angular at the posterior main rib; (*4*) the theca is areolate and not reticulate; (*5*) on the right valve of the epitheca as well as of the hypotheca there is a well-developed parasagittal list. The differences between these two species, therefore, appear to be more profound than the similarities. However, in spite of this, *P. circumcinctum* is probably rather closely related to *P. apicatum* and, preliminarily, should be placed in the Argus group. Most of the characters of *P. circumcinctum* which are different from those of *P. apicatum* either have maintained a comparatively primitive type or they are expressions of "tendencies" inherent in the Argus group but not developed morphologically in most of the members of this group. For example, the angularity of the margin of the left sulcal list and the areolation of the thecal wall in *P. circumcinctum* probably are relatively primitive features; they are found also in *P. porodictyum* which is closely related to *P. apicatum* and *P. argus*. A parasagittal list on the right valve also is characteristic of *P. blackmani*, which undoubtedly is a very close relative of *P. striatum* and thus also of *P. apicatum* and *P. argus* (see p. 107).

The T-shaped fission rib of the left sulcal list is a character that is known only in *Phalacroma circumcinctum* and *P. ovum*. These two species resemble each other also in the width, structure, and inclination of the cingular lists, in the size and shape of the right sulcal list, and in the surface markings of the theca; they differ in the relative height of the epitheca, in the shape of the epitheca and of the hypotheca in dorsoventral view, in the relative length and the inclination of the posterior main rib of the left sulcal list, and in the presence or absence of a parasagittal list.

It also should be noted in this connection that *Phalacroma circumcinctum* resembles *P. limbatum* in the subequatorial position of the girdle, in having a parasagittal list on the right valve of both the epitheca and the hypotheca, in the subbiconical shape of the body in dorsoventral view, and in the structure of the sulcus and of the adjacent regions (compare Plate 1, fig. 4, and Plate 3, fig. 3). *Phalacroma limbatum* is easily distinguished from *P. circumcinctum* in the subcircular shape of its body in lateral view, in the high structural differentiation of its right parasagittal list, in having two parasagittal lists, in the size and shape of its left sulcal list, in the structure of its theca, and in the narrowness of its body in dorsoventral view.

Occurrence: — *Phalacroma circumcinctum* is recorded at only one (4671) of the 127 stations, on the second line of the Expedition and in the Peruvian Current, from 300–0 fathoms, in a surface temperature of 66°, with a frequency of less than 1% (one specimen).

PHALACROMA OVUM Schütt

Figure 11

Phalacroma ovum SCHÜTT, 1895, p. 90.
?*Phalacroma operculatum* STEIN, 1883, *partim*, pl. 18, fig. 7. ?FORTI, 1922, *partim*, p. 105, 190, 208, pl. 7, fig. 111. *non* SCHÜTT, 1895, p. 93, pl. 2, fig. 10: 1–3. *non* JÖRGENSEN, 1923, p. 9, 10, fig. 7.
Phalacroma operculoides SCHÜTT, 1895, *partim*, pl. 2, fig. 11: 2. OKAMURA, 1912, p. 18, fig. 81, 82. JÖRGENSEN, 1923, p. 8, 9, 45, fig. 5. *non* CLEVE, 1899c, p. 40. *non* LOHMANN, 1902, p. 53. *non* FORTI, 1922, p. 106, 190, 208, pl. 7, fig. 111.

Diagnosis: — Body obovate in lateral outline, deepest at or somewhat behind girdle; length: depth, 1.20–1.31 : 1; longitudinal axis deflected posteroventrally at 0°–4°. In dorsal view narrowly obovate, 1.59–1.64 times longer than wide. Posterior cingular list 0.28–0.36 the length of body from apex. Cingular lists probably without ribs. Left sulcal list 0.43–0.53 the length of body; distance between R_1 and R_3 is 0.33–0.37 the length of body; R_1 is 0.10–0.13, R_3 is 0.30–0.37 the greatest depth of body; margin forms angle of 60°–90° at R_3; R_2 is T-shaped; R_3 usually club-shaped and inclined posteriorly at about 30°. Theca finely and closely areolate. Length, 58.2–76.1 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is obovate in lateral view, deepest at, or, in most specimens, somewhat behind the girdle, and about 1.26 (1.20–1.31) times longer than deep. The longitudinal axis of the body either is perpendicular to the girdle, or it is slightly (1°–4°) deflected posteroventrally.

The epitheca is 0.93 (0.91–0.96) as deep as the hypotheca, and moderately elevated or very prominent above the anterior cingular list; sometimes (Figure 11: 1) it is strongly and evenly convex, dome-shaped, sometimes (Figure 11: 3, 2) of moderate convexity or rather flat; in most cases it is highest in the center, but in some specimens (Figure 11: 6) somewhat dorsally to the center. The transverse furrow is flat or slightly convex, and its width is 0.37 (0.26–0.42) the greatest height of the epitheca. The posterior cingular list is 0.32 (0.28–0.36) the length of the body from the apex. The hypotheca sometimes is symmetrical, sometimes it has a slight posteroventral inclination (see above); sometimes (Figure 11: 4) it is of an oval wedge shape, with rather flat dorsal and ventral margins; sometimes (Figure 11: 1) it is regularly oval, with well or moderately rounded dorsal and ventral margins; its posterior margin is strongly convex and confluent with the dorsal and ventral margins. The posterior portion of the body is strikingly narrower than the anterior. In dorsoventral view the body is narrowly and regularly obovate, 1.59–1.64 times longer than wide, and widest at the girdle.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; they appear to be without structural differentiation. The right sulcal list extends to a point midway between the fission rib and the posterior main rib of the left sulcal list, or it is slightly longer or shorter; in some specimens it is subtriangular, decreasing gradually in width posteriorly; in others it is subequal in width throughout its anterior half or even throughout the greater

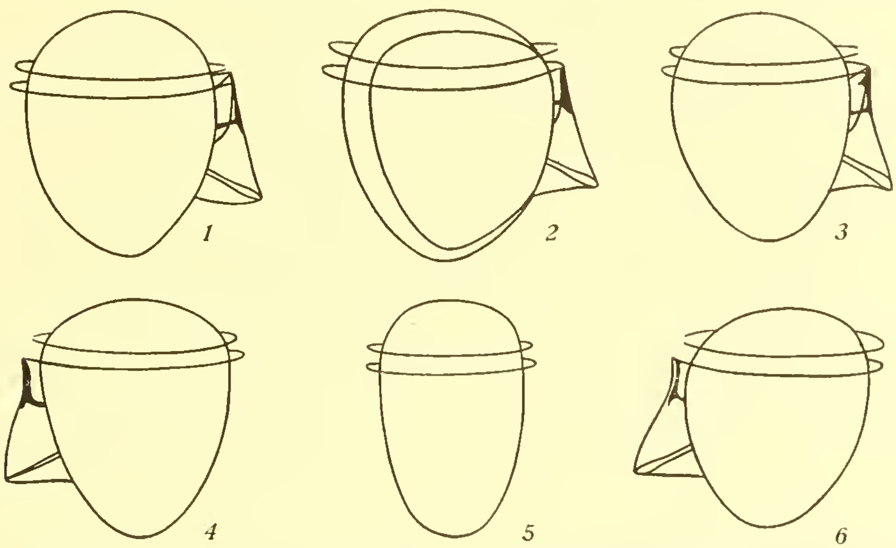

FIGURE 11.—*Phalacroma ovum* Schütt. 1, 2, 3, in right lateral view; 4, 6, in left lateral view; 5, in dorsal view. 2, from a megacytic specimen; surface markings omitted. × 430. 1, from Station 4737 (300–0 fathoms); 2, from Station 4709 (300–0 fathoms); 3, from Station 4721 (300–0 fathoms); 4, 5, from Station 4681 (300–0 fathoms); 6, from Station 4709 (300–0 fathoms).

portion of its length; anteriorly it is about as wide as the transverse furrow. The left sulcal list is of moderate length, narrow anteriorly and wide posteriorly. Its length is 0.50 (0.43–0.53) the length of the body, and the distance between the anterior and posterior main ribs is 0.35 (0.33–0.37) the length of the body. The anterior main rib, when present, is 0.12 (0.10–0.14), the fission rib 0.12 (0.10–0.13), and the posterior main rib 0.33 (0.30–0.37) the greatest depth of the body. Behind the last-mentioned rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list sometimes is almost straight or gently concave, sometimes it is gently sigmoid, concave anteriorly and convex posteriorly; at the posterior main rib it forms an angle of 75° (60°–90°); behind the last-mentioned rib it is almost straight, or gently concave or convex. The fission rib is T-shaped, being divided distally into two branches, which form a marginal rib along the anterior third or half of the list; this marginal rib is sometimes more or less irregular. The posterior main rib is straight, or but slightly concave posteriorly, and in most cases somewhat club-shaped distally; it has a posterior inclination of 30° (25°–32°). Sometimes this list appears to have a faint reticulation (Stein, 1883, pl. 18, fig. 7). There are no accessory lists or sails.

The thecal wall is finely and closely areolate and has scattered pores; the areoles are of about the same size as the pores (Jörgensen, 1923, fig. 5).

Megacytic stages have been seen (Figure 11: 2). Sometimes the megacytic specimen has the transdiameter subequal to the length of the body.

The proportions of six Expedition specimens, and of the specimens figured by Schütt (1895) and Jörgensen (1923) were measured.

Dimensions: — Expedition specimens: Length of body, 66.9–76.1 μ (average, 71.4 μ). Greatest depth of body, 55.0–58.9 μ (average, 56.9 μ). The type specimen as figured by Schütt (1895, pl. 2, fig. 11: 2) was 61 μ long and 46 μ deep; Jörgensen's (1923), 60–66 μ long. According to the given magnifications, the specimens figured by Okamura (1912, pl. 5, fig. 81, 82) were about 58 μ and 34 μ long, respectively (see p. 120).

Variations: — Judging by the available figures, this species appears to be rather constant. The most variable features are the size of the body, the relative height and the shape of the epitheca, and the shape of the two posterior main ribs of the left sulcal list. With regard to the porulation of the theca, see *Phalacroma operculoides* and *P. operculatum* Jörgensen (1923, p. 8, 9).

Comparisons: — Most of the Expedition specimens agree closely with the type specimen as figured by Schütt (1895, pl. 2, fig. 11: 2). They differ in having the fission rib of the left sulcal list T-shaped and the posterior main rib of this list club-shaped. It should be mentioned, however, that in some of these specimens the last-mentioned rib was not club-shaped.

The specimen figured by Jörgensen (1923, fig. 5) under the name of *Phalacroma operculoides* shows also a close agreement with the type. Those figured by Okamura (1912, pl. 5, fig. 81, 82) are comparatively small; according to the magnifications given, they are only 58 μ and 34 μ long, respectively. The last measurement may be erroneous, and due to a mistake in the magnification; it has been disregarded in the diagnosis.

Judging by the simplicity of its structure, *Phalacroma ovum* probably is fairly closely related to the comparatively primitive members of this genus, *e.g.*, *P. porodictyum* Stein, *P. operculoides* Schütt *s. str.*, *P. operculatum* (Stein) Jörgensen, and *P. argus* Stein. Due to the simplicity of their organization, the interrelationships of these species are very difficult to establish. However, it seems rather plausible that *P. ovum* is more closely related to *P. porodictyum* than to any other known species. *Phalacroma ovum* is most easily distinguished from all these species by the shape and structure of its left sulcal list.

Phalacroma circumcinctum, which differs very strikingly from *P. ovum* in the subequatorial position of its girdle, has the fission rib of the left sulcal list T-shaped in the same way as the last species.

Judging by the great similarities in the size and shape of the body and in the shape and structure of the left sulcal list, *Phalacroma ovum* and *P. doryphorum* probably are rather closely related. The last species differs strikingly from the first in having a large, triangular posterior sail.

Synonymy: — The synonymy of this species is complicated to such an extent that it is difficult, if not impossible, to unravel it. Stein (1883, pl. 18, fig. 7–10) figures, under the name of *Phalacroma operculatum*, two forms which probably are specifically distinct. Jörgensen (1923, p. 9), the first to point out this fact, applies the name *operculatum* to the specimen represented by Stein (pl. 18, fig. 8). This specimen therefore becomes the type of a species which should be named *P. operculatum* (Stein) Jörgensen. The specimens represented by Stein (pl. 18, fig. 7, 9, 10) are assigned by Jörgensen (1923, p. 9) to *P. porodictyum* Stein. However, on account of the almost complete agreement between the specimen represented by Figure 11: 1 and Stein's Plate 18, fig. 7, with regard to the shape of the body and the position of the girdle, it seems more plausible that these specimens of Stein belong to the species described and figured above under the name of *P. ovum* Schütt. The uncertainty of the assignment is mainly due to the fact that the left sulcal list is incomplete (damaged ?) in Stein's Plate 18, fig. 7. The lack of porulation in the last figure probably is due to an omission; see Jörgensen (1923, p. 9). If our identification is correct, Stein (1883, pl. 18, fig. 7, 9, 10) was the first to figure a specimen of *P. ovum*, and *P. operculatum* Stein, *partim*, is a synonym of *P. ovum* Schütt.

Phalacroma operculatum Stein is used by Daday (1888, p. 99; *Phalorocoma operculatum, lapsu pennae*), Schütt (1895, p. 93, pl. 2, fig. 10), Hensen (1895, p. 190; 1911, p. 137, 138, 166, 167, 393, tab. 15), Lemmermann (1899, p. 371; 1901a, p. 373; 1905a, p. 35), Murray & Whitting (1899, p. 330, tab. 1, 2, 3, 4, 5, 6, 7, 8, 9), Schröder (1900a, p. 9, 11, 19; 1906a, p. 321, 327, 330; 1911, p. 17, 37), Rauschenplat (1900, p. 134), Cleve (1901a, p. 17; 1901c, p. 272; 1902b, p. 37; 1903b, p. 347), Lohmann (1902, p. 53; 1920, p. 485, 492, 496, 504, 505, 507, 509, 511, 513, 515, 517, 524, 525, 529, 532, 536, 537, 544, 551, 554, 561, 572, 574, 585, 596), Entz (1902b, p. 94; 1904, p. 14; 1905, p. 111), Pavillard (1905, p. 59, 81, 102; 1909, p. 283; 1916, p. 44, 47, 48, 49, 50, 54), Zacharias (1906, p. 509, 530, 534, 536, 544, 557), Karsten (1907, p. 236, 247, 263, 304, 349, 355, 359), Nathansohn (1908, p. 60; 1909, p. 42), Stüwe (1909, p. 237, 252, 287), Schiller (1912, p. 27), Forti (1922, p. 105, 190, 208, pl. 7, fig. 110, 112; fig. 112 is erroneously called *P. porodictyum*, and the figure representing the last species has no number), Jörgensen (1923, p. 9, 10, fig. 7), and Lindemann (1924, p. 10). Most of the investigators mentioned in this paragraph do not give any information as to which of the two forms figured by Stein (1883) under the name of *P. operculatum* they refer to. Daday, Hensen, Lemmermann, Murray and Whitting, Schröder, Rauschenplat, Cleve, Lohmann, Entz, Pavillard, Zacharias, Karsten, Nathansohn, Stüwe, Schiller, and Lindemann have not been included in the bibliographical list of *P. ovum*. The remaining ones give figures by means of which their determinations can be checked. Forti (1922) refers to both the forms figured by Stein (1883) under the name of *P. operculatum*.

According to Jörgensen (1923, p. 8) "two apparently different species" are figured by Schütt (1895, pl. 2, fig. 11: 1–3) under the name of *Phalacroma operculoides*. Jörgensen applies the name *operculoides* to the specimen represented by Schütt (1895, pl. 2, fig. 11: 2); the second figure was chosen because "unfortunately, his [Schütt's] first figure is uncertain, and seems to represent the same species which he notes, lower down on the same plate, as *Phalacroma porodictyum* var. *parvulum*, while the second figure shows a characteristic species closely related to the foregoing [*P. porodictyum*], and possibly merging into the same" (Jörgensen, 1923, p. 8). It seems almost unquestionable that the specimens represented by Schütt (1895, pl. 2, fig. 11: 1–3) belong to two specifically distinct forms. However, it is necessary to reject Jörgensen's decision as to the nomenclature of these two forms, since Schütt (1895, p. 90) refers to his Plate 2, fig. 11: 2 as *P. ovum;* on the other hand, except in the explanation of the plates, Schütt never refers to this figure as representing *P. operculoides*. The name *P. operculoides* therefore should be used for the species represented by Schütt (1895, pl. 2, fig. 11: 1, 3), while the name *P. ovum* should be applied to the species represented by Plate 2, fig. 11: 2.

Phalacroma operculoides Schütt has been used by several authors, viz., Cleve (1899c, p. 40), Lemmermann (1899, p. 372; 1901a, p. 373; 1905a, p. 35), Lohmann (1902, p. 53), Stüwe (1909, p. 252, 287), Okamura (1912, p. 18, fig. 81, 82), Pavillard (1916, p. 54; 1923a, p. 879), Forti (1922, p. 106, 190, 208, pl. 7, fig. 111), and Jörgensen (1923, p. 8, 9, 45, fig. 5). *P. operculoides* Cleve (1899c) refers to *P. rotundatum*, according to Cleve (1901c, p. 241); see also Paulsen (1908, p. 18). Lemmermann only refers to data given by other writers. The specimens referred by Lohmann (1902, p. 53) to *P. operculoides* were only 35 μ long, which indicates that they are referable to *P. operculoides s. str.* Stüwe (1909) and Pavillard (1916, 1923a) do not give any information as to which of the two forms figured by Schütt (1895) under the name of *P. operculoides* they refer to. Under these circumstances these authors are not included in the bibliography of *P. ovum*. Forti (1922) refers to Schütt (1895, pl. 2, fig. 11: 1), not to *P. ovum*. *P. operculoides* Okamura (1912) and Jorgensen (1923) refer to *P. ovum* (see p. 120).

Occurrence: — *Phalacroma ovum* is recorded at ten of the 127 stations. There are 2, 1, 1, 2, 4, and 0 stations on the six lines of the Expedition. Of these ten stations, one (4587) is in the Mexican Current; one (4617) in the Panamic Area; one (4657) in the Peruvian Current; and seven (4681, 4709, 4711, 4721, 4724, 4730, 4737) in the South Equatorial Drift. At one station (4724) the species was taken in a haul from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these ten stations at the surface was 68°–82°; the average temperature was 75.8°.

At one station (4657) the frequency is 1%, at the remaining stations it is less.

Schütt (1895) did not give any information as to the localities of his specimens; however, his material probably was taken either at Naples, or in the tropical or subtropical regions of the Atlantic. Jörgensen (1923) found this species "fairly common" in the Mediterranean, and "most frequent in the inner parts" of this sea. Okamura (1912) recorded it from Japanese waters.

Judging by the numerous records which possibly may refer to *Phalacroma ovum* (see p. 121), this species appears to be eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. The ten record stations are distributed fairly evenly over the area investigated by the Expedition. The absence of surface records is noteworthy. The species probably has its optimum habitat in deeper waters within the levels of photosynthesis.

Phalacroma pyriforme, sp. nov.

Figure 4: 4, 5

Diagnosis: — Body obovate in lateral outline, deepest at girdle; length: depth, 1.13: 1. In dorsal view inverted pyriform, widest at girdle, broadly rounded anteriorly, narrowly rounded posteriorly; hypotheca with concave side contours; length: width, 1.30: 1. Posterior cingular list 0.43 the length of body from apex. Cingular lists somewhat wider than transverse furrow. Left sulcal list relatively large; its length 0.56 the length of body; throughout its anterior half it is of uniform width, 0.25 the depth of body; posteriorly it decreases gradually in width; its free margin gently and evenly convex; structure unknown. Theca finely and closely areolate. Length, 48.2 μ.

Eastern tropical Pacific.

Description: — A small species, with the body obovate in lateral outline, deepest at the girdle. The ratio between the length and the depth is 1.13: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about as deep as the hypotheca, highest in the center, evenly and strongly convex, dome-shaped, and very prominent above the anterior cingular list. The transverse furrow is gently convex, and its width is 0.45 the greatest height of the epitheca. The posterior cingular list is about 0.43 the length of the body from the apex. The hypotheca is symmetrical; its dorsal and ventral margins are evenly and moderately convex and confluent with the posterior margin, which is strongly and evenly convex. The posterior portion of the body is strikingly narrower than the anterior. In dorsoventral view the body is inverted pyriform in outline, widest at the girdle, broadly rounded anteriorly, narrowly rounded posteriorly, and with the lateral contours of the hypotheca moderately concave; the ratio between the length and the width is 1.30: 1.

The cingular lists are subhorizontal, subequal, and somewhat wider than the transverse furrow; their structure is unknown. The right sulcal list is about half as long as the left; its anterior half is subuniform in width, and about half as wide as the transverse furrow; posteriorly it decreases gradually in width. The left sulcal list is relatively large; its length is about 0.56 the length of the body; throughout its anterior half it is of uniform width and about 0.25 the greatest depth of the body; posteriorly it decreases gradually in width; its free margin is gently and evenly convex; in other words, it is not angular posteriorly, as in most species of the genus; its structure is unknown. There are no accessory lists or sails.

The thecal wall is finely and closely areolate, about as in *Phalacroma doryphorum*. Pores have not been seen.

Megacytic stages were not recorded.

The proportions of the type were measured.

Dimensions: — Length of body, 48.2 μ. Greatest depth of body, 42.5 μ.

Comparisons: — *Phalacroma pyriforme* is established on two outline drawings made from a specimen found in the material of the Expedition.

The species appears to occupy a rather isolated position. The symmetry and small size of its body, and the fine and close areolation of its thecal wall are features that affiliate it with the relatively primitive members of the genus, *e.g.*, *Phalacroma parvulum*, *P. operculoides s. str.*, and *P. lens*. In the shape of its body in lateral view and in its relatively high epitheca, it resembles *P. argus*, *P. porodictyum*, *P. ovum*, and some other obovoidal species. The shape of its left sulcal list recalls *P. argus*, *P. apicatum*, and the species of the Cuneus group. The pyriform shape of its body in dorsoventral view is unique but approaches the cuneate shape of the species of the Cuneus and Rapa groups.

Occurrence: — This species is recorded at one of the 127 stations. This station (4713) is on the fourth line of the Expedition and in the Galapagos Eddy. The depth is 300–0 fathoms, the surface temperature 73°, and the frequency less than 1% (one specimen).

4. Cuneus Group. *Phalacroma blackmani* is the only species of this group that is not included in the Expedition collections.

Phalacroma cuneus Schütt

Figure 12, 13

Phalacroma cuneus Schütt, 1895, p. 148, pl. 3, fig. 14; 1896, p. 27, fig. 38B. Ostenfeld, 1898a, p. 428. Murray & Whitting, 1899, p. 330, tab. 4. Lemmermann, 1899a, p. 372; 1901a, p. 372. Schröder, 1900a, p. 19; 1906a, p. 322, 327, 330. Cleve, 1901a, p. 16; 1901c, p. 270; 1902b, p. 35; 1903b, p. 347. Ostenfeld & Schmidt, 1901, p. 175. Zacharias, 1906, p. 534. Kofoid, 1907a, p. 195. Karsten, 1907, p. 325, 353, 355. Pavillard, 1909, p. 283; 1915a, p. 2; 1916, p. 47, 49, 52. Stüwe, 1909, p. 287. Okamura, 1912, p. 18, pl. 5, fig. 76. Jörgensen, 1923, p. 11, fig. 11.

Phalacroma cuncus Stüwe, 1909, p. 252 (*lapsus pennae*).

Phalacroma mitra Oltmanns, 1922, *partim*, fig. 38: 1.

Diagnosis: — Body cuneate in lateral outline; epitheca very broadly rounded; posterior portion of hypotheca fairly broadly to rather narrowly rounded; deepest at posterior cingular list; length: depth, 0.92–1.09: 1; longitudinal axis deflected posteroventrally at 4°–5°. In dorsal view cuneate; posterior portion of hypotheca narrowly rounded to subacute; length: width, 1.22: 1. Posterior cingular list 0.23–0.28 the length of body from apex. Of the cingular lists the anterior is reticulated, the posterior is ribbed. Left sulcal list 0.50–0.67 the length of body; distance from R_1 to R_3 is 0.40–0.47 the length of body; R_2 is 0.09–0.11, and R_3 is 0.07–0.10 the greatest depth of body; widest somewhat in front of R_3; its ventral margin gently convex at R_3, seldom subangular; R_3 inclined posteriorly at 45°–

60°; irregularly and incompletely reticulate. Theca reticulate; twenty-five to thirty-five polygons border girdle posteriorly. Length, 72–88 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is cuneate in lateral outline, with a rather low and very broadly rounded epitheca, with the posterior portion of the hypotheca fairly broadly to rather narrowly rounded, with the greatest depth at the posterior cingular list, and about as deep as long. The ratio between the length and the depth of the body is 0.98 (0.92–1.09): 1. The longitudinal axis is deflected posteroventrally at an angle of 4°–5°.

The epitheca is about as deep as the hypotheca, very broadly and almost evenly convex, highest in or near the center, and moderately elevated above the anterior cingular list. The transverse furrow is flat to somewhat concave, and its width is 0.35–0.50 the greatest height of the epitheca. The posterior cingular list is 0.23–0.28 the length of the body from the apex. The hypotheca tapers posteriorly and is somewhat deflected posteroventrally (see above); its dorsal margin is almost straight or slightly convex to concave; its ventral margin is nearly straight or gently convex; its postmargin is evenly, and fairly broadly to rather narrowly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of the hypotheca narrowly rounded to subacute; the side contours of the hypotheca are almost straight or slightly concave; the ratio between the length and the width is about 1.22: 1.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow. Along the base of the anterior cingular list, there is a series of ribs anastomosing into a row of polygons, which have about the same size and shape as the polygons in the transverse furrow; sometimes a more or less complete row of similar polygons is developed outside the basal row. The posterior cingular list has a great number of straight and simple ribs (Schütt, 1895, pl. 3, fig. 14: 2). The sulcus is about half as long as the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. The right sulcal list is long and rather narrow; usually it ends at a point about half way between the fission rib and the posterior main rib of the left sulcal list, but sometimes it extends to the last-mentioned rib; anteriorly it is about as wide as or somewhat narrower than the transverse furrow, and posteriorly it tapers gradually. The left sulcal list is of moderate size. Its length is 0.50–0.67 the length of the body, and the distance between the anterior and posterior main ribs is 0.40–0.47 the length of the body. The anterior main rib, when present, is about 0.07–0.09, the fission rib 0.09–0.11, and the posterior main rib 0.07–0.10 the greatest depth of the body. The greatest width of this list, which in most specimens is located somewhat in front of the posterior main rib, is about 0.12–0.20 the greatest depth of the body. In most specimens the free margin of this list is either gently sigmoid, concave anteriorly and convex posteriorly, or it is evenly to somewhat irregularly convex throughout; in other words, it is gently convex at the posterior main rib, and not angular as in most species of the genus. In exceptional cases (Figure 12: 2) this margin is slightly convex between the anterior and posterior main ribs, and subangular at and gently concave behind the posterior main rib. Posteriorly this list either tapers more or less suddenly, or it is more or less decurrent (Figure 12: 2). The main ribs of this list are straight and rather weak; none of them is club-shaped, but the posterior sometimes is rather wide. The distance between the anterior main rib and the fission rib is 0.28–0.35 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 45°–60°. Besides the main ribs, the left sulcal list has an irregular and incomplete reticulation. At least in some specimens (Jörgensen, 1923, fig. 11), there is a very narrow parasagittal list extending on the hypotheca from the left sulcal list to the posterior cingular list.

The thecal wall has a reticulum of medium-sized polygons, and each polygon has a small pore in the center. The polygons usually are about equal in size, and on each valve from twenty-five to thirty-five of them border the posterior margin of the girdle. In most specimens there are two rows of polygons in the transverse furrow, each row with twenty-five to thirty polygons on each valve; in other cases the two rows, partly or wholly, merge into a single row. Some of the polygons may be subdivided (Jörgensen, 1923, p. 12). From a point near the middle of the right sulcal list a spine-like process projects into the cytoplasm.

Megacytic stages of this species have been seen by Pavillard (1916) and are contained in the ALBATROSS collection.

The dimensions of three specimens were measured.

Dimensions: — Expedition specimens: Length of body, 80–87 μ (average, 84 μ). Greatest depth of body, 77–95 μ (average, 86 μ). The largest of the specimens represented by Schütt (1895, pl. 3, fig. 14: 1) is about 88 μ long. The type specimen (Schütt, 1895, pl. 3, fig. 14: 3) is somewhat smaller, but its length cannot be determined, since it is figured in a tilted position. According to Jörgensen (1923, p. 11), the length is 72–88 μ.

Variations: — This species appears to be rather remarkably constant in shape and in structure. A fairly large number of specimens from Station 4664 were submitted to a careful examination; most of these agreed very closely with the specimen represented by Figure 12: 1. The size and the shape of the body and of the sulcal lists are the most variable characters. The body sometimes is longer than deep, and sometimes deeper than long; sometimes (Figure 12: 1) the posterior portion of the hypotheca is rather broad, sometimes (Figure 12: 2) it is rather narrow; the dorsal margin of the hypotheca may be straight, or gently convex to concave. Posteriorly the left sulcal list either tapers more or less suddenly (Figure 12: 1), or it is more or less decurrent (Figure 12: 2); its free margin

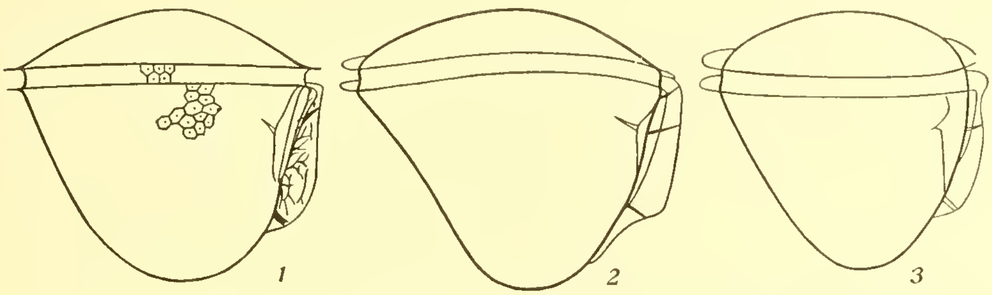

FIGURE 12.— *Phalacroma cuneus* Schütt, right lateral view. Structure of thecal wall and of left sulcal list indicated only in 1; 3 is somewhat tilted. × 430. 1, 3, from Station 4664 (300–0 fathoms); 2, from Station 4737 (300–0 fathoms).

usually is gently concave anteriorly and convex posteriorly, but it may be *vice versa*. The variations probably are partly apparent, and due to the tilting of some of the specimens examined.

Comparisons: — Schütt (1895) does not give any diagnosis or description of *Phalacroma cuneus*, and the specimens figured in lateral view by him are drawn in tilted positions. In spite of these discrepancies, the characteristics represented probably are sufficient for certainty of specific assignment. The Expedition specimens agree quite closely with those figured by Schütt (1895, pl. 3, fig. 14: 1–8).

Phalacroma cuneus is very closely related in structure to *P. blackmani*, *P. striatum*, and *P. giganteum*. They all agree in the following respects: — their epitheca is rather low and very broadly rounded; their hypotheca is more or less cuneate in lateral as well as in dorsoventral view; in lateral view the posterior portion of the hypotheca is fairly broadly to rather narrowly rounded, in dorsoventral view it is narrowly rounded or even acute. The free margin of their left sulcal list is gently convex at the posterior main rib, and not angular as in most species of this genus.

Without giving any reasons, Jörgensen (1923, p. 11) places *Phalacroma blackmani* as a synonym of *P. cuneus*. Is this justifiable? According to the only drawing of this species available, *viz.*, that of the type specimen (Murray and Whitting, 1899, pl. 31, fig. 4), *P. blackmani* is about 125 μ long, has a parasagittal list which extends on the hypotheca from the left sulcal list to the posterior cingular list and is locally wider on the posterior portion of the hypotheca, and its left sulcal list lacks reticulation and has the main ribs concave anteriorly. *P. cuneus* has a maximum length of 88 μ, and its left sulcal list has an incomplete and irregular reticulation and straight main ribs. At least in some specimens (Jörgensen, 1923, fig. 11), *P. cuneus* has, just as *P. blackmani*, a parasagittal list extending on the hypotheca from the left sulcal list to the posterior cingular list, but this parasagittal list is very narrow throughout its whole length. Schröder (1906a, p. 330), Karsten (1907, p. 262, 473), and Stüwe (1909, p. 238), who have recorded *P. blackmani*, found also *P. cuneus* in the material examined by them. In short, according to the available descriptions and figures differences do exist between *P. cuneus* and *P. blackmani* which appear to be of specific nature, and some investigators have separated the two forms. Until further data are available, these two forms should be considered specifically distinct.

Phalacroma cuneus differs from *P. striatum* in its smaller size (72–88 μ, as compared with 102–136 μ) and its less developed left sulcal list. From *P. giganteum* it is easily distinguished by its smaller size (72–88 μ, as compared with 148 μ). For further discussion about the relationships of these species, see p. 133.

Synonymy: — The presence of a parasagittal list in the specimens determined as *P. cuneus* by Jörgensen (1923) calls for a reëxamination of this species to determine the prevalence of this structure which was not observed by Schütt (1895) or by us.

Occurrence: — *Phalacroma cuneus* is recorded at sixty-three of the 127 stations. There are 9, 19, 7, 10, 11, and 7 stations on the six lines of the Expedition. Of these sixty-three stations, one (4583) is in the California Current; six (4587, 4590, 4594, 4598, 4605, 4545) in the Mexican Current; six (4609, 4613, 4617, 4634, 4637, 4638) in the Panamic Area; eighteen (4647, 4650, 4655, 4657, 4660, 4661, 4662, 4663, 4664, 4665, 4666, 4667, 4668, 4669, 4670, 4671, 4675, 4676) in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) in the Easter Island Eddy; one (4713) in the Galapagos Eddy; twenty-one (4679, 4681, 4683, 4701, 4705, 4706, 4707, 4709, 4711, 4719, 4724, 4728, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4739, 4740) in the South Equatorial Drift; three (4742, 4743, 4540) in the South Equatorial Current; two (4541, 4542) in the Equatorial Counter Current. There are thirteen records from the surface (Stations 4657, 4660 [Salpa], 4664, 4669, 4675, 4706 [Salpa], 4731, 4733, 4743, 4540, 4541, 4542, 4545); at ten of these stations the species was taken in surface hauls only; at three stations (4657, 4664, 4675) in hauls from 300–0 fathoms as well as at the surface. At one station (4737) the species is recorded from 100–0 fathoms and 300–0 fathoms; at one station (4713) from 150–0 fathoms and 300–0 fathoms; at three stations (4681, 4724, 4732) from 800–0 fathoms and 300–0 fathoms; at four stations (4647, 4662, 4666, 4670) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only. The species was taken also in surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these sixty-three stations at the surface was 65°–85°; the average was 74.7°. At the thirteen stations in the surface catches of which the species was found, the surface temperature ranged from 67° to 80°; the average was 74.5°. At Acapulco it was 83°.

For the surface catches the following frequencies are recorded: — 4% at one station (4669); 3% at two stations (4542, 4545); 2% at one station (4675); 1% at two stations (4657, 4664); in the remaining cases the frequency was less than 1%. For the catches from 100, 150, 300, or 800 fathoms to the surface the records of frequency are as follows: — 40% at one station (4664); 10% at one station (4663); 6% at two stations (4613, 4666); 4% at one station (4662); 3% at two stations (4671, 4742); 2% at five stations (4609, 4634, 4689, 4713, 4740); 1% at twelve stations (4590, 4594, 4598, 4638, 4650, 4657, 4665, 4667, 4681, 4701, 4732, 4739); at the remaining stations the frequency is less than 1%. For the catch made in Acapulco Harbor the frequency of 1% is recorded.

Schütt (1895) does not give any information as to the type locality of *Phalacroma cuneus;* however, it is probably either Naples or in the Atlantic Ocean. Later investigators have shown this species to be widely distributed. The following authors have found it in the Atlantic, between lat. 40° N. and lat. 28° S.: — Ostenfeld (1898), Murray and Whitting (1899), Cleve (1901c, 1902b, 1903b), Stüwe (1909), and Jörgensen (1923). Cleve (1901c) recorded it from the Caribbean Sea. Jörgensen (1923) found it at a fairly great number of stations throughout the Mediterranean. It is also recorded from the Gulf of Lyons, Pavillard (1909, 1916). Naples, Schröder (1900a); Zacharias (1906). Ionian Sea, Schröder (1906a). Arabian Sea, Schröder (1906a); Cleve (1901a, 1903b); Ostenfeld and Schmidt (1901). Indian Ocean, Schröder (1906a); Cleve (1901a); Karsten (1907). Japan, Okamura (1912).

According to the authors noted, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations	Salinity	Range	Number and Mean of Observations
Murray and Whitting (1899)	79°					
Cleve (1901c)		56.8°–81.5°	28 73°		35.63–37.43	22 36.49
Cleve (1902b)			6 69.6°			6 36.24
Cleve (1903b)		60.3°–82.0°	6 75.7°		36.13–36.49	6 36.40
Stüwe (1909)	80.2°					

Only Schütt (1895), Okamura (1912), and Jörgensen (1923) give figures or descriptions by means of which their determinations of this form may be judged.

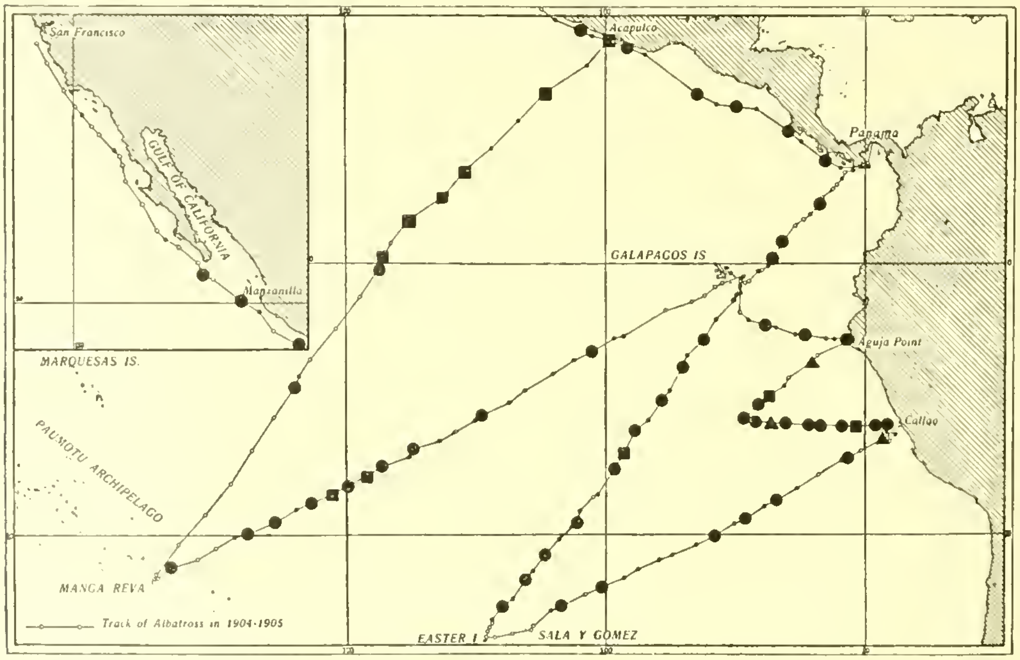

FIGURE 13.—Occurrence of *Phalacroma cuneus* Schütt. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

Phalacroma cuneus is eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. While previous writers have found it to be rare, it is one of the most abundant of the species of the genus found by the Expedition. In the Eastern Pacific it occurs throughout the whole area investigated. According to the records, there is a center of abundance in the relatively cool Peruvian Current. Out of the twenty-eight stations with frequencies of 1% or more, not less than eleven are in that Current; and all the stations with frequencies of 4% or more are located there. The frequent occurrence of *P. cuneus* in the coolest (65°–72°) of the regions investigated is the more noteworthy, since the species has not been found as yet outside of tropical, subtropical, and warm-temperate waters. The relatively frequent occurrence of this species in our surface catches is another outstanding feature. Of the species of Phalacroma only *P. doryphorum* (twenty-six surface records) and *P. rapa* (twenty-two surface records) were found more frequently than *P. cuneus* (thirteen surface records) in the surface catches of the Expedition. Of *P. favus*, which next to *P. cuneus* was the most frequent species of this genus in the surface catches, there are only six surface records.

Phalacroma striatum Kofoid

Plate 2, fig. 5, 8. Figure 14:3; 15

Phalacroma striata Kofoid, 1907a, p. 195, pl. 12, fig. 73. Kofoid & Michener, 1911, p. 289.
Phalacroma striatum Jörgensen, 1923, p. 12, 43, fig. 12.

Diagnosis: — Body cuneate in lateral view, with very broadly rounded epitheca, and with posterior portion of hypotheca fairly broadly rounded; deepest at posterior cingular list; length: depth, 1.00–1.04:1; longitudinal axis deflected posteroventrally at 6°–9°. In dorsal view cuneate; posterior portion of hypotheca narrowly rounded to acute; length: width, 1.34–1.54:1. Posterior cingular list 0.20–0.24 the length of body from apex. Cingular lists with numerous simple or branched ribs, or reticulate. Left sulcal list extends to or almost to antapex; distance from R_1 to R_3 is 0.57–0.63 the length of body; R_2 is 0.13–0.18, and R_3 is 0.06–0.16 the greatest depth of body; widest somewhat in front of R_3; margin gently sigmoid, gently convex at R_3; R_3 inclined posteriorly at about 90°; irregularly and incompletely reticulate. Theca reticulate; 25–35 polygons border girdle posteriorly. Length, 102–136 μ.

Eastern tropical Pacific, Mediterranean, Guinea Current.

Description: — This is a comparatively large species, the body of which is cuneate in lateral view, with a rather low and very broadly rounded epitheca, with the posterior portion of the hypotheca fairly broadly rounded, with the greatest depth at the posterior cingular list, and about as deep as long. The ratio between the length and the depth of the body is 1.02 (1.00–1.04):1. The longitudinal axis is deflected posteroventrally at an angle of 6°–9°.

The epitheca is about as deep as the hypotheca, very broadly and usually almost evenly convex, highest at or somewhat dorsally to the center, and moderately elevated above the anterior cingular list. The transverse furrow is somewhat concave, and its width is 0.35–0.50 the greatest height of the epitheca. The posterior cingular list is 0.22 (0.20–0.24) the length of the body from the apex.

The hypotheca tapers posteriorly and is somewhat deflected posteroventrally (see p. 131); its dorsal margin is almost straight, slightly convex or concave, or slightly sigmoid, concave anteriorly and convex posteriorly; its ventral margin is almost straight, gently concave or convex, or slightly irregular (Figure 14: 3); its postmargin is evenly and fairly broadly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of the hypotheca narrowly rounded to acute; the side contours of the hypotheca are gently concave in the middle, or gently sigmoid, concave anteriorly and convex posteriorly; the ratio between the length and the width is 1.34–1.54: 1.

The cingular lists are subhorizontal and subequal; their width about equals or in some specimens slightly exceeds the width of the transverse furrow; each of these lists has, on each valve, about 35–45 straight or more or less irregular ribs, which often anastomose and form a more or less regular reticulum (Jörgensen, 1923, p. 12, fig. 12). The sulcus is about 0.45–0.55 the length of the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve two or three rather small pores are found on the sagittal suture, just in front of the anterior cingular list (Plate 2, fig. 5). The right sulcal list extends to or somewhat beyond the point midway between the fission rib and the posterior main rib of the left sulcal list; in some specimens its ventral margin, even in the widest region, does not quite extend to the ventral margin of the left sulcal list, but in others it does. The anterior half to two thirds of the free margin of this list is fairly deeply concave and is, at least in some specimens (Plate 2, fig. 8), strengthened by a marginal rib; the posterior portion of this margin, which forms a distinct angle with the anterior portion, is more or less convex, or sometimes almost straight. The greatest height of this list is located just behind the concavity. Along the base of this list a reticulum of about the same type as that of the thecal wall may be developed. The left sulcal list is unusually large. In most specimens it extends to or almost to the antapex, and the distance between the anterior and posterior main ribs is 0.57–0.63 the length of the body. The anterior main rib, when present, is about 0.08–0.10, the fission rib is 0.13–0.18, and the posterior main rib is 0.06–0.16 the greatest depth of the body. The greatest width of this list, which is located somewhere between the fission rib and the posterior main rib, is about 0.20–0.22 the greatest depth of the body. Anteriorly the free margin of this list is gently sigmoid, concave, or almost straight; posteriorly it is convex; in other words, this margin is gently convex at the posterior main rib, and not angular as in most species of the genus. The main ribs of this list are rather weak and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35–0.45 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 90°. Besides the main ribs, the left sulcal list has a "more or less distinct structure of incomplete areoles, which often present the impression of irregular radial striation" (Jörgensen, 1923, p. 12). There are no accessory lists or sails.

The thecal wall has a reticulum of medium-sized polygons, and each polygon has a small pore in the center; the reticulation often is "faint and thin-walled" (Jörgensen, 1923, p. 12). The polygons usually are about equal in size, and on each valve about 25–35 of them border the posterior margin of the girdle. In most specimens there are two rows of polygons in the transverse furrow, each row with 25–30 polygons on each valve. From a point near the middle of the right sulcal list a spine-like process projects into the cytoplasm.

Megacytic stages have not been recorded.

The proportions of three Expedition specimens were measured.

Dimensions: — Expedition specimens: Length of body, 108–115 μ (average, 111 μ; type, 108 μ). Greatest depth of body, 105–114 μ (average, 109 μ; type, 109 μ). Jörgensen (1923, p. 12): "Length of cell (height) almost equal to breadth in dorso-ventral direction, or somewhat greater; the latter 102–136 μ."

Variations: — Apart from variations in size, this species appears to be unusually constant.

Comparisons: — The description and figures of this species are based on the type material.

Phalacroma striatum is structurally very close to *P. cuneus*, *P. blackmani*, and *P. giganteum* (see *P. cuneus*, p. 127). It differs from *P. cuneus* in the larger size of its body (102–136 μ, as compared with 80–88 μ), and in its larger left sulcal list. From *P. blackmani* it is easily distinguished by its lack of parasagittal lists, and by the large size and the structure of its left sulcal list. From *P. giganteum* it differs in the smaller size of its body (102–136 μ, as compared with 148 μ), and in the large size and the structure of its left sulcal list.

The four species mentioned in the last paragraph form a natural systematic group, the Cuneus group. The closest relative of *Phalacroma striatum*, outside of this group, presumably is *P. argus*. With regard to the characters in which the last two species resemble each other, see *P. argus* (p. 107). *Phalacroma striatum* is easily distinguished from *P. argus* by its low and broadly rounded epitheca, its cuneate hypotheca, and its exceptionally large left sulcal list. The most striking feature of this relationship is that *P. argus* appears to be more closely related to *P. striatum* than to *P. cuneus*, although the latter species is smaller and has a smaller and less differentiated left sulcal list (compare, for instance, the directions of the posterior main ribs) and a simpler right sulcal list than *P. striatum*. The CUNEUS group probably evolved from an ancestral form of about the same habitus as *P. argus*.

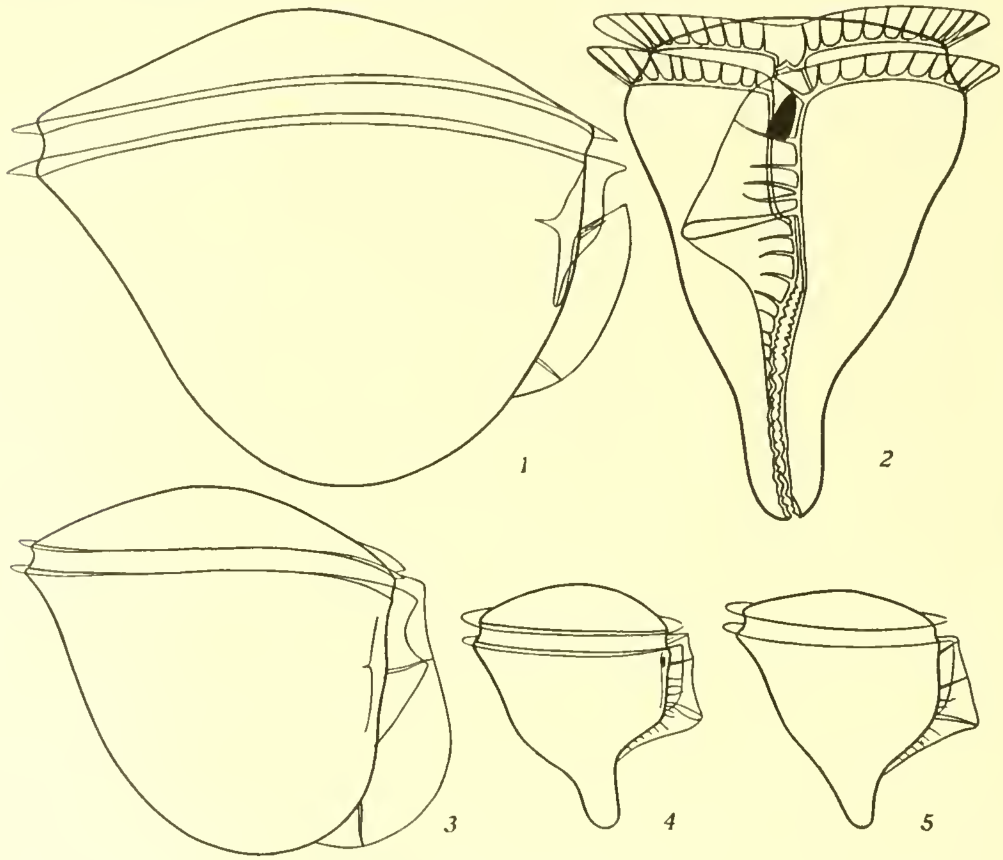

FIGURE 14.— 1, *Phalacroma giganteum* Kofoid and Michener, right lateral view of right valve of type specimen. × 430. Station 4734 (300–0 fathoms). 3, *Phalacroma striatum* Kofoid, right lateral view. × 430. Station 4719 (300–0 fathoms). 2, 4, 5, *Phalacroma favus* Kofoid and Michener. 2, ventral view of type specimen; somewhat tilted. × 900. Station 4737 (300–0 fathoms). 4, 5, right lateral view; 4, from type specimen. × 430. Station 4737 (300–0 fathoms).

Occurrence: — *Phalacroma striatum* is recorded at twenty of the 127 stations. There are 0, 3, 3, 6, 6, and 2 stations on the six lines of the Expedition. Of these twenty stations, three (4634, 4637, 4638) are in the Panamic Area; one (4699) is in the Easter Island Eddy; two (4713, 4715) in the Galapagos Eddy; thirteen (4679, 4681, 4685, 4701, 4705, 4707, 4717, 4719, 4721, 4722, 4724, 4732, 4740) in the South Equatorial Drift; and one (4742) in the South Equatorial

Current. At two stations (4717, 4732) the species is recorded from 300–0 fathoms and 800–0 fathoms; at two stations (4701, 4721) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only. In other words, the species has not been found as yet at the surface.

The temperature range of these twenty stations at the surface was 68°–81°; the average was 74.7°.

The frequency is less than 1% except at two stations (4732, 4742), where it is 1%.

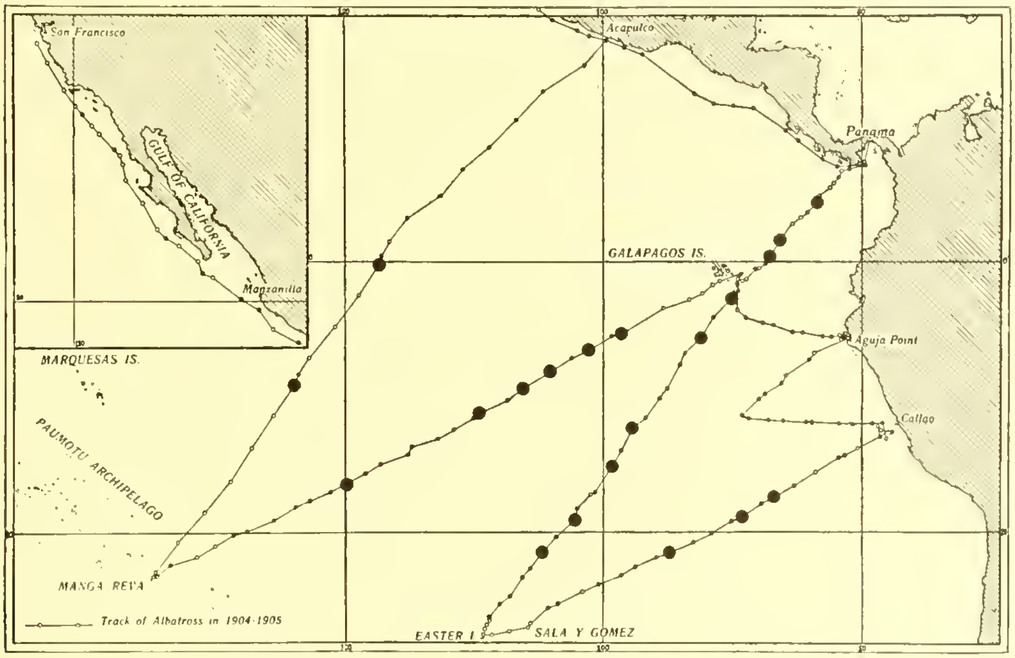

FIGURE 15.— Occurrence of *Phalacroma striatum* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

This species was first recorded by Kofoid (1907a) from Stations 4638 and 4719. Of these stations, 4638 is the type locality. Jörgensen (1923, p. 12), who found this species at two stations in the Mediterranean, the THOR Expedition, and in catches from the Guinea Current, German South Pole Expedition, 1903, writes as follows about its occurrence in the Mediterranean: "Undoubtedly one of the tropical species which come in at times from the Atlantic through the Straits of Gibraltar, and are as a rule only found later on in deeper water in the inner parts of the Mediterranean, where they seem to be able to exist for a more or less considerable time."

Phalacroma striatum is eupelagic and probably widely distributed in tropical, subtropical, and warm-temperate seas. The most outstanding peculiarities of its distribution in the Eastern Pacific, according to our data, are its absence from surface waters, and its absence from the Californian, Mexican, and Peruvian Currents. The lack of surface records is noteworthy, since the species appears to be highly adapted to flotation. Compare, for instance, the size of the sulcal lists in this species and in the closely related *P. cuneus*, which has been found repeatedly in surface hauls.

Phalacroma giganteum Kofoid and Michener

Plate 2, fig. 2, 4; Plate 3, fig. 2. Figure 14: 1

Phalacroma gigantea Kofoid & Michener, 1911, p. 289.

Diagnosis: — Body cuneate in lateral outline, with very broadly rounded epitheca, and with posterior portion of hypotheca fairly broadly rounded; deepest at anterior cingular list; length : depth, 0.86 : 1; longitudinal axis deflected posteroventrally at 3°–4°. In dorsal view cuneate; posterior portion of hypotheca narrowly rounded to subacute; length and width subequal. Posterior cingular list about 0.25 the length of body from apex. Left sulcal list about 0.50 the length of body; distance from R_1 to R_3 is about 0.42 the length of body; R_2 is 0.09–0.10, and R_3 is 0.06–0.07 the greatest depth of body; widest about midway between R_2 and R_3; margin gently sigmoid, gently convex at R_3; R_3 inclined posteriorly at about 50°. With narrow parasagittal list on hypotheca. Theca faintly reticulate, with about thirty-five polygons bordering girdle posteriorly, or without reticulation. Length, 148 μ.

Eastern tropical Pacific.

Description: — This is an unusually large species, the body of which is cuneate in lateral outline, with a rather low and very broadly rounded epitheca, with the posterior portion of the hypotheca fairly broadly rounded, with the greatest depth at the anterior cingular list, and somewhat deeper than long. The ratio between the length and the depth of the body is 0.86 : 1. The longitudinal axis is deflected posteroventrally at an angle of 3°–4°.

The epitheca is about as deep as the hypotheca, very broadly and almost evenly convex or with more or less flattened dorsal and ventral margins, highest at or somewhat dorsally to the center, and moderately elevated above the anterior cingular list. The transverse furrow is somewhat concave, and its width is about 0.50 the greatest height of the epitheca. The posterior cingular list is about 0.25 the length of the body from the apex. The hypotheca tapers posteriorly and is slightly deflected posteroventrally (see above); its dorsal margin is almost straight, or slightly convex or concave, or slightly sigmoid, concave anteriorly and convex posteriorly; its ventral margin is moderately convex; its postmargin is evenly and fairly broadly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of the hypotheca narrowly rounded to subacute; the side contours of the hypotheca are gently concave in the middle or nearly straight; the length and the width are subequal.

The cingular lists are subhorizontal and subequal; their width about equals, or in some specimens slightly exceeds, the width of the transverse furrow. Each of these lists has, on each valve, about 65–75 more or less straight, simple (always?) ribs. However, judging by one of our drawings, in one of the specimens these lists lacked ribs; this specimen was megacytic, and its thecal wall was faintly reticulated. The sulcus is about 0.40–0.45 the length of the hypotheca. The flagellar pore is somewhat less than a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve two pores of moderate size are found on the sagittal suture, just in front of the anterior cingular list. The right sulcal list extends to or somewhat beyond the point midway between the fission rib and the posterior main rib of the left sulcal list; anteriorly, where it is widest, it is about as wide as or somewhat narrower than the transverse furrow; posteriorly it tapers gradually; its free margin is concave anteriorly and posteriorly and convex in the middle. The left sulcal list is of moderate size. Its length is about 0.50 the length of the body, and the distance between the anterior and posterior main ribs is about 0.42 the length of the body. The anterior main rib, when present, is about 0.07–0.08, the fission rib 0.09–0.10, and the posterior main rib 0.06–0.07 the greatest depth of the body. The greatest width of this list, which is located about midway between the fission rib and the posterior main rib, is about 0.09 the greatest depth of the body. The free margin of this list is either gently and almost evenly convex, or it is gently sigmoid, concave anteriorly and convex posteriorly; in other words, it is gently convex at the posterior main rib, and not angular as in most species of the genus. The main ribs of this list are straight and rather weak, and not club-shaped or otherwise modified. The distance between the anterior main and the fission rib is about 0.35–0.40 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 50°. Except the main ribs, no structure was observed in this list. A parasagittal list, which forms a direct continuation of the left sulcal list, extends on the right valve of the hypotheca from the left sulcal list to the posterior cingular list. The width of this parasagittal list is about one third of that of the transverse furrow, and the list either has fine riblets or is without structure. In Plate 2, fig. 2, which was drawn from a detached valve, there is no parasagittal list.

The theca is fragile. Its surface either is smooth, with numerous small, regularly spaced pores, or it has a faint reticulation of medium-sized polygons, each with a small pore in its center. In the specimens with the thecal wall reticulated, there are two rows of polygons in the transverse furrow; each of these rows has on each valve about thirty-five polygons. The polygons of the epitheca and of the hypotheca are of about the same size as those in the transverse furrow. From a point near the middle of the right sulcal list a spine-like process projects into the cytoplasm.

Megacytic stages of this species occur (Plate 3, fig. 2).

The dimensions of two of the specimens were measured.

Dimensions: — Length of body, 148 μ. Greatest depth of body, 173 μ.

Comparisons: — The description and drawings of this species are based on the type material.

Phalacroma giganteum is structurally very close to *P. cuneus*, *P. blackmani*, and *P. striatum* (see p. 127, section on comparisons). It is easily distinguished from these species by its large size. Indeed, as its name suggests, it is the largest-known species of this genus.

While the relatively small *Phalacroma cuneus* has a rather heavy theca, the large *P. giganteum* is characterized by its thin and apparently very fragile theca. The reduced thickness of the thecal wall in the latter species may be interpreted as an adaptation to flotation, counterbalancing the reduction in the relative surface of resistance caused by the increase in the size of the body.

Occurrence: — *Phalacroma giganteum* is recorded at five of the 127 stations. There are 0, 0, 0, 2, 2, and 1 stations on the six lines of the Expedition. Of these five stations, two (4695, 4699) are in the Easter Island Eddy; two (4730, 4734) in the South Equatorial Drift; one (4742) in the South Equatorial Current. All records refer to catches from 300–0 fathoms only.

The temperature range of these five stations at the surface was 74°–81°; the average was 77.2°.

The frequency is less than 1% except at one station (4699), where it is 1%.

Phalacroma giganteum is eupelagic and of rare occurrence in tropical waters. Its occurrence in the Eastern Pacific resembles that of *P. striatum*. It is absent from surface waters and has not been found in the California Current, Mexican Current, Panamic Area, and Peruvian Current.

5. Rapa Group. None of the four more or less primitive members of this group was taken by the Expedition. Only the top members, viz., *Phalacroma rapa*, *P. favus*, and *P. hindmarchi*, were recorded.

Phalacroma rapa Stein

Figure 16, 17

Phalacroma rapa Stein, 1883, p. 23, pl. 19, fig. 5–8. Bütschli, 1885, pl. 55, fig. 2. Whitelegge, 1891, p. 184. Hensen, 1895, p. 190; 1911, p. 166, 167. Lemmermann, 1899a, p. 372; 1901a, p. 373; 1905a, p. 35. Schröder, 1900a, p. 19. Cleve, 1901a, *partim*, p. 17; 1901c, p. 273; 1902b, p. 37; 1903b, p. 348. Ostenfeld & Schmidt, 1901, p. 176. Entz, 1902b, p. 94; 1905, p. 111. Chun, 1903, p. 75, fig. d. Karsten, 1906, p. 188; 1907, p. 238, 249, 299, 348. Zacharias, 1906, p. 509, 526, 536. Stüwe, 1909, p. 238, 252, 288. Nathansohn, 1910b, p. 61, fig. 29: 5–8. Pavillard, 1916 (*non* 1915a, p. 2, fig. A), p. 47, 48, 49, 55, fig. 13A; 1923a, p. 879. Forti, 1922, p. 107, 190, 208, fig. 113. Jörgensen, 1923 (*non* 1915a, p. 2, fig. A), p. 14, 15, 16, 41, fig. 14.
Phalacroma mitra Okamura, 1907 (*non* 1912), p. 134, pl. 5, fig. 45.

Diagnosis: — Body subcuneate in lateral view; epitheca moderately convex to almost flat; posterior portion of hypotheca narrowly rounded to subacute, but not mammilliform; ventral margin of hypotheca strikingly angular at R_3 of left sulcal list; deepest at or somewhat behind girdle; length: depth, 1.00–1.34: 1; longitudinal axis deflected posteroventrally at 0°–5°. In dorsal view cuneate; hypotheca very narrowly rounded to subacute posteriorly, and its side contours gently concave or gently undulating. Posterior cingular list 0.10–0.25 the length of body from apex. Left sulcal list 0.36–0.55 the length of body; distance from R_1 to R_3 is 0.26–0.44 the length of body; R_2 is 0.09–0.14, and R_3 is 0.13–0.20 the greatest depth of body; margin forms angle of 75°–100° at R_3; R_3 inclined posteriorly at 0°–25°; sometimes with faint reticulation. Theca reticulate; 20–25 polygons border girdle posteriorly. Length, 70–95 μ.

Widely distributed in tropical to temperate seas.

Description: — A medium-sized species, the body of which is subcuneate in lateral view, with moderately convex to almost flat epitheca, with the posterior portion of the hypotheca narrowly rounded to subacute, but not mammilliform, with the ventral margin of the hypotheca strikingly angular at the posterior main rib of the left sulcal list, and with the greatest depth at or somewhat behind the girdle. The ratio between the length and the depth of the body is 1.19 (1.00–1.34): 1. The longitudinal axis is deflected posteroventrally at an angle of 0°–5°.

The epitheca is about as deep as the hypotheca or slightly less, moderately and evenly convex to almost flat, highest in or near the center, and moderately to but slightly elevated above the anterior cingular list. The transverse furrow usually is somewhat concave, but sometimes flat or even slightly convex, and its width is 0.4–1.0 the greatest height of the epitheca. The posterior cingular list is

0.18 (0.10–0.25) the length of the body from the apex. The hypotheca is often slightly deflected posteroventrally (see p. 139). The dorsal margin (from the girdle to the antapex) is somewhat variable in shape; in most of the specimens it is evenly and moderately convex; in other specimens (see Stein, 1883, pl. 19, fig. 5, and Figure 16: 3) it forms a more or less pronounced, broadly rounded corner somewhat behind the middle, and in front of and behind this corner it is almost straight or even slightly concave. The portion of the ventral margin that is in front of the posterior main rib of the left sulcal list is almost straight or somewhat concave or convex; it either is about perpendicular to the girdle, or it is inclined posteroventrally at 4°–30°. The portion of this margin that is behind the posterior main rib of the left sulcal list is 1.0–2.5 the length of the anterior portion, gently to moderately concave, and forms with the anterior portion a very pronounced, although rounded, corner. The posterior portion of the hypotheca is narrowly rounded to subacute but not mammilliform. In dorsal view the body is cuneate, with very broadly rounded to flat epitheca, with the hypotheca very narrowly rounded to subacute posteriorly, and with the side contours of the hypotheca evenly and gently concave, or gently undulating, *i.e.*, slightly concave just in front of and behind the middle; the ratio between the length and the width is about 1.5: 1.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; each of them has, on each valve, about 20–30 rather strong, straight, simple, and nearly equidistant ribs. The sulcus is about 0.30–0.40 the length of the hypotheca. The right sulcal list varies in length; sometimes it ends at the fission rib of the left sulcal list, and sometimes it extends to or even slightly beyond the posterior main rib of the last-mentioned list; in most specimens it is subtriangular, decreasing gradually in width posteriorly; in others it is of subequal width throughout the greater portion of its length; anteriorly it is about as wide as or somewhat narrower than the transverse furrow. The left sulcal list is of moderate size to rather small. Its length is 0.36–0.55 the length of the body, and the distance between the anterior and posterior main ribs is 0.26–0.44 the length of the body. It extends to or somewhat beyond the ventral angular process of the body (Figure 16: 1, 2). The anterior main rib, when present, is about 0.07–0.14, the fission rib 0.09–0.14, and the posterior main rib 0.13–0.20 the greatest depth of the body. Behind the posterior main rib this list either decreases suddenly in width, or it is somewhat decurrent (Figure 16: 1, 2). Between the anterior and posterior main ribs, the free margin of this list is almost straight, gently concave or convex, or slightly irregular; at the posterior main rib it forms an angle of 75°–100°; behind the last-mentioned rib it usually is straight, but sometimes gently convex or concave. The main ribs of this list are of moderate strength, and generally straight or almost so; in exceptional cases (Figure 16: 2) the posterior one of them is slightly club-shaped. The distance between the anterior main rib and the fission rib is 0.25–0.53 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 0°–25°. In a few specimens (Figure 16: 3) this list has one or a few short ribs besides the three main ribs, and sometimes it is characterized by a faint reticulation (Jörgensen, 1923, p. 14). There are no accessory lists or sails in the specimens examined by us. The specimen figured by Jörgensen (1923, fig. 14) appears to have had a very short and narrow parasagittal list on the antapex.

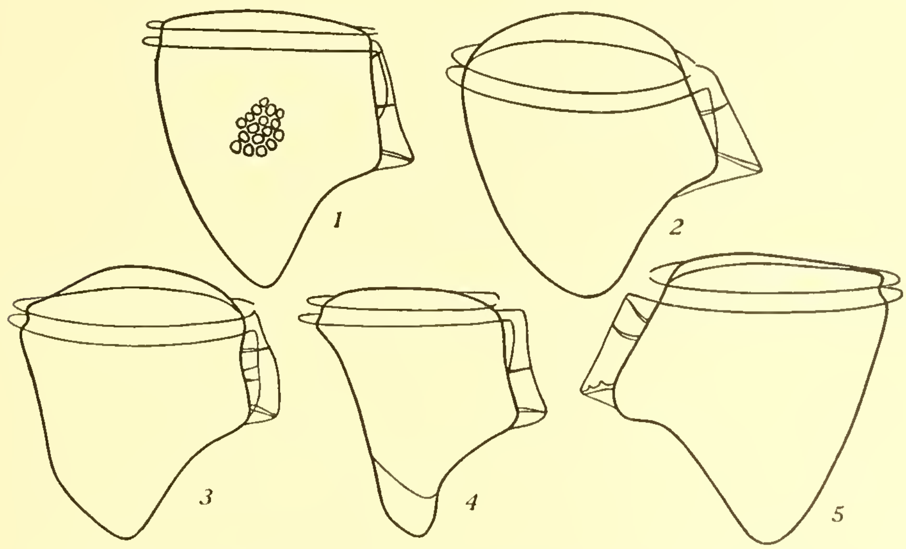

FIGURE 16.— *Phalacroma rapa* Stein. 1–4, right lateral view; 5, left lateral view. Structure of thecal wall indicated only in 1. 2, 3, 5, somewhat tilted. 4, specimen in which posterior portion of right valve is much shorter than that of left valve. × 430. 1, from Station 4709 (300–0 fathoms); 2, from Station 4605 (300–0 fathoms); 3, from Station 4681 (300–0 fathoms); 4, from Station 4681 (800–0 fathoms); 5, from Station 4695 (300–0 fathoms).

The thecal wall has a reticulum of medium-sized, subequal polygons, each with a small central pore. There are twenty to twenty-five of them bordering the posterior margin of the girdle on each valve, and two rows of polygons in the transverse furrow, each row with twenty to twenty-five polygons on each valve.

Megacytic stages of this species were seen by Stein (1883) and by Pavillard (1916).

The proportions of four of the Expedition specimens, and of the specimens represented by Stein (1883), Okamura (1907), and Pavillard (1916) were measured.

Dimensions: — Length of body, 77–87 μ (average, 81.6 μ). Greatest depth of body, 58–70 μ (average, 67.4 μ). The right valve of the specimen represented by Figure 16: 4 is 65.5 μ long. We do not know the size of the type specimen (Stein, 1883, pl. 19, fig. 5); according to his statement (1883, p. 31), however, this specimen was somewhere between 95–145 μ long and 70–108 μ deep. The specimen figured by Okamura (1907, pl. 5, fig. 43) was 70 μ long and 70 μ deep; the one figured by Pavillard (1916, fig. 13A), 80 μ long and 64 μ deep. The specimens measured by Jörgensen (1923) were 72–85 μ long and 60–64 μ deep.

Variations: — Some of the Pacific specimens of *Phalacroma rapa* examined (Figure 16: 3) conform rather closely to Stein's (1883) Plate 19, fig. 5. The anterior portion of the dorsal margin of the body in these is nearly straight or even slightly concave and forms with the posterior portion of this margin a broadly rounded but distinct corner; and the portion of the ventral margin of the body that is in front of the posterior main rib of the left sulcal list is somewhat concave or almost straight, and nearly parallel to the longitudinal axis of the body. However, most of the specimens found in the material of the Expedition (Figure 16:5) have a habitus that resembles very closely that of *P. mitra* Okamura (1907, pl. 5, fig. 43). These specimens are characterized by an evenly and gently convex dorsal margin of the body, and the portion of the ventral margin of the body which is in front of the posterior main rib of the left sulcal list is nearly straight or slightly convex or concave, and has a more or less decided posteroventral inclination. In other words, most of the Expedition specimens differ rather strikingly from the type as figured by Stein (1883). Between the extreme forms of *P. rapa*, as figured by Stein (1883) and by Okamura (1907), there is in the Expedition material a nearly continuous series of intergrading specimens.

These differences, although very striking, probably do not indicate that *Phalacroma rapa* is composed of two or more closely related systematic units. They probably are the results of regulatory processes of growth and absorption following binary fission. Figure 16: 4 shows that the two valves of the theca may be very different; the left valve of the specimen represented is decidedly longer than the right. In another specimen the left valve had an angular, and the right valve an evenly and gently convex dorsal margin.

According to Stein (1883, p. 23), the epitheca of *Phalacroma rapa* is "scheibenförmig;" according to Jörgensen (1923, p. 14), it is "flat, in profile hardly projecting beyond the girdle." In the Expedition specimens, as well as in those figured by Okamura (1907, pl. 5, fig. 43) and by Pavillard (1916, fig. 13A), it is of moderate convexity; in the Expedition specimens the degree of this convexity is somewhat variable. Following this evidence, it appears probable that these variations in the convexity and the relative height of the epitheca are partly due to regulatory processes; partly they may be apparent, due to the tilting of some of the specimens examined. In addition, we have no evidence that they are genetic.

According to Pavillard (1916, p. 55) this species exhibits about the same variations in the Gulf of Lyons as in the Eastern Pacific (see Forti, 1922, p. 107).

Comparisons: — The structurally closest-known relative of *Phalacroma rapa* is *P. mitra*. Indeed, these two forms are so similar that Cleve (1901c, p. 273) considered them as identical, and Pavillard (1916, p. 53) and Jörgensen (1923, p. 15) held their specific separation as questionable. The data available at the present time are not sufficient to settle the question as to whether or not these two forms are specifically distinct. The most important distinguishing characteristic appears to be the shape of the ventral margin of the body. In *P. rapa* this margin is more or less strikingly angular at the posterior end of the left sulcal list, while in *P. mitra*, according to Schütt's (1895, pl. 4, fig. 18: 1) figure of the type specimen, it is strongly and evenly sigmoid. In addition, *P. mitra* has a somewhat larger right sulcal list than has *P. rapa*.

Another very close relative of *Phalacroma rapa* is *P. favus*. Sometimes these two species are so similar that even their specific differentiation is difficult; compare, for instance, Pavillard's (1916) figure 13A and our Figure 14: 5. As far as known, *P. favus* can always be distinguished from *P. rapa* by its relatively longer and more decurrent left sulcal list, which has a fairly great number of short ribs besides the three main ribs. Furthermore, the posterior portion of the hypotheca in *P. favus* is somewhat more contracted, *i.e.*, mammilliform, than in *P. rapa*.

Phalacroma dolichopterygium, *P. acutum*, and *P. hindmarchi* are, next to *P. mitra* and *P. favus*, the nearest in structure to *P. rapa*. *Phalacroma mitra* may be regarded as a connecting link between *P. rapa* and *P. dolichopterygium*, and the last species (figured by Jörgensen, 1923, fig. 15) as intermediate between *P. mitra* and *P. acutum*. In *P. acutum* the epitheca is relatively high and the ventral margin of the hypotheca is rounded angular at the posterior main rib of the left sulcal list. *Phalacroma dolichopterygium* has the hypotheca of about the same shape as in *P. acutum*, but its epitheca is about as low as in *P. mitra* and *P. rapa*. *Phalacroma hindmarchi*, on the other hand, appears to represent an independent evolutionary branch of this group of species in which the progressive reduction of the height of the epitheca has been inhibited, while the tendency to constrict the posterior portion of the hypotheca into a mammilliform projection has been carried out to about the same extent as in the highly differentiated *P. favus*. *Phalacroma rapa* is readily distinguished from *P. dolichopterygium*, *P. acutum*, and *P. hindmarchi* by the pronounced angularity of the ventral margin of its body.

All the species mentioned in this section probably evolved from a regularly obovoidal species of about the same habitus as *Phalacroma vastum*.

The great similarity between *Phalacroma rapa* and *P. mitra* makes a partial confusion of these two forms by previous investigators appear very probable. The bibliographical list of *P. rapa* has therefore been made very conservative, but includes a list of all the references to *P. rapa*, except Pavillard (1915a, p. 2, fig. A), which refers to *P. mitra*, according to Pavillard's (1916, p. 54, footnote) own statement. However, it should be remembered that the assignment of *P. mitra* Pavillard (1916) must be regarded as somewhat uncertain. As mentioned in the last section, the shape of the ventral margin of the body appears to be the most important morphological difference between *P. rapa* and *P. mitra*. The ventral margin of the specimen of *P. mitra* figured by Pavillard (1916, fig. 13B) is strikingly angular at the posterior end of the left sulcal list (just as in *P. rapa*), its anterior half is gently convex, and its posterior half gently concave. In the type specimens of *P. mitra* (Schütt, 1895, pl. 4, fig. 18:1), on the other hand, this margin is strongly and evenly sigmoid. (See Pavillard, 1923a, p. 879.) Forti's (1922, pl. 7, fig. 109) determination of *P. mitra* evidently is based on Pavillard's (1916) conception of this species. Only one reference to *P. mitra* has been included in our bibliographical list of *P. rapa*, viz., *P. mitra* Okamura (1907); see the section on the variations; also Pavillard (1916, p. 54), Jörgensen (1923, p. 15), and Pavillard (1923a, p. 879). (On the other hand, *P. mitra* Okamura, 1912, is not a synonym of *P. rapa* Stein.) Jörgensen (1923, p. 15) notes that *P. mitra* Murray and Whitting (1899) is "doubtless" *P. rapa* Stein. This statement may be correct, but there is no morphological evidence as yet bearing on the question. Cleve (1901c, p. 273) includes *P. mitra* Schütt as a synonym of *P. rapa* Stein.

Even though the extent of the confusion of *Phalacroma rapa* and *P. mitra* by previous investigators cannot be fully established, there are reasons to assume that, with the exceptions mentioned in the last paragraph, it is not very great and that, therefore, the bibliographical list of *P. rapa* is fairly correct. This statement is based on the fact that *P. rapa* and *P. mitra* are recorded as specifically distinct by most of the investigators, Ostenfeld and Schmidt (1901), Zacharias (1906), Karsten (1906, 1907), Stüwe (1909), and Hensen (1911), who do not give any descriptions or figures by means of which their determinations may be checked.

Occurrence: — *Phalacroma rapa* is recorded at fifty-three of the 127 stations. There are 17, 9, 10, 7, 6, and 4 stations on the six lines of the Expedition. Of these fifty-three stations, two (4580, 4583) are in the California Current; nine (4587, 4590, 4594, 4596, 4598, 4600, 4604, 4605, 4607) are in the Mexican Current; eleven (4609, 4613, 4615, 4617, 4619, 4624, 4634, 4635, 4637, 4640, 4644) in the Panamic Area; six (4650, 4661, 4665, 4666, 4676, 4678) in the Peruvian Current; six (4689, 4691, 4692, 4695, 4697, 4699) in the Easter Island Eddy; seventeen (4679, 4680, 4681, 4683, 4685, 4701, 4705, 4709, 4711, 4719, 4721, 4722, 4724, 4737, 4739, 4740, 4741) in the South Equatorial Drift; two (4742, 4743) in the South Equatorial Current. There are twenty-two records from the surface (Stations 4590, 4596, 4600, 4604, 4607, 4615, 4617, 4619, 4624, 4635, 4640, 4644, 4650, 4661 [Salpa], 4666, 4676, 4678, 4680, 4692, 4709 [Salpa], 4741, 4743); at eighteen of these stations the species was taken in surface hauls only; at four stations (4590, 4617, 4650, 4709) in hauls from 300–0 fathoms as well as at the surface. At one station (4737) the species is recorded from 100–0 fathoms and 300–0 fathoms; at four stations (4681, 4689, 4701, 4724) from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these fifty-three stations at the surface was 67°–85°; the average was 76.2°. At the twenty-two stations in the surface catches of which the species was found, the surface temperature ranged from 67° to 84°; the average was 76.0°.

For the surface catches the following frequencies are recorded: — 2% at three stations (4615, 4624, 4650), 1% at three stations (4600, 4619, 4666), and less than 1% in the remaining cases. For the catches from 100, 300, or 800 fathoms to the

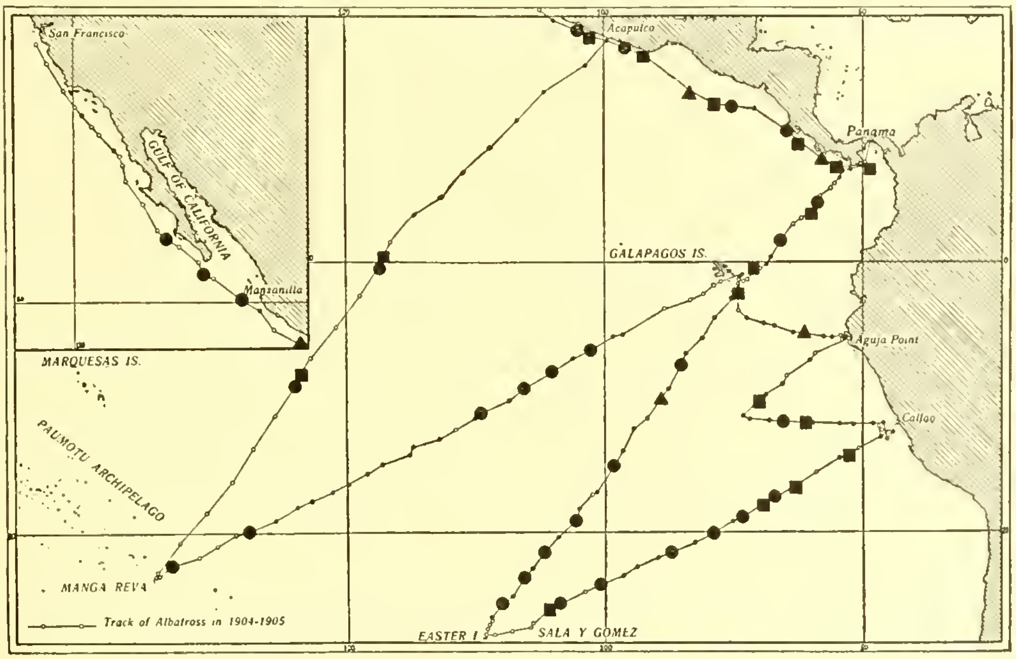

FIGURE 17.— Occurrence of *Phalacroma rapa* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

surface the records of frequency are as follows: —5% at one station (4709), 3% at one station (4695), 2% at one station (4697), 1% at seven stations (4598, 4613, 4617, 4681, 4689, 4701, 4721), and less than 1% at the remaining stations.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." Hensen (1895, 1911) found it at a great number of stations throughout the tropical, subtropical, and warm-temperate regions of the Atlantic; Cleve (1901c, 1902b, 1903b), at a fairly great number of stations in the Atlantic, between lat. 42° N. and lat. 20° S., in the Caribbean Sea, in the Arabian Sea, and the Indian Ocean and recorded it at lat. 36°–37° N. and long. 10° E.–5° W.;

Karsten (1906) in the Atlantic, at lat. 5° N. and long. 13° W.; Stüwe (1909) off the west coast of Africa, between lat. 4° N. and lat. 9° N.; Jörgensen (1923) in the Bay of Cadiz, off the coast of Portugal, and southwest of Brittany, and at a fairly great number of stations in various parts of the Mediterranean; Pavillard (1916) in the Gulf of Lyons; Forti (1922) in the Ligurian Sea; Schröder (1900a) at Naples; Zacharias (1906) at Naples and in the Adriatic; Entz (1902b, 1905) in the Adriatic Sea. Ostenfeld and Schmidt (1901) found it in the Gulf of Aden; Karsten (1907) in the Indian Ocean; Whitelegge (1891) on the east coast of Australia; and Okamura (1907) in Japanese waters.

According to the authors noted, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations		Salinity	Range	Number and Mean of Observations	
Cleve (1901c)		56.0°–82.0°	39	70.0°		33.44–37.63	28	35.80
Cleve (1902b)	72.6°						12	36.27
Cleve (1903b)		59.2°–83.0°	13	70.0°		36.02–37.29	13	36.59
Ostenfeld and Schmidt (1901)	79.5°							
Stüwe (1909)	80.6°–82.8°							

Of the writers who have contributed to our knowledge of the distribution of this species, only Stein (1883), Okamura (1907), Pavillard (1916), Forti (1922), and Jörgensen (1923) give descriptions or figures by means of which their determinations may be judged. It should be mentioned that Cleve (1901c, p. 273) gives *Phalacroma mitra* Schütt as a synonym of *P. rapa* Stein. Some of the data referred to *P. rapa* by Cleve therefore may be referable to *P. mitra*.

This is a eupelagic species occurring in tropical, subtropical, and temperate regions of all seas. According to the Expedition records it is almost evenly distributed throughout the area investigated. It probably has its optimum habitat in deeper waters, within the levels of photosynthesis, but it appears to occur more frequently at the surface than most of the other species of Phalacroma. Indeed, of the species of this genus only *P. doryphorum* (twenty-six surface records) was found more frequently than *P. rapa* (twenty-two surface records) in the surface catches. Of *P. cuneus* and *P. favus*, which next to *P. rapa* were the most frequent in the surface catches, there are only thirteen and six records, respectively.

Phalacroma favus Kofoid and Michener

Plate 2, fig. 7. Figure 14: 4, 5

Phalacroma favus Kofoid & Michener, 1911, p. 289. Pavillard, 1923a, p. 879.
Phalacroma hindmarchii Pavillard, 1916, p. 53; cf. 1923a, p. 879.
?*Phalacroma favus* Jörgensen, 1923, p. 15, 16, 43, fig. 16.
Phalacroma simulans Jörgensen ms., 1923, p. 15.

Diagnosis: — Body subcuneate in lateral view; epitheca very broadly rounded; posterior portion of hypotheca constricted, mammilliform; ventral margin of hypotheca broadly rounded or somewhat angular at R_3 of left sulcal list; deepest at posterior cingular list; length: depth, 1.14–1.21:1; longitudinal axis deflected posteroventrally at 5°–10°. In dorsal view cuneate; hypotheca very narrowly rounded to subacute posteriorly, and its side contours gently undulating; length: width, 1.45–1.50:1. Posterior cingular list 0.21–0.27 the length of body from apex. Left sulcal list 0.50–0.65 the length of body; distance from R_1 to R_3 is 0.25–0.31 the length of body; unusually decurrent behind R_3; R_2 is 0.12–0.14, and R_3 is 0.14–0.22 the greatest depth of body; margin forms angle of 100°–130° at R_3; R_3 inclined posteriorly at 5°–30°; with about 8–15 short riblets. Theca reticulate; 20–25 polygons border girdle posteriorly. Length, 54–83 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is subcuneate in lateral view, with very broadly rounded epitheca, with the posterior portion of the hypotheca constricted and mammilliform, with the ventral margin of the hypotheca broadly rounded or somewhat angular at the posterior main rib of the left sulcal list, and with the greatest depth at the posterior cingular list. The ratio between the length and the depth of the body is 1.18 (1.14–1.21):1. The longitudinal axis is deflected posteroventrally at 5°–10°.

The epitheca is about as deep as the hypotheca or slightly less, very broadly convex, highest in or near the center, and moderately elevated above the anterior cingular list. The transverse furrow is somewhat concave, and its width is 0.50–0.67 the greatest height of the epitheca. The posterior cingular list is 0.24 (0.21–0.27) the length of the body from the apex. The hypotheca is somewhat deflected posteroventrally (see above). The dorsal margin, from the girdle to the antapex, is gently undulating, convex in the middle, and concave anteriorly and posteriorly; or its anterior half is almost straight and its posterior half gently concave (Jörgensen, 1923, fig. 16). The portion of the ventral margin that is in front of the posterior main rib of the left sulcal list is almost straight or gently convex or concave, and about perpendicular to the girdle. The portion of this margin that is behind the posterior main rib of the left sulcal list is 1.7–2.7 the length of the anterior portion, and moderately to rather strikingly concave. At the mentioned rib this margin is either broadly rounded or somewhat angular. The posterior portion of the hypotheca is constricted and mammilliform, and the antapex is narrowly rounded to subacute. In dorsal view the body is cuneate, with very broadly convex epitheca and with the posterior portion of the hypotheca narrowly rounded to subacute; the side contours of the hypotheca are gently undulating, convex in the middle, and concave anteriorly and posteriorly; the ratio between the length and the width is 1.45–1.50: 1.

The cingular lists are subhorizontal, subequal, and about as wide as or slightly narrower than the transverse furrow; each of them has, on each valve, twenty to thirty rather strong, straight, simple, and nearly equidistant ribs. The sulcus is about 0.30–0.40 the length of the hypotheca. The flagellar pore is at the junction of the sulcus and the cingulum. The right sulcal list extends to the posterior main rib of the left sulcal list; in some specimens it is subtriangular, decreasing gradually in width posteriorly, in others it is of subequal width throughout the greater portion of its length; anteriorly it is about as wide as or somewhat narrower than the transverse furrow. The left sulcal list is of moderate size. Its length is 0.50–0.65 the length of the body, and the distance between the anterior and posterior main ribs is 0.25–0.31 the length of the body. It extends to the base of the posterior mammilliform projection of the body. The anterior main rib is 0.08–0.11, the fission rib 0.12–0.14, and the posterior main rib 0.14–0.22 the greatest depth of the body. Behind the posterior main rib this list is unusually decurrent. Between the anterior and posterior main ribs, the free margin of this list is nearly straight, gently convex, or gently concave between the anterior main rib and the fission rib as well as between the fission rib and the posterior main rib; at the posterior main rib it forms an angle of 100°–130°; behind the last-mentioned rib it is straight or gently concave. The main ribs of this list generally are of moderate strength and straight or almost so; in exceptional cases, for instance, in the type specimen, the posterior rib is club-shaped. The distance from the anterior main rib to the fission rib is 0.33–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 5°–30°. Besides the main ribs, this list has about eight to fifteen short riblets. At least in some specimens (Jörgensen, 1923, fig. 16) the left sulcal list is continued by a very narrow parasagittal list extending around the posterior portion of the hypotheca.

The thecal wall has a reticulum of medium-sized, subequal polygons, each with a small pore in the center. There are twenty to twenty-five of them bordering the posterior margin of the girdle and two rows in the transverse furrow, each with twenty to twenty-five polygons on each valve.

Megacytic stages were seen by Jörgensen (1923, p. 16).

The proportions of two of the Expedition specimens and the one represented by Jörgensen (1923) were measured.

Dimensions: — Length of body, 72–76 μ (average, 74.3 μ; type, 76 μ). Greatest depth of body, 62.7–63.6 μ (average, 63.2 μ; type, 62.7 μ). The specimens measured by Jörgensen (1923, p. 15) formed two size classes, the one 81–83 μ long and 68–71 μ deep, the other 54–62 μ long and 54 μ deep.

Variations: — Judging by the material thus far examined, this species appears to be fairly constant. Most of the specimens examined and the specimen represented by Jörgensen (1923, fig. 16) are strikingly similar. The most variable characters are the size of the body and the shape of the posterior portion of the hypotheca.

Comparisons: — The description and figures of *Phalacroma favus* are based on the type material.

Phalacroma rapa probably is structurally the closest relative of *P. favus.* Indeed, these two forms sometimes are so similar that even their specific differentiation is difficult; compare Pavillard (1916, fig. 13A) and Figure 14: 5. However, we do not agree with Jörgensen's (1923, p. 16) statement that *P. favus* is so closely related to *P. rapa* "that there might be some grounds for regarding it as a variety of that species." The most important distinguishing characteristics are:— (*1*) *P. favus* has a relatively longer and more decurrent left sulcal list, which has a fairly great number of short riblets besides the three main ribs; (*2*) the posterior portion of the hypotheca in *P. favus* is somewhat more contracted, *i.e.*, mammilliform, than in *P. rapa*. *P. favus* is most easily distinguished from *P. hindmarchi* by its lower epitheca, its relatively longer and more decurrent left sulcal list, which has a fairly great number of short riblets besides the three main ribs, and the polygonate reticulation of its theca. It differs from *P. mitra*, *P. dolichopterygium*, and *P. acutum* in the shape and structure of its left sulcal list and in the mammilliform shape of the posterior portion of its hypotheca. See *P. rapa*, p. 143, and Jörgensen, 1923, p. 15, 16.

Occurrence: — *Phalacroma favus* is recorded at twelve of the 127 stations. There are 6, 1, 0, 0, 2, and 3 stations on the six lines of the Expedition. Of these twelve stations, six (4587, 4590, 4592, 4594, 4604, 4545) are in the Mexican Current; one (4617) is in the Panamic Area; one (4665) is in the Peruvian Current; three (4730, 4737, 4741) are in the South Equatorial Current; one (4542) is in the Equatorial Counter Current. At one of these stations (4617) this species was taken in a surface haul as well as in a haul from 300–0 fathoms; at five stations (4592, 4604, 4741 [Salpa], 4542, 4545) in surface hauls only. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these twelve stations at the surface was 68°–84°;

the average was 80.2°. At the six stations in the surface catches of which this species was found, the surface temperature ranged from 78° to 84°; the average was 80.8°.

At two stations (4604, 4542) the frequency is 1%; in the remaining cases it is less.

The species was first recorded by Kofoid and Michener (1911) at Station 4737 of the Expedition. Later Jörgensen (1923) found it in the Bay of Cadiz and in the Ionian Sea. Pavillard (1916) reported it from the Gulf of Lyons under the name of *Phalacroma hindmarchii.*

This is a eupelagic, stenothermal, and warm-water species. Presumably it is widely distributed in tropical and subtropical seas, and it occurs only occasionally in warm-temperate regions. According to the Expedition records, it is found in waters of very high average temperature (80.2°). Most of the record stations are in the warm Mexican Current, and in the western portion of the South Equatorial Drift, and only one is located in the relatively cooler Peruvian Current. Another outstanding peculiarity in the occurrence of this species, according to the Expedition data, is the exceptionally high percentage (50%) of surface records. In no other species of this genus has such a high percentage been recorded.

Phalacroma hindmarchi Murray and Whitting

Figure 18, 19

Phalacroma hindmarchii Murray & Whitting, 1899, p. 330, tab. 4, 5, 6, 8, 9, pl. 31, fig. 5. Lemmermann, 1899a, p. 372; 1901a, p. 372. Cleve, 1901c, p. 271; 1902b, p. 36. Jörgensen, 1923, p. 15, 16. Pavillard, 1923a, p. 879 (*non* 1916, p. 53).
Phalacroma hindmarchi Stüwe, 1909, p. 254, 288.

Diagnosis: — Body of inverted fig-shape in lateral view; epitheca broadly and more or less strongly convex; posterior portion of hypotheca constricted, mammilliform; ventral margin sigmoid, convex anteriorly, concave posteriorly; deepest at or somewhat behind girdle; length: depth, 1.15–1.31 : 1; longitudinal axis usually perpendicular to girdle. Dorsoventral and lateral views almost similar. Posterior cingular list 0.27–0.44 the length of body from apex. Cingular lists possibly without structure. Left sulcal list 0.33–0.50 the length of body; distance from R_1 to R_3 is 0.24–0.33 the length of body; R_2 is 0.09–0.16, and R_3 is 0.20–0.25 the greatest depth of body; margin forms angle of 70°–100° at R_3; R_3 inclined posteriorly at 15°–35°; often club-shaped; sometimes reticulate. Theca finely and closely areolate. Length, 82–98 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is of inverted fig-shape in lateral view, with broadly and more or less strongly convex epitheca, with the posterior portion of the hypotheca constricted and mammilliform, with the ventral margin of the hypotheca sigmoid, convex anteriorly and concave posteriorly, and with the greatest depth at or somewhat behind the girdle. The ratio between the length and the depth of the body is 1.25 (1.15–1.31): 1. The longitudinal axis usually is about perpendicular to the girdle, but sometimes it is slightly deflected posterodorsally or posteroventrally.

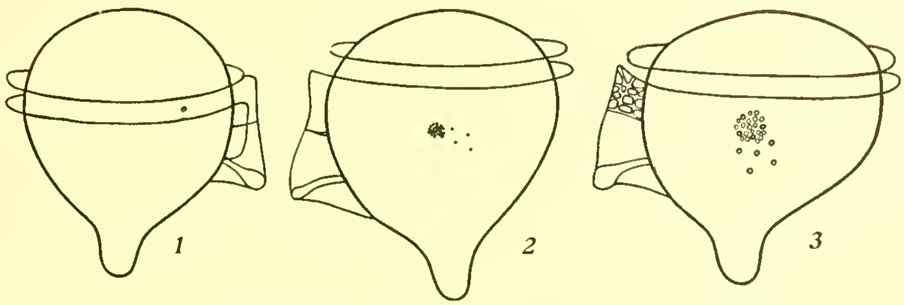

FIGURE 18.— *Phalacroma hindmarchi* Murray and Whitting. 1, right lateral view. 2, 3, left lateral view; surface markings, areolation, and porulation indicated only on small portion of theca in 2, 3. × 430. 1, from Station 4737 (150–0 fathoms). 2, 3, from Station 4730 (300–0 fathoms).

The epitheca is about as deep as the hypotheca or somewhat less, broadly and more or less strongly convex, often dome-shaped, highest in or near the center, and moderately elevated or generally very prominent above the anterior cingular list. The transverse furrow is nearly flat or slightly convex, and its width is 0.20–0.40 the greatest height of the epitheca. The posterior cingular list is 0.38 (0.27–0.44) the length of the body from the apex. The hypotheca sometimes is almost symmetrical, as in the type specimen and in Figure 18: 1; sometimes its dorsal and ventral margins, which are sigmoid, convex anteriorly and concave posteriorly, are more or less different (Figure 18: 3). The posterior portion of the hypotheca is constricted and mammilliform; in none of the Expedition specimens was this constriction quite so pronounced as in the type (Murray and Whitting, 1899, pl. 31, fig. 5). The antapex is narrowly rounded to subacute. In dorsoventral view the body has about the same shape as in lateral view, with the exception that it is somewhat narrower.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; judging by the figures of the type and by Figures 18, 19, these lists are hyaline and without structure. The sulcus is about 0.4 the length of the hypotheca. The right sulcal list extends to the posterior main rib of the left sulcal list, is of subequal width throughout the greater part of its length, as wide as or somewhat narrower than the transverse furrow, and rounded posteriorly. The left sulcal list is of moderate size. Its length is 0.33–0.50 the length of the body, and the distance between the anterior and posterior main ribs is 0.24–0.33 the length of the body. It ends somewhat in front of the base of the posterior mammilliform projection of the body. The anterior main rib, when present, is 0.07–0.14, the fission rib 0.09–0.16, and the posterior main rib 0.20–0.25 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs, the free margin of this list is almost straight, gently convex or concave, sigmoid, *i.e.*, concave an-

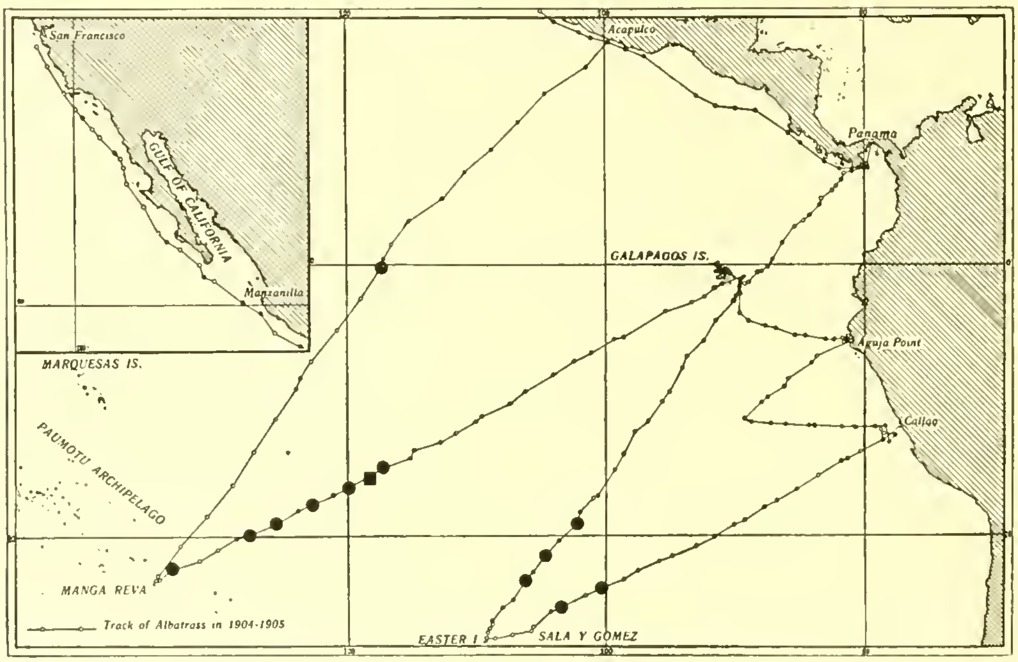

FIGURE 19. — Occurrence of *Phalacroma hindmarchi* Murray and Whitting. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

teriorly and convex posteriorly, or it is somewhat irregular; at the posterior main rib it forms an angle of 70°–100°; behind the last-mentioned rib it is either straight or gently concave or convex. The anterior main rib and the fission rib of this list are of moderate strength or rather weak; the posterior main rib usually is quite heavy and club-shaped distally; all of them are straight or almost so, or the posterior has a gentle posterior concavity. The distance between the anterior main rib and the fission rib is about 0.33–0.50 the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of 15°–35°.

Besides the main ribs, this list sometimes has a well-developed reticulation (Figure 18: 3). There are no accessory lists or sails.

The thecal wall has a fairly great number of scattered pores, interspersed with more numerous, small, rounded, and closely set areoles of somewhat varying size (Figure 18: 2, 3). Usually the areoles are of about the same size as the pores, but sometimes they are smaller (see Cleve, 1901c, p. 271).

Megacytic stages were found.

The proportions of five of the Expedition specimens and of the type specimen as represented by Murray and Whitting (1899) were measured.

Dimensions: — Length of body, 82–98 μ (average, 87 μ). Greatest depth of body, 65–75 μ (average, 69.5 μ). The type specimen as represented by Murray and Whitting (1899, pl. 31, fig. 5) was about 92 μ long and 75 μ deep.

Variations: — The length of the body, the relative height of the epitheca, the degree of symmetry and of posterior constriction of the hypotheca, and the structure of the theca and of the left sulcal list appear to be the most variable characters.

Comparisons: — Most of the Expedition specimens referred to *Phalacroma hindmarchi* (Figure 18: 1) agree closely with the type as figured by Murray and Whitting (1899, pl. 31, fig. 5). Others are more or less aberrant (Figure 18: 2, 3), but even in their case the assignment may be regarded as certain.

Phalacroma hindmarchi is closely related to *P. favus*, *P. rapa*, *P. mitra*, and *P. dolichopterygium*, although this relationship appears to be collateral rather than linear. In other words, *P. hindmarchi* seems to be a highly differentiated member of an evolutionary branch originating from the same ancestral form as the branch represented by the last four species and partly embodying the same tendencies as the latter branch, *e.g.*, the tendency to constrict the posterior portion of the hypotheca into a mammilliform projection. *Phalacroma hindmarchi* is easily distinguished from *P. favus*, *P. rapa*, *P. mitra*, and *P. dolichopterygium* by its higher and more dome-shaped epitheca, and by having its thecal wall finely areolated instead of reticulated.

According to Murray and Whitting (1899, p. 330), *Phalacroma hindmarchi* is "closely allied to *P. operculatum*." However, this relationship is not so evident as the ones suggested above.

Occurrence: — *Phalacroma hindmarchi* is recorded at thirteen of the 127 stations. There are 0, 0, 2, 3, 7, and 1 stations on the six lines of the Expedition. Of these thirteen stations, four (4689, 4691, 4697, 4699) are in the Easter Island Eddy; eight (4701, 4730, 4731, 4732, 4734, 4736, 4737, 4739) are in the South

Equatorial Drift; one (4742) is in the South Equatorial Current. At one of these stations (4731) the species is recorded from the surface; at one station (4737) from 100–0 fathoms as well as from 300–0 fathoms. The remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these thirteen stations at the surface was 72.0°–81.5°; the average was 77.2°. At Station 4731, the only surface record, the surface temperature was 79.5°.

At four stations (4689, 4731, 4734, 4739) the frequency is 1%; in the remaining cases it is less.

The species was first recorded by Murray and Whitting (1899), who found it at nine stations in the tropical and subtropical regions of the Atlantic, between lat. 14° N. and 31° N., and in the Caribbean Sea. Later Cleve (1901c, 1902b) reported it from the Atlantic, between lat. 9° N. and 34° N., and from the Caribbean Sea; and Stüwe (1909) from the Atlantic, at lat. 3° 50′ N., long. 26° 15′ W. (South Equatorial Current).

According to these authors, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations		Salinity	Range	Number and Mean of Observations	
Murray and Whitting (1899)	67°–69°							
Cleve (1901c)		70.0°–82.0°	16	75.5°		34.88–37.43	10	36.27
Cleve (1902b)	76.3°				37.17			
Stüwe (1909)	80.2°							

Of the authors who have contributed toward a knowledge of the distribution of this species only Murray and Whitting (1899) give any descriptions or figures by means of which their determinations may be checked.

Jörgensen (1923, p. 16) writes as follows: "I have not noticed that the species I have noted from the cruise of the THOR as *Ph. Hindmarchii* . . ." However, *P. hindmarchi* is not mentioned by this author except in connection with the discussion of *P. favus*. The statement quoted above therefore is either due to a *lapsus pennae*, or the account of *P. hindmarchi* was overlooked.

This species is eupelagic and widely distributed, but rare, in tropical, subtropical, and warm-temperate seas. Its distribution in the Eastern Pacific, according to the Expedition data, is remarkably similar to that of *Amphisolenia schauinslandi* and *A. thrinax* (see p. 442). Although there are as many as thirteen record stations, the species was never found in the California Current, Mexican Current, Panamic Area, and Peruvian Current. With one exception, all the record stations are in or near the Easter Island Eddy and in the western portion of the South Equatorial Drift. The average temperature of its habitat is high, 77.2.°

6. Expulsum Group. Both the species referred to this group, *Phalacroma protuberans* and *P. expulsum*, were found in the material of the Expedition.

Phalacroma protuberans, sp. nov.

Figure 20: 6–9

Diagnosis: — Body subovate to subcircular in lateral outline, with dorsal shoulder-like constriction at posterior cingular list, deepest in or somewhat in front of the middle, and 1.08–1.18 times longer than deep; longitudinal axis perpendicular to girdle or deflected posteroventrally at 1°–4°. In dorsal view wedge-shaped, widest just behind girdle, subacute to narrowly rounded posteriorly, and with more or less pronounced rounded protuberances just behind girdle; length: width, 1.38–1.74 : 1. Posterior cingular list 0.23–0.26 the length of body from apex. Cingular lists 1.7–2.0 the width of transverse furrow; their structure unknown. Left sulcal list 0.64–0.65 the length of body; R_1 is 0.18–0.20, R_2 is 0.14–0.16 the greatest depth of body; R_3 absent; margin rounded or rounded angular posteriorly. Length, 53.0–59.6 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subovate to subcircular in lateral outline, with a dorsal shoulder-like constriction at the posterior cingular list, and deepest in or somewhat in front of the middle. The ratio between the length and the depth of the body is 1.13 (1.08–1.18) : 1. The longitudinal axis is perpendicular to the girdle, or it has a posteroventral deflection of 1°–4°.

The epitheca is 0.74 (0.71–0.76) as deep as the hypotheca, highest in the center, of moderate convexity or more or less flat, and moderately to rather slightly elevated above the anterior cingular list. The transverse furrow is somewhat concave, and about as wide as or somewhat narrower than the greatest height of the epitheca. The posterior cingular list is 0.25 (0.23–0.26) the length of the body from the apex. The hypotheca sometimes is subsymmetrical (Figure 20:6), sometimes it is decidedly flatter ventrally than dorsally (Figure 20:8). The dorsal margin is subuniformly, and gently to moderately convex except just behind the girdle where it is more bulging. The ventral margin, from the girdle to the posterior end of the left sulcal list, is gently convex. The postmargin is moderately to rather strongly convex and confluent with the dorsal and ventral margins. In dorsoventral view the body is wedge-shaped, widest just behind the girdle, subacute to narrowly rounded posteriorly, and with broadly rounded, more or less prominent protuberances just behind the girdle, one on each side of the body; the ratio between the length and the width of the body is 1.56 (1.38–1.74):1.

The cingular lists are subhorizontal and subequal; their width is about 1.7–2.3 the width of the transverse furrow and 0.23–0.26 the greatest depth of the body; their structure is unknown. The right sulcal list is unusually short, extending to or slightly beyond the fission rib of the left sulcal list, and subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is about 0.64–0.65 the length of the body and of subuniform width throughout the greater portion of its length. The anterior main rib is 0.18–0.20, the fission rib 0.14–0.16 the greatest depth of the body. The posterior main rib is lacking. The anterior two thirds of the free

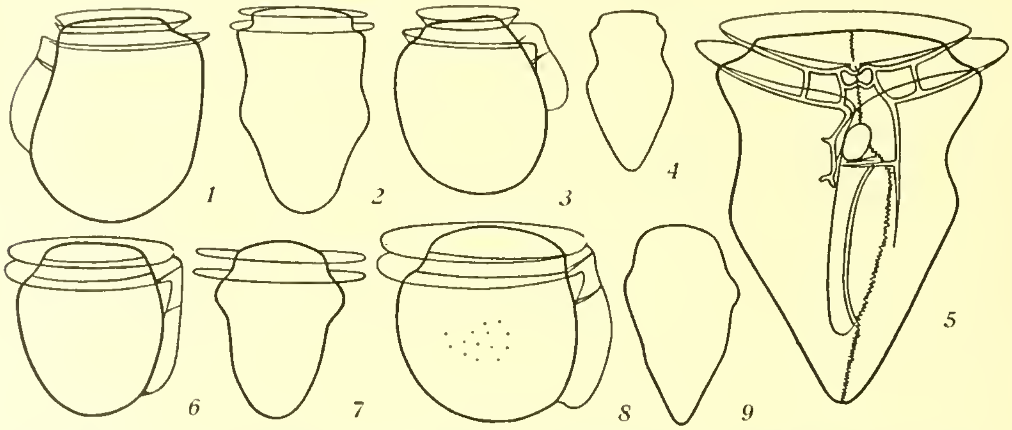

FIGURE 20.— 1–5, *Phalacroma expulsum* (Kofoid and Michener). 1, in left lateral view; 2, 4, in dorsal view; 3, in right lateral view; 5, in ventral view. 2, from the same specimen as 1; 4, from the same specimen as 3. 1–3, × 430; 4, of unknown magnification; 5, × 890. 1, 2, from Station 4713 (300–0 fathoms); 3, 4, from Station 4724 (300–0 fathoms); 5, from Station 4717 (300–0 fathoms). 6–9, *Phalacroma protuberans*, sp. nov. 6, 8, in right lateral view; 7, 9, in dorsal view. 7, from the same specimen as 6; 8, 9, from type specimen. Porulation of theca indicated only in 8. × 430. Station 4730 (300–0 fathoms).

margin of this list is almost straight, or gently sigmoid, concave anteriorly and convex posteriorly. The posterior portion of this margin, which is confluent with the anterior, is gently convex (Figure 20:6) to rounded angular (Figure 20:8). The main ribs are straight or almost so, and not club-shaped or otherwise modified. There are no accessory lists or sails. The thecal wall is porulate.

Megacytic specimens were not recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 53.0–59.6 μ (type, 59.6 μ). Greatest depth of body, 44.9–55.2 μ (type, 55.2 μ).

Variations: — The two specimens differ strikingly from each other in the depth of the body, in the width and shape of the left sulcal list, in the development of the lateral expansions and constrictions of the body, and in the width of the posterior end of the body when seen in dorsoventral view. Figure 20:6 may, however, represent a specimen drawn in a somewhat tilted position.

Comparisons: — *Phalacroma protuberans* is established on four outline drawings made from the two Expedition specimens. The structure of the cingular and sulcal lists and of the thecal wall is unknown.

In spite of several rather striking differences, this species probably is closely related to *Phalacroma expulsum.* It differs most strikingly from this species in the less-developed posteroventral inclination of the longitudinal axis of the body, in the greater width and subhorizontal position of the cingular lists, in the greater length of the left sulcal list, and in having a pair of broadly rounded lateral protuberances just behind the girdle. For further discussion on the relationships of these two species, see *P. expulsum* (p. 159).

Occurrence: — *Phalacroma protuberans* is recorded at only one (4730, type locality) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 79°. The frequency is less than 1% (two specimens).

Phalacroma expulsum (Kofoid and Michener)

Plate 5, fig. 1. Figure 20: 1–5

Dinophysis expulsa Kofoid & Michener, 1911, p. 268.
Phalacroma stenopterygium Jörgensen, 1923, p. 11, 24, 44, fig. 10.

Diagnosis: — Body sack-like in lateral outline, truncate anteriorly, with dorsal shoulder-like constriction at girdle, broadly rounded posteriorly, deepest in the middle, and 1.02–1.24 times longer than deep; longitudinal axis deflected posteroventrally at 5°–15°. In dorsal view wedge-shaped, widest at posterior cingular list or in the middle, subacute to narrowly rounded posteriorly, and with broad constriction in front of the middle; length: width, 1.42–1.82: 1. Posterior cingular list 0.11–0.17 the length of body from apex; epitheca barely if at all visible above anterior cingular list. Cingular lists inclined anteriorly at 30°–45°, with or without ribs; the anterior about as wide as or somewhat narrower than transverse furrow; the posterior narrower than the anterior. Left sulcal list 0.42–0.57 the length of body; R_1 is 0.12–0.16, R_2 is 0.09–0.17 the greatest depth of body; R_3 absent; margin rounded, not angular, posteriorly. Theca centrally faintly reticulate; about 17–20 polygons border girdle posteriorly. Length, 53.7–67.5 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is sack-like in lateral outline, truncate anteriorly, with dorsal shoulder-like constriction at girdle, broadly rounded posteriorly, and deepest in or near the middle. The ratio between the length and the depth of the body is 1.02–1.24 : 1; in the Expedition specimens this ratio is 1.15 (1.08–1.24) : 1; in Jörgensen's (1923) it varied between 1.02 : 1 and 1.23 : 1. The longitudinal axis is inclined posteroventrally at 5°–15°; in the Expedition specimens this angle is 8° (5°–10°), in that figured by Jörgensen (1923, fig. 10) it is 15°.

The epitheca is 0.60 (0.54–0.66) as deep as the hypotheca, gently convex or flat, highest in or ventrally to the center, and barely if at all visible above the anterior cingular list. The transverse furrow is somewhat concave, and about as wide as or somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.15 (0.11–0.17) the length of the body from the apex. The hypotheca is more or less inclined posteroventrally (see above). The dorsal margin is subuniformly and gently to moderately convex. The ventral margin, from the girdle to the posterior end of the left sulcal list, is almost straight or gently concave or convex. The postmargin is subuniformly and broadly rounded, subsemicircular, and either confluent with the dorsal and ventral margins, or (Jörgensen, 1923, fig. 10) forming a distinct although well-rounded angle at the posterior end of the left sulcal list. In dorsoventral view the body is wedge-shaped, widest at the posterior cingular list or in the middle, and subacute to narrowly rounded posteriorly; between the middle, where the body is more or less expanded, and the posterior cingular list, there is a broad and more or less pronounced constriction; the ratio between the length and the width is 1.60 (1.42–1.82) : 1.

The cingular lists, which are characterized by an anterior inclination of 30°–45°, usually are subequal, but sometimes the posterior is more or less strikingly narrower than the anterior. The anterior is about as wide as or somewhat narrower than the transverse furrow and about 0.11 (0.09–0.13) the greatest depth of the body. In the specimens examined both these lists are hyaline and lack distinct ribs. Jörgensen (1923, p. 11), on the other hand, writes about these lists: "both without or with distinct short radial transverse ribs, innermost by the cell." The right sulcal list is unusually short and extends to or slightly beyond the fission rib of the left sulcal list; it is subtriangular, or rounded anteriorly, and decreases gradually in width posteriorly; its maximum width does not exceed the width of the transverse furrow. The left sulcal list is 0.51 (0.42–0.57) the length of the body, and of subuniform width throughout the greater part of its length.

The anterior main rib is 0.13 (0.12–0.16) and the fission rib 0.13 (0.09–0.17) the greatest depth of the body. The posterior main rib is usually lacking, but sometimes a short rudiment may be found (Jörgensen, 1923, p. 11). The anterior half of the free margin of this list is straight or gently concave or convex; the posterior half, which is confluent with the anterior, is gently, moderately, or strongly convex, and not angular as in most species of the genus. The main ribs are straight or almost so, and not club-shaped or otherwise modified. With the exception of the main ribs, this list appears always to lack structural differentiation. There are no accessory lists or sails.

Except along the dorsal, posterior, and ventral margins, the thecal wall of the hypotheca has a fine reticulum of polygonate meshes; the posterior margin of the girdle is bordered by seventeen to twenty polygons. Sometimes the polygons are subequal in size, sometimes they decrease somewhat in size posteriorly. In the transverse furrow there are two rows of polygons of about the same average size as the hypothecal polygons. On the epitheca no reticulation has been observed. The whole theca is furnished with evenly scattered pores. In the transverse furrow every polygon has a pore, which usually is located in or near the center.

Megacytic stages were not recorded.

The dimensions of six of the Expedition specimens and of the specimen figured by Jörgensen (1923, fig. 10) were measured.

Dimensions: — Length of body, 53.7–64.5 μ (average, 58.3 μ; type, 55.8 μ). Greatest depth of body, 45.7–51.2 μ (average, 49.1 μ; type, 47.8 μ). The specimens measured by Jörgensen (1923) were, according to a statement in the text, 54–63 μ long and 53–58 μ deep; the one figured (1923, fig. 10) was 67.5 μ long and 55.0 μ deep.

Variations: — *Phalacroma expulsum* is rather variable. The following characters are the most variable: — the size of the body, the relative depth and width of the body, the degree of the posteroventral inclination of the longitudinal axis, the relative depth of the epitheca, the shape of the ventral margin of the hypotheca, the development of the lateral expansions and constrictions of the body, and the width of the posterior end of the body when seen in dorsoventral view.

Comparisons: — The description and figures of this species are based on the type material. The most aberrant specimen is represented by Figure 20:3, 4. It differs from the remaining specimens in its narrower body, in the subuniform convexity of the ventral margin of its body from the girdle to the antapex, and in the shortness of its left sulcal list. Its present assignment is tentative. It has been referred here mainly because of the fact that its body, in dorsoventral view, has an outline of about the same shape as that of the typical specimens.

The specimen figured by Jörgensen (1923, fig. 10) as *Phalacroma stenopterygium* differs from the typical representatives mainly in the following respects: its longitudinal axis has a more pronounced posteroventral inclination (15°, as compared with 5°–10°), the ventral margin of its body forms a distinct, although rounded corner at the posterior end of the left sulcal list, and its posterior cingular list is decidedly narrower. Jörgensen (1923) states that his specimens were 54–63 μ long and 53–58 μ deep. From this it is evident that at least some of his specimens were decidedly deeper relatively than any of the Expedition specimens.

The generic assignment of this species is somewhat uncertain. Kofoid and Michener (1911) allocated it to Dinophysis on account of the narrowness of the epitheca, the shape of the hypotheca in lateral view, and the position and anterior inclination of the cingular list. Jörgensen (1923, p. 11), on the other hand, writes that: "Despite the great resemblance to the Dinophysis species, I have ascribed it to the genus Phalacroma, chiefly on account of the wedge-shaped cell and also because the lower girdle list can apparently have the same short radial ribs as the upper." With regard to the last-mentioned character it should be pointed out, first, that in the specimens examined both the cingular lists lacked ribs; and, second, that even though the ribbing of the posterior cingular list is a character frequently found in the species of Phalacroma, nevertheless, it is not limited to this genus but is found also in typical representatives of Dinophysis; see *Dinophysis triacantha*, Figure 42:2. Furthermore, *Dinophysis cuneiformis*, which is a typical representative of its genus, is narrowly wedge-shaped in dorsoventral view (Meunier, 1910, pl. 14, fig. 32). However, Jörgensen's (1923) decision is accepted by the close agreement between the dorsoventral outline of the body in this species and in some species of Phalacroma, *e.g.*, in *Phalacroma favus* (Figure 14:2); by the regularly ovate, ellipsoidal, or bilaterally flattened dorsoventral outline of almost all the other known species of Dinophysis; and by the fact that in the closely related *Phalacroma protuberans* the epitheca is rather large and the cingular lists are subhorizontal. Of course, the question is of minor importance, since the genera Dinophysis and Phalacroma are so closely related that their separation is almost arbitrary.

The structurally closest-known relative of *Phalacroma expulsum* is *P. protuberans*. The former species differs most strikingly from the latter in the more pronounced posteroventral inclination of the longitudinal axis of the body, in the anterior inclination of the cingular lists, and in the relative shortness of the left sulcal list. These two species occupy structurally a rather isolated position and ought to be made the only representatives of a special group. Jörgensen (1923) assigned *P. expulsum* to the CUNEUS group. This allocation undoubtedly was made on account of the wedge-like shape of the body in dorsoventral view and because of the fact that the free margin of the left sulcal list is rounded posteroventrally, instead of angular as in most of the species of Phalacroma. However, this allocation greatly decreases the structural uniformity of the CUNEUS group, and for that reason should not be maintained. Note, for instance, the relative narrowness of the epitheca and the sack-like, instead of wedge-like, shape of the hypotheca of *P. expulsum* in lateral view. On the other hand, these two species show distinct affiliation to the CUNEUS group and should thus be placed near to it. Jörgensen (1923, p. 11) also points out that *P. expulsum* "in several respects, especially in the left longitudinal furrow list," is "remarkably like" *Dinophysis sphaerica* (= *similis*). However, the relationship between these two species must be regarded as uncertain; the similarities in the shape of the hypotheca in lateral view and in the shape of the left sulcal list are rather superficial, while the difference in the shape of the body in dorsoventral view is profound. It also may be worth mentioning that *Dinophysis okamurai* (Figure 31:5) shows a certain resemblance to *Phalacroma expulsum* in the shape of the body in lateral view.

Occurrence: — *Phalacroma expulsum* is recorded at four of the 127 stations. There are 0, 0, 0, 1, 3, and 0 stations on the six lines of the Expedition. Of these four stations, one (4713) is in the Galapagos Eddy, and three (4717, 4720, 4724) are in the South Equatorial Drift. There is one record from a surface haul (4720, from Salpa stomach). The remaining records refer to hauls from 300–0 fathoms.

The temperature range of these four stations at the surface was 73°–81°, and the average was 76.8°. At Station 4720, where the species was taken at the surface, the surface temperature was 76°.

The frequency is in every case less than 1%.

The species was first recorded by Kofoid and Michener (1911) from Station 4717 of the Expedition, the type locality. Later Jörgensen (1923) reported it to be "scattered throughout the whole of the Mediterranean to the Bay of Corinth, often in deep water samples." It is probably widely distributed in tropical, subtropical, and warm-temperate seas.

7. LIMBATUM GROUP. Three species, viz., *Phalacroma limbatum*, *P. bipartitum*, and *P. pulchrum*, belong to this group, and all of them occurred in the collections of the Expedition.

PHALACROMA LIMBATUM Kofoid and Michener

Plate 3, fig. 3–5. Figure 21: 1

Phalacroma limbata KOFOID & MICHENER, 1911, p. 290.

Diagnosis: — Body subcircular in lateral outline, deepest near the middle; length: depth, 1.08–1.10: 1. In dorsal view lens-shaped, 2.27 times longer than wide, with narrowly rounded apices. Posterior cingular list 0.38–0.50 the length of body from apex. Cingular lists appear to be without ribs. Left sulcal list: distance between R_1 and R_3 is 0.25–0.28 the length of body; R_2 is 0.12–0.14 and R_3 is 0.19–0.24 the greatest depth of body; margin forms angle of 70°–90° at R_3; R_3 inclined posteriorly at 20°–35°. Two parasagittal lists encircle body; the left of subuniform width throughout, and its maximum width is subequal to or somewhat less than width of transverse furrow; the right resembles the left but forms on antapex an acute, wedge-shaped, posterior sail directed posteriorly. Sail 0.15–0.27 the greatest depth of body in length, with central rib, whose proximal half might form more or less complex reticulum; angle at its tip, 35°–50°. Right parasagittal list forms direct continuation of left sulcal list. Central portion of each thecal valve with reticulum of moderate-sized mesh. Length, 68.9–76.5 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subcircular in lateral outline, slightly longer than deep, and deepest near the middle. The ratio between the length and the greatest depth of the body is 1.09 (1.08–1.10): 1. The longitudinal axis is perpendicular to the girdle.

The epitheca is about 0.87 as deep as the hypotheca, strongly and evenly convex, dome-shaped, highest in the center, and very prominent above the anterior cingular list. The transverse furrow is flat, or slightly convex or concave, and its width is 0.24–0.32 the greatest height of the epitheca. The posterior cingular list is 0.38–0.50 the length of the body from the apex. The hypotheca is symmetrical; its dorsal, posterior, and ventral margins are well and evenly convex, and confluent. Its posterior portion is of about the same depth as the anterior portion of the body. In dorsoventral view the body is lens-shaped, about 2.27 times wider than long, widest at the girdle, and with narrowly rounded apices; the side contours are nearly evenly convex.

The cingular lists are subhorizontal and subequal; their width about equals or somewhat exceeds the width of the transverse furrow; and they are without ribs, according to available drawings (see p. 164). The sulcus is about half as long as the hypotheca. The flagellar pore is just behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a small pore is found near the sagittal suture, just in front of the anterior cingular list. The right sulcal list extends to the posterior main rib of the left sulcal list; it is subtriangular, decreasing gradually in width posteriorly, and anteriorly it is about as wide as the transverse furrow. The left sulcal list is of moderate width and rather short. The distance between the anterior and posterior main ribs is 0.25–0.28 the length of the body. The anterior main rib is 0.13–0.14, the fission rib 0.12–0.14, and the posterior main rib 0.19–0.24 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The free margin of this list is gently sigmoid or nearly straight between the anterior and posterior main ribs; at the posterior main rib it forms an angle of 70°–90°; behind the posterior main rib it is gently concave. The main ribs of this list are of moderate strength and almost straight; or the posterior one is rather strong and gently concave posteriorly; none of them is club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.33–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 20°–35°. Besides the three main ribs, this list sometimes has a faint reticulation; and just behind the posterior main rib it has a fine rib with a posterior inclination of about 50°–60°. Two parasagittal lists encircle the entire body; the one on the right valve of the hypotheca forms a direct continuation of the left sulcal list. The left parasagittal list is of subuniform width throughout its entire length, has a maximum width subequal to or somewhat less than the width of the transverse furrow, and is furnished with a moderate number of simple, free or anastomosing, incomplete riblets. The right parasagittal list resembles the left, but it forms on the antapex an acute, wedge-shaped posterior sail, directed posteriorly. When fully developed, the sail is 0.15–0.27 the greatest depth of the body in length and has a central rib, whose proximal half might form a more or less complex reticulum; the angle at its tip is 35°–50°.

The central portion of each thecal valve, with the exception of the transverse furrow, is characterized by a reticulum of closely set, rather heavily margined polygons of moderate size. The polygons are subequal, and on each valve about thirty of them border the posterior margin of the transverse furrow. The entire theca is furnished with scattered pores. There is a central pore in most of the polygons; and in the transverse furrow there are three rows of pores, each row with thirty to forty pores on each valve.

Megacytic stages were not found.

The proportions of two specimens were measured.

Dimensions: — Length of body, 68.9–76.5 μ (average, 72.7 μ; type, 76.5 μ). Greatest depth of body, 62.4–70.6 μ (average, 66.5 μ; type, 70.6 μ).

Variations: — This species is fairly constant; the relative height of the epitheca, the width of the parasagittal lists, and the size and structure of the posterior sail of the right parasagittal list are the most variable characters.

Comparisons: — The description and figures are based on the type material.

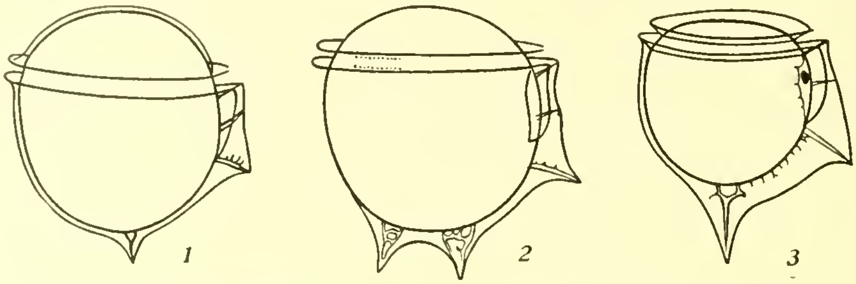

FIGURE 21.— 1, *Phalacroma limbatum* Kofoid and Michener, right lateral view. × 430. Station 4722 (300–0 fathoms). 2, *Phalacroma bipartitum*, sp. nov., right lateral view of type specimen; porulation indicated only on portion of transverse furrow. × 430. Station 4736 (300–0 fathoms). 3, *Phalacroma pulchrum* Kofoid and Michener, right lateral view of type specimen. × 430. Station 4699 (300–0 fathoms).

We refer the specimen, Plate 3, fig. 4, tentatively to this species; the similarities between it and those described above are as follows: — the body is subcircular in lateral outline; the girdle is subequatorial in position; only the central portions of the thecal valves are reticulated; there is an accessory rib in the left sulcal list just behind the posterior main rib. On the other hand, the differences exhibited by the first specimen also are conspicuous; for instance, it lacks parasagittal lists except on the antapical portion of the hypotheca; at the antapex its right parasagittal list is rather wide, but no acute, wedge-shaped projection supported by a central rib is developed. This specimen has been referred to this species, since these differences probably are due to regulatory adjustments following binary fission. However, since the regulatory structural changes that take place at binary fission are unknown, this assignment must be regarded as tentative. The specimen is not included in the description given above, and its locality is omitted from the account of the occurrences. Its length is 84 μ, its greatest depth, 78 μ; its cingular lists are ribbed. It was taken at Station 4687 of the Expedition, in a haul from 300–0 fathoms; surface temperature, 73°.

Phalacroma limbatum is structurally closely related to *P. bipartitum.* These species resemble each other in the following respects: — (*1*) the body is subcircular in lateral view; (*2*) the longitudinal axis of the body is perpendicular to the girdle; (*3*) the epitheca is high; (*4*) the cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; (*5*) the left sulcal list is angular at the posterior main rib and is continued posteriorly by a parasagittal list that has one or two acute, wedge-shaped posterior sails with a more or less complex reticulum of irregular ribs; (*6*) the central portion of each valve, with the exception of the transverse furrow, has a reticulum of closely placed, rather heavily margined polygons; the polygons are subequal, of moderate size, and most of them have a central pore; in the transverse furrow and near the sagittal margins, the valves are porulate but not reticulate; (*7*) the size of the body is the same. It should be remembered, however, that several of these similarities are due to the fact that these two species in some respects are fairly low in the scale of the evolutionary development of the genus. The subcircular shape of the body in lateral view, the longitudinal axis of the body being perpendicular to the girdle, the relatively great height of the epitheca, the cingular lists being subhorizontal, subequal, and about as wide as the transverse furrow, and the angularity of the left sulcal list at the posterior main rib are more or less primitive characters and, therefore, must be considered to have relatively little importance in an attempt to determine the degree of relationship between these and other more or less primitive species of this genus. *Phalacroma limbatum* is more primitive than *P. bipartitum* in having a relatively higher epitheca, and in the right parasagittal list having one, instead of two, acute triangular posterior sails. On the other hand, it is more advanced than the last species in having the two parasagittal lists encircle the entire body.

Phalacroma limbatum is probably also rather closely related to *P. pulchrum*. This relationship is indicated by the following similarities: — (*1*) the body of these two species is subcircular in lateral view and lens-shaped in dorsoventral view; (*2*) on the hypotheca both have two parasagittal lists; the left parasagittal list is narrow and of subuniform width throughout; the right forms a direct continuation of the left sulcal list and has a large, acute, wedge-shaped posterior sail, which is furnished with a central rib; (*3*) at least in some specimens of *P. pulchrum* (Jörgensen, 1923, fig. 18), the left sulcal list has behind the posterior main rib an accessory rib of the same kind as that found in *P. limbatum*. *Phalacroma limbatum* is more primitive than *P. pulchrum* in having a relatively higher epitheca and subhorizontal cingular lists. It is more advanced in size of body, and in having parasagittal lists on the epitheca.

With regard to the relationship between the species mentioned above and *Dinophysis collaris* (p. 295), see the section on comparisons.

Occurrence: — *Phalacroma limbatum* is recorded at six of the 127 stations.

There are 0, 1, 2, 2, 1, and 0 stations on the six lines of the Expedition. Of these six stations, two (4667, 4676) are in the Peruvian Current; one (4699) is in the Easter Island Eddy; and three (4681, 4705, 4722) are in the South Equatorial Drift. At one station (4681) the species is recorded from 300–0 fathoms and 800–0 fathoms. All the other records refer to hauls from 300–0 fathoms only.

The temperature range of these six stations at the surface was 68°–75°; the average was 71.2°.

At two stations (4676, 4705) the frequency is 1%; at the remaining stations it is less.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) at Station 4667 of the Expedition, which thus is the type locality.

Phalacroma bipartitum, sp. nov.

Figure 21: 2

Diagnosis: — Body subcircular in lateral outline, deepest in the middle; length: depth, 1.04: 1. Posterior cingular list 0.30 the length of body from apex. Left sulcal list: distance between R_1 and R_3 is 0.41 the length of body; R_2 is 0.13 and R_3 is 0.25 the greatest depth of body; margin acuminate at R_3 at angle of 40°; R_3 inclined posteriorly at 20°. Around posterior portion of hypotheca there is on right valve a parasagittal list forming direct continuation of left sulcal list; parasagittal list forms two subequal, acute, wedge-shaped posterior sails, one on each side of midline, both with irregularly anastomosing ribs; length of sails equals length of R_3; angles at their tips, 30°–40°; width of list between sails and between ventral sail and R_3 is 0.20 the length of R_3. Central portion of each valve reticulated with heavily margined polygons of moderate size. Length, 68 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subcircular in lateral outline, about as long as deep and deepest near the middle. The ratio between the length and the greatest depth of the body is 1.04: 1. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is 0.87 as deep as the hypotheca, strongly and evenly convex, dome-shaped, highest in the center, and very prominent above the anterior cingular list. The transverse furrow is slightly convex; and its width is 0.37 the greatest height of the epitheca. The posterior cingular list is 0.30 the length of the body from the apex. The hypotheca is symmetrical; its dorsal, posterior, and ventral margins are well and evenly convex, and confluent. In the type specimen the posterior end of the body is slightly narrower than the anterior.

The cingular lists are subhorizontal and subequal; their width about equals the width of the transverse furrow; their structure is unknown. The right sulcal list extends to a point about halfway between the fission rib and the posterior main rib of the left sulcal list; it is of subuniform width throughout the greater part of its length, and its greatest width is somewhat less than the length of the fission rib of the left sulcal list; its free margin is sigmoid, being slightly concave anteriorly and rather strongly convex posteriorly. The left sulcal list is of moderate length and width. The distance between the anterior and posterior main ribs is 0.41 the length of the body. The anterior main rib and the fission rib are subequal and 0.13 the greatest depth of the body; the posterior main rib is 0.25 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The free margin of this list is gently concave between the anterior main rib and the fission rib as well as between the fission rib and the posterior main rib; at the posterior main rib it is acuminate and forms an angle of about 40°; behind the posterior main rib it is gently concave. The main ribs of this list are of moderate strength and almost straight, and none of them is club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is about 0.50 the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of about 20°. There are no ribs except the three main ribs, but, judging by the short projections from the anterior side of the posterior main rib in the drawing of the type specimen (Figure 21:2), this list probably has a faint reticulation. On the right valve there is a parasagittal list, which forms a direct continuation of the left sulcal list, runs around the posterior portion of the hypotheca and extends to the posterior end of the dorsal margin of the hypotheca. The parasagittal list is characterized by two subequal, acute, wedge-shaped posterier sails, one on either side of the midline, and both furnished with irregularly anastomosing ribs. The length of these sails about equals the length of the posterior main rib of the left sulcal list; and the angles at their tips are about 30°–40°. The width of the parasagittal list, between the left sulcal list and the ventral sail and between the two sails, is about 0.20 the length of the posterior main rib of the left sulcal list. It is not known whether there is any parasagittal list on the left valve of the hypotheca; nor whether the parasagittal list of the right valve ever extends farther on the dorsal side than in Figure 21:2 (as in the closely related *Phalacroma limbatum*). The epitheca had no parasagittal lists in the type specimen.

The structure of the theca is about the same as in *Phalacroma limbatum*; *i.e.*, the central portion of each valve, with the exception of the transverse furrow, has a reticulum of closely placed, rather heavily margined polygons. The polygons are subequal and of moderate size, and most of them have a central pore; on each valve about thirty polygons border the posterior side of the transverse furrow. In the transverse furrow and near the sagittal margins the valves are porulate, but not reticulate. In the transverse furrow there are two transverse rows of fine pores, on each valve about forty to fifty pores in each row.

Megacytic stages were not found.

The proportions of the type specimen were measured.

Dimensions: — Length of body, 68.0 μ. Greatest depth of body, 65.5 μ.

Comparisons: — The description of the type is incomplete in some respects; *e.g.*, the shape of the body in dorsoventral view and the structure of the cingular lists are unknown; and the number and the extension of the parasagittal lists are uncertain.

The structurally closest-known relative of *Phalacroma bipartitum* is *P. limbatum* (see p. 164). The former is more advanced than the latter in having a relatively lower epitheca and in having a parasagittal list with two, instead of one, acute, triangular posterior sails. It is more primitive in having the parasagittal list of the hypotheca relatively shorter and in lacking parasagittal lists on the epitheca. It should be noted, however, that the extension of the parasagittal list of the hypotheca presumably is variable (see *Dinophysis collaris*, p. 295).

Phalacroma bipartitum resembles *Dinophysis collaris* in having the parasagittal list of the right valve furnished with two subequal and triangular posterior sails. Whether or not this similarity is an indication of a close relationship cannot be decided. *Dinophysis collaris* is more advanced than *Phalacroma bipartitum* in the rather irregular shape of its body in lateral view, in the reduced height of its epitheca, and in its larger and more differentiated cingular and sulcal lists.

Occurrence: — This species is recorded at only one (4736, the type locality) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 81°. The frequency is less than 1% (one specimen).

Phalacroma pulchrum Kofoid and Michener

Plate 3, fig. 1, 6. Figure 21: 3

Phalacroma pulchra Kofoid & Michener, *partim*, 1911, p. 290, 291.
Phalacroma circumsutum Jörgensen, *partim*, 1923, p. 17, 43, fig. 18.
Phalacroma pulchrum Jörgensen, 1923, p. 18.

Diagnosis: — Body subcircular in lateral outline, subtruncate anteriorly, deepest near the middle; length: depth, 0.99–1.03:1. In dorsal view narrowly obovate, 1.80 times longer than wide. Posterior cingular list 0.19–0.24 the length of body from apex; epitheca sometimes hardly visible above anterior cingular list. Cingular lists somewhat inclined anteriorly, without ribs. Left sulcal list: distance between R_1 and R_3 is 0.41–0.43 the length of body; R_2 is 0.14–0.16, and R_3 is 0.33–0.38 the greatest depth of body; margin forms angle of 50°–60° at R_3; R_3 inclined posteriorly at 35°–40°. Two parasagittal lists on hypotheca; the left very narrow, sometimes possibly absent. The right continues left sulcal list; dorsally its maximum width is subequal to or less than half the width of transverse furrow; on antapex it forms an acute, wedge-shaped posterior sail directed posteriorly. Sail, when fully developed, 0.33–0.43 the greatest depth of body in length, with central rib whose base might be divided; angle at tip, 30°–40°. Ventrally to sail, width of list is 0.50–1.75 the width of transverse furrow; with about 8–11 short riblets. Theca with fine reticulation. Length, 51.2–52.5 μ.

Tropical, subtropical, and warm-temperate seas.

Description: — A rather small species, the body of which is subcircular in lateral outline, subtruncate anteriorly, and deepest near the middle. The ratio between the length and the greatest depth of the body is 0.99–1.03: 1. The longitudinal axis is perpendicular to the girdle.

The epitheca is 0.77–0.80 as deep as the hypotheca, highest in the center, of moderate convexity to rather flat, and but slightly elevated above the anterior cingular list. The transverse furrow is flat, or slightly convex to concave, and its width is 0.8–2.0 the greatest height of the epitheca. The posterior cingular list is 0.19–0.24 the length of the body from the apex. The hypotheca is almost symmetrical; sometimes, as in the type specimen, it is subcircular, with confluent dorsal, posterior, and ventral margins; sometimes, as in the specimen figured by Jörgensen (1923, fig. 18), its ventral margin is flattened, and its postmargin forms a broadly rounded, subrectangular corner. In dorsoventral view the body is narrowly obovate, about 1.80 times longer than wide, widest somewhat in front of the middle, somewhat more broadly rounded anteriorly than posteriorly, narrowly rounded posteriorly, and with evenly convex side contours.

The cingular lists have an anterior inclination of 20°–40°; the anterior is about as wide as the transverse furrow, the posterior often is slightly narrower. The sulcus is about half as long as the hypotheca. The flagellar pore is located at a distance about equaling its own diameter behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a small pore is found near the sagittal suture, just in front of the anterior cingular list. The right sulcal list sometimes ends at or somewhat behind a point midway between the fission rib and the posterior main rib of the left sulcal list; sometimes it extends even to the last-mentioned rib; its anterior half is about as wide as the transverse furrow; posteriorly it decreases gradually in width. The left sulcal list is rather large; the distance between its anterior and posterior main ribs is 0.41–0.43 the length of the body. The anterior main rib is 0.14–0.15, the fission rib 0.14–0.16, and the posterior main rib 0.33–0.38 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list either is nearly straight or slightly sigmoid; in the latter case it is slightly concave anteriorly and convex posteriorly, or *vice versa;* at the posterior main rib it is somewhat acuminate and forms an angle of 50°–60°; behind the last-mentioned rib it is gently concave. The main ribs of this list are of moderate strength and straight or almost so; none of them is club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.33–0.37 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 35°–40°. Somewhat behind the posterior main rib there is in some specimens (Jörgensen, 1923, fig. 18) a fine rib with a posterior inclination of about 75°. Except the ribs mentioned above, the left sulcal list lacks structural differentiations. There are two parasagittal lists on the hypotheca, but none on the epitheca. The left one of these two lists extends, on the dorsal side of the body, from the posterior cingular list to the antapex; it is very narrow, of subuniform width throughout its entire length, and furnished with a few cross-ribs; its maximum width is less than half the width of the transverse furrow; in some specimens (Jörgensen, 1923, fig. 18) it may be absent. The right parasagittal list forms a direct continuation of the left sulcal list; sometimes, as in the type specimen, it extends to the posterior cingular list; sometimes, as in the specimen figured by Jörgensen (1923, fig. 18), it is not developed on the dorsal side of the hypotheca. On the dorsal side this list is narrow, about as wide as or slightly wider than, the left list, of subuniform width throughout, and furnished with a few cross-ribs; posteriorly it forms an acute, wedge-shaped posterior sail directed posteriorly. The sail, when fully developed, is 0.33–0.43 the greatest depth of the body in length, and has a central rib which arises from the antapex, and whose base might be divided; the angle at its tip is 30°–40°. Between this rib and the posterior main rib of the left sulcal list, the right parasagittal list has a minimum width equaling 0.50–1. 75 the width of the transverse furrow, and its margin is evenly concave, or slightly undulating as in the type specimen; along the base of this portion of the list there are 8–11 short, nearly equidistant, simple or bifurcate riblets; see also the accessory rib of the left sulcal list.

The thecal wall is finely reticulate (Jörgensen, 1923, fig. 18) and furnished with scattered pores. Sometimes the reticulation is so faint as to make it difficult to detect.

Megacytic stages were not recorded.

The dimensions of the type and of the specimen figured by Jörgensen (1923, fig. 18) were measured.

Dimensions: — Length of body, 51.2 μ. Greatest depth of body, 51.6 μ. Specimen figured by Jörgensen (1923, fig. 18): Length of body, 52.5 μ. Greatest depth of body, 51.0 μ.

Variations: — Very little is known about the variability of this species. The specimen figured by Jörgensen (1923) is somewhat more pointed posteriorly than the type specimen, and its right sulcal list is somewhat smaller. The structure of the thecal wall is sometimes fairly well developed, sometimes almost invisible.

Comparisons: — The description and figures are based on the type material.

The structurally closest-known relative of *Phalacroma pulchrum* is *P. limbatum*. The former can easily be distinguished by its low epitheca and by the absence of parasagittal lists from the epitheca (see *P. limbatum*, p. 164).

Synonymy: — Some of the specimens on which Kofoid and Michener (1911) based their description, have in the present paper been referred to *P. cuneolus*, sp. nov. *Phalacroma circumsutum* Jörgensen (1923) includes *P. circumsutum* Karsten and *P. pulchrum* Kofoid and Michener.

Occurrence: — *Phalacroma pulchrum* is recorded at six of the 127 stations. There are 0, 0, 0, 4, 1, and 1 stations on the six lines of the Expedition. Of these six stations, one (4699) is in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; four (4701, 4705, 4730, 4740) are in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these six stations at the surface was 72°–81°; the average was 75.9°.

The frequency is less than 1% in all the cases recorded.

The species was first recorded by Kofoid and Michener (1911) at Station 4699, the type locality. Later Jörgensen (1923) found it in the Mediterranean, the Thor Expedition, and possibly also in the Guinea Current, the German South Pole Expedition.

This is a eupelagic species widely distributed in tropical, subtropical, and warm-temperate seas. The most outstanding peculiarities of its distribution in the Eastern Pacific are its absence from surface catches, as well as from the California Current, Mexican Current, Panamic Area, and Peruvian Current. Its optimum habitat probably is in deeper waters within the levels of photosynthesis, and in the most distinctively tropical regions.

8. Doryphorum Group. Of the five species of this group only *Phalacroma pugiunculus* was not found by the Expedition.

Phalacroma mucronatum, sp. nov.

Figure 22: 4, 6, 8

Diagnosis: — Body subcircular in lateral outline, sometimes slightly deeper anteriorly than posteriorly; length: depth, 1.07–1.11:1. Posterior cingular list 0.33–0.41 the length of body from apex. Left sulcal list 0.50–0.54 the length of body; distance from R_1 to R_3 is 0.33–0.37 the length of body; R_2 is about 0.17, and R_3 about 0.30 the greatest depth of body; margin forms angle of 80°–90° at R_3; R_3 inclined posteriorly at 30°–40°. With triangular posterior sail, placed on antapex and directed posteriorly; when fully developed, its length is 0.28–0.40 the greatest depth of body, and it is somewhat narrower than long; without or with central rib; well separated from left sulcal list. Theca porulate (and finely areolate?). Length, 35.0–45.4 μ.

Eastern tropical Pacific.

Description: — A small species, the body of which is subcircular in lateral outline, deepest near the middle, and sometimes slightly deeper anteriorly than posteriorly. The ratio between the length and the depth is 1.07–1.11:1. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is 0.89–0.94 as deep as the hypotheca, evenly and moderately convex, highest in the center, and moderately elevated or rather prominent above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 0.5–1.0 the greatest height of the epitheca. The posterior cingular list is 0.33–0.41 the length of the body from the apex. The hypotheca is symmetrical, with well or moderately rounded dorsal and ventral margins; the posterior margin is rather strongly convex and confluent with the dorsal and ventral margins. The posterior portion of the hypotheca is of about the same width as, or slightly narrower than, the epitheca. The shape of the body in dorsoventral view is not known with certainty, as all the specimens drawn in this aspect were megacytic. It appears to be rather narrowly obovate, widest somewhat in front of the middle, with rounded apices, and with the antapical end somewhat narrower than the epitheca.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; their structure is unknown. The right sulcal list is unknown. The left sulcal list is of moderate length and width. Its length is 0.50–0.54 the length of the body, and the distance between the anterior and posterior main ribs is 0.33–0.37 the length of the body. The anterior main rib is 0.15–0.20, the fission rib about 0.17, and the posterior main rib about 0.30 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight or slightly concave; at the posterior main rib it forms an angle of 80°–90°; behind the last-mentioned rib it is almost straight or slightly concave or convex. The main ribs of this list are of moderate strength, straight or almost so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is about 0.50 the distance between the anterior and posterior main ribs. The posterior rib has a posterior inclination of 30°–40°. Except for the three main ribs, this list appears to lack structural differentiations. On the right valve there is an acute, triangular posterior sail, which is located on the antapex and is directed posteriorly. When fully developed, its length is 0.28–0.40 the greatest depth of the body, and it is somewhat narrower at its base than it is long; sometimes its length is about twice the basal width. Its margins are almost straight or gently concave, convex or sigmoid, and the angle at its tip is 15°–40°. In some specimens this sail lacks structural differentiations, in others it has a central rib which may be divided at the base. The sail is well separated from the left sulcal list. The distance between these two structures is variable; in the specimens examined it equals at least half the basal width of the sail. There are no parasagittal lists.

The thecal wall has scattered pores. Areolation was not seen, but might have been overlooked.

Megacytic stages have been seen (Figure 22: 6).

The proportions of three specimens were measured.

Dimensions: — Length of body, 35.0–45.4 μ (average, 40.7 μ; type, 38.8 μ). Greatest depth of body, 32.6–41.2 μ (average, 36.2 μ; type, 34.9 μ).

Variations: — The five specimens examined are very similar. They exhibit variations mainly in the size of the body, the relative height of the epitheca, and the shape and structure of the posterior sail.

Comparisons: — The species is established on outline drawings of five Expedition specimens.

It probably has about the same habitus as the ancestral form from which *Phalacroma doryphorum*, *P. circumsutum*, *P. cuneolus*, and *P. pugiunculus* originated. The following of its characters are more or less primitive: its small size, its subcircular shape in lateral view, the relatively great height of its epitheca, the fact that its left sulcal list is relatively long and not unusually wide posteriorly, and that the posterior main rib of this list is not club-shaped. *Phalacroma mucro-*

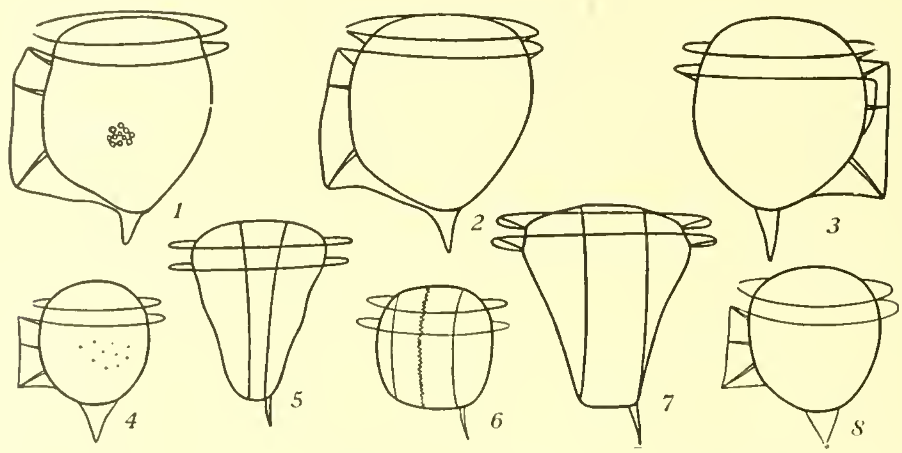

FIGURE 22.— 1, 2, 3, 5, 7, *Phalacroma cuneolus*, sp. nov. 1, 2, left lateral view; 3, right lateral view; 5, 7, dorsal view (megacytic). Surface markings, areolation, indicated only on small portion of theca in 1. 1, 5, from type specimen. × 430. Station 4711 (300–0 fathoms). 4, 6, 8, *Phalacroma mucronatum*, sp. nov. 4, 8, left lateral view; 6, dorsal view (megacytic). × 430. 4, 6, type specimen, from Station 4730 (300–0 fathoms); 8, from Station 4638 (300–0 fathoms).

natum differs from the four species mentioned in its smaller size and in the subcircular shape of its body. *Phalacroma doryphorum* appears to be its closest relative.

Occurrence: — *Phalacroma mucronatum* is recorded at four of the 127 stations. There are 0, 1, 1, 1, 1, and 0 stations on the six lines of the Expedition. Of these four stations, one (4638) is in the Panamic Area, and three (4681, 4711, 4730) are in the South Equatorial Drift. All records refer to hauls from 300–0 fathoms only. Station 4730 is the type locality.

The temperature range of these four stations at the surface was 68°–79°; the average was 74.5°.

At one station (4638) the frequency is 2%; in the remaining cases it is less than 1%.

PHALACROMA DORYPHORUM Stein

Figure 23: 1–5; 24

Phalacroma doryphorum STEIN, 1883, p. 23, pl. 19, fig. 1–4. BÜTSCHLI, 1885, p. 942. SCHÜTT, 1895, p. 56, 89, pl. 4, fig. 19; 1899, p. 42, pl. 6, fig. 17. MURRAY & WHITTING, 1899, p. 330, tab. 1–9. LEMMERMANN, 1899a, p. 319, 320, 372; 1901a, p. 372; 1905a, p. 35. SCHRÖDER, 1900a, p. 19; 1906a, p. 325, 327, 330; 1911, p. 25, 37. CLEVE, 1900b, p. 1031; 1901a, p. 17; 1901c, p. 270; 1902b, p. 36; 1903b, p. 347. SCHMIDT, 1901, p. 137. OSTENFELD & SCHMIDT, 1901, p. 176. ENTZ, 1902b, p. 94; 1905, p. 111. LOHMANN, 1902, p. 53; 1908a, p. 161; 1920, p. 484, 492, 568. PAVILLARD, 1905, p. 58, 81, 102; 1909, p. 283; 1915a, p. 2, fig. B; 1916, p. 47, 49, 50, 52, 60, fig. 12, pl. 3, fig. 8. KARSTEN, 1906, p. 185, 187, 189, 191; 1907, p. 228, 238, 240, 247, 257, 285, 295, 304, 318, 321, 334, 337, 340, 341, 343, 347, 348, 349, 352, 354, 355, 421, 438, 464, 471. NATHANSOHN, 1908, p. 604; 1909, p. 47; 1910a, p. 14, 17, 20; 1910b, p. 61. GRÄF, 1909, p. 136. STÜWE, 1909, p. 252, 287. HENSEN, 1911, p. 166, tab. 15. OKAMURA, 1912, p. 18, pl. 5, fig. 77. SCHILLER, 1912, p. 27. FORTI, 1922, p. 104, 190, 208, fig. 107. JÖRGENSEN, 1923, p. 16, 17, 37, 44, fig. 17. FORTI & ISSEL, 1923, p. 3.

Diagnosis:—Body obovate or subovate in lateral outline, deepest at or generally somewhat behind girdle; length: depth, 1.05–1.17: 1. In dorsal view narrowly obovate or subcuneate; narrowly rounded or subacute posteriorly. Posterior cingular list 0.17–0.37 the length of body from apex. Cingular lists without ribs. Left sulcal list rather short, often high posteriorly; length, 0.41–0.55 the length of body; distance between R_1 and R_3 is 0.26–0.38 the length of body; R_2 is 0.11–0.17, R_3 is 0.24–0.45 the greatest depth of body; margin forms angle of 50°–90° at R_3; R_3 inclined posteriorly at 15°–40°, often club-shaped. With triangular posterior sail, either on or usually somewhat ventrally to antapex, and inclined ventrally at 0°–35°; when fully developed, its length is 0.20–0.37 the greatest depth of body, and it is about as wide as long or slightly narrower; with or without central rib or reticulation; usually well separated from left sulcal list. Theca finely and closely areolate. Length, 54–86 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is obovate or subobovate in lateral outline, deepest at or in most specimens somewhat behind the girdle and 1.11 (1.05–1.17) times longer than deep. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is evenly and moderately convex to rather flat, highest in the center, and moderately or but slightly elevated above the anterior cingular list. In the Expedition specimens it is about 0.90 (0.85–0.92) as deep as the hypotheca; in the specimen represented by Stein (1883, pl. 19, fig. 2), on the other hand, the epitheca and the hypotheca are of about equal depth. The transverse furrow is flat or slightly convex, and its width is about 0.33–0.50 the greatest height of the epitheca. The posterior cingular list is 0.31 (0.17–0.37) the length of the body from the apex. The hypotheca is symmetrical; sometimes it is, as Jörgensen (1923, p. 16) expresses it, of an "oval wedge-shape," with rather flat dorsal and ventral margins; sometimes it is regularly oval, with well or moderately rounded dorsal and ventral margins; the posterior margin is strongly convex and confluent with the dorsal and ventral margins. The posterior portion of the body is strikingly narrower than the anterior. In dorsoventral view (Stein, 1883, pl. 19, fig. 4; Okamura, 1912, pl. 5, fig. 77b) the body is narrowly obovate or subcuneate, widest somewhat in front of the middle, and narrowly rounded or subacute posteriorly.

The cingular lists are subequal and subhorizontal, or slightly inclined anteriorly; their width about equals the width of the transverse furrow, and they are hyaline, and without ribs or other structural differentiations. The right sulcal list ends at a point about halfway between the fission rib and the posterior main rib of the left sulcal list, or it extends to or even slightly beyond the posterior main rib of the last-mentioned list; in some specimens it is subtriangular, decreasing gradually in width posteriorly; in other specimens it is of almost equal width throughout its anterior half or even throughout the greater portion of its length; anteriorly it is about as wide as the transverse furrow. The left sulcal list is rather short, and often comparatively high posteriorly. Its length is 0.46 (0.41–0.55) the length of the body, and the distance between the anterior and posterior main ribs is 0.29 (0.26–0.38) the length of the body. The anterior main rib is 0.11 (0.08–0.14), the fission rib 0.13 (0.11–0.17), and the posterior main rib 0.31 (0.24–0.45) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list often is almost straight; sometimes it is gently concave or convex, or it is slightly sigmoid, concave anteriorly and convex posteriorly; at the posterior main rib it forms an angle of 70° (50°–90°); behind the last-mentioned rib it is almost straight, or gently concave or convex. The main ribs of this list are of moderate strength and straight or nearly so; in most of the specimens examined the posterior main rib is club-shaped (see also Schütt, 1895, pl. 4, fig. 19: 2, and Jörgensen, 1923, fig. 17); in the specimens drawn by Stein (1883), on the other hand, this rib is not club-shaped. The distance between the anterior main rib and the fission rib is 0.35–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 25° (15°–40°). Except for the three main ribs, this list seems to be without structure in most specimens; sometimes it may have a very faint reticulation. On the right valve there is an acute, triangular, posterior sail, which is situated either on or usually somewhat ventrally to the antapex, and is inclined ventrally at 0°–35°. The size of this sail is somewhat variable, probably due to the fact that in each binary fission one of the daughter schizonts has to form this structure anew. When fully developed, its length is 0.20–0.37 the greatest depth of the body, and it is about as wide at the base as it is long or slightly narrower. Its margins are almost straight, or gently concave, convex, or sigmoid, and the angle at its tip is 40°–90°. In some specimens the sail has a central rib, in others it is more or less reticulated, especially in its central portion; sometimes both the central rib and the reticulation are developed, sometimes no structure can be distinguished. In most specimens the sail is well separated from the left sulcal list; the distance between these two structures is variable, but usually it equals at least half the basal width of the posterior sail. Only in one specimen (Figure 23: 5) were these structures connected, and this specimen appeared still to be in a condition of reorganization following binary fission. There are no parasagittal lists.

The thecal wall is finely and closely areolate and has scattered pores; the areoles are subequal or somewhat unequal in size. In the transverse furrow there are two rows of pores.

Megacytic stages have been recorded (see Pavillard, 1916, fig. 12, and Jörgensen, 1923, p. 17).

The proportions of seven Expedition specimens and of the specimens drawn by Stein (1883), Schütt (1895), Okamura (1912), and Jörgensen (1923) were measured.

Dimensions: — Length of body, 62.7–73.8 μ (average, 67.2 μ). Greatest depth of body, 56.7–62.8 μ. Though the size of the type specimen figured by Stein (1883, pl. 19, fig. 1) is not known it probably was somewhere between 69 μ and 104 μ long; and the specimen represented by Stein (1883, p. 31, pl. 19, fig. 2) was somewhere between 86 μ and 128 μ long. The specimen figured by Schütt (1895, pl. 4, fig. 19: 2) was about 70.5 μ long and 61.6 μ deep; Okamura's (1912, pl. 5, fig. 77) about 54 μ long and 48.7 μ deep; and Jörgensen's (1923) about 68 μ long and 62 μ deep. According to Lohmann (1902, p. 53), this species is 86 μ long.

Variations: — In spite of the fact that *Phalacroma doryphorum* is "a very characteristic and easily recognizable species" (Jörgensen, 1923, p. 16), it exhibits a considerable variability in several respects. The following characters are more or less strikingly variable: — the size and shape of the body, the relative height of the epitheca, the shape of the left sulcal list, the length and shape of the posterior main rib of this list, the position, direction, and structure of the posterior sail, and the distance between this structure and the left sulcal list.

Comparisons: — Under the name of *Phalacroma doryphorum*, Stein (1883, pl. 19, fig. 1, 2, 3) figures three specimens of fairly different habitus. One, the type specimen (pl. 19, fig. 1), has a regularly obovoidal body, deepest somewhat behind the girdle, and with comparatively high epitheca. The others (pl. 19, fig.

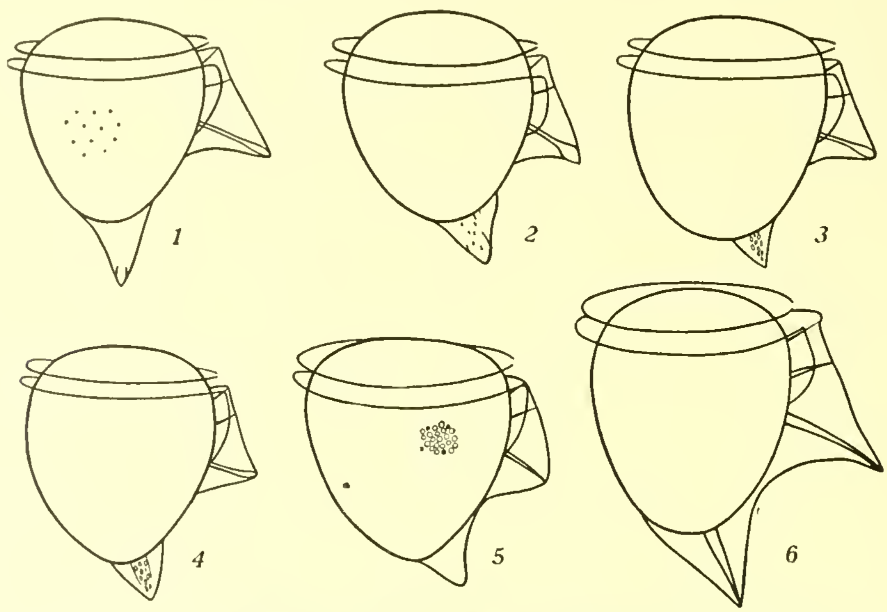

FIGURE 23.— 1–5, *Phalacroma doryphorum* Stein, right lateral view. Surface markings, areolation, and porulation indicated only on small portion of theca in 1 and 5. × 430. 1, from Station 4737 (300–0 fathoms); 2, from Station 4590 (300–0 fathoms); 3, 4, from Station 4664 (300–0 fathoms); 5, from Station 4681 (300–0 fathoms). 6, *Phalacroma circumsutum* Karsten, right lateral view. × 430. Station 4638 (300–0 fathoms).

2, 3) are deepest at the girdle, and have the epitheca rather flat and the hypotheca of an oval wedge-shape. The question as to whether or not these differences are specific cannot be settled. Most of the specimens in the material of the Expedition assigned to *P. doryphorum* agree fairly closely with the type specimen as far as the shape of the body is concerned, but differ in the shape and relative length of the left sulcal list and of its posterior main rib, and in the position and direction of the posterior sail. In spite of these differences our assignments may be regarded as fairly certain.

The specimens figured by Schütt (1895), Okamura (1912), and Jörgensen (1923) fall within the range of variations established for the Expedition specimens.

The structurally closest-known relative of *Phalacroma doryphorum* is *P. circumsutum.* The first species differs from the last mainly in having the left sulcal list and the posterior sail well separated; furthermore, the posterior main rib of its left sulcal list generally is club-shaped.

Next to *Phalacroma circumsutum*, *P. mucronatum* appears to be the nearest-known relative of *P. doryphorum*. *Phalacroma mucronatum* probably agrees fairly closely with the ancestral form from which *P. doryphorum* evolved, as indicated by the following characteristics: — it is a small species, 35.0–45.4 μ long, subcircular in lateral view, with rather high epitheca, with the left sulcal list relatively long and not exceptionally wide posteriorly, and with the posterior main rib of this list not club-shaped.

Phalacroma cuneolus and *P. pugiunculus* may possibly also belong to the same evolutionary series as *P. doryphorum;* the last is readily distinguished from these two species by its regularly obovoidal body and wider posterior sail.

With regard to the possible relationship between *Phalacroma doryphorum* and *P. ovum*, see the section on comparisons (p. 120).

Synonymy: — With regard to Jörgensen's (1923, pl. 17) assumption that figure G: 2, of *Dinophysis galea* Pouchet (1883), represents a specimen of *Phalacroma doryphorum*, see *P. circumsutum*, p. 184.

Occurrence: — *Phalacroma doryphorum* is recorded at seventy-five of the 127 stations. There are 16, 21, 8, 9, 12, and 9 stations on the six lines of the Expedition. Of these seventy-five stations, one (4583) is in the California Current; twelve (4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4545, 4546) are in the Mexican Current; nine (4609, 4611, 4613, 4617, 4619, 4631, 4634, 4637, 4644) are in the Panamic Area; twenty (4646, 4647, 4648, 4650, 4651, 4652, 4655, 4659, 4660, 4661, 4662, 4663, 4664, 4665, 4667, 4669, 4671, 4675, 4676, 4678) are in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; two (4713, 4715) are in the Galapagos Eddy; twenty (4679, 4681, 4683, 4701, 4707, 4709, 4711, 4717, 4719, 4720, 4721, 4722, 4724, 4728, 4730, 4732, 4734, 4737, 4739, 4740) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; two (4541, 4542) are in the Equatorial Counter Current; and one (4543) is in the North Equatorial Current. There are twenty-six records from the surface (Stations 4583, 4588, 4592, 4596, 4600, 4604, 4611, 4617, 4619 [Salpa], 4631, 4644, 4648, 4660 [Salpa], 4664 [Salpa], 4669, 4675, 4676, 4678, 4720 [Salpa], 4743, 4540, 4541, 4542, 4543, 4545, 4546); at four of these stations (4648, 4664, 4675, 4676) the species was taken in hauls from 300–0 fathoms as well as at the surface; at the other twenty-two stations in surface hauls only. At one station (4652) the species is recorded from 100–0 fathoms; at one station (4737) from 100–0 fathoms and 300–0 fathoms; at one station

(4655) from 400–0 fathoms; at two stations (4701, 4724) from 300–0 fathoms and 800–0 fathoms; at three stations (4647, 4751, 4662) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only.

The species is also recorded from surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these seventy-five stations at the surface was 65°–85°; the average was 75.3°. At the twenty-six stations in the surface catches of

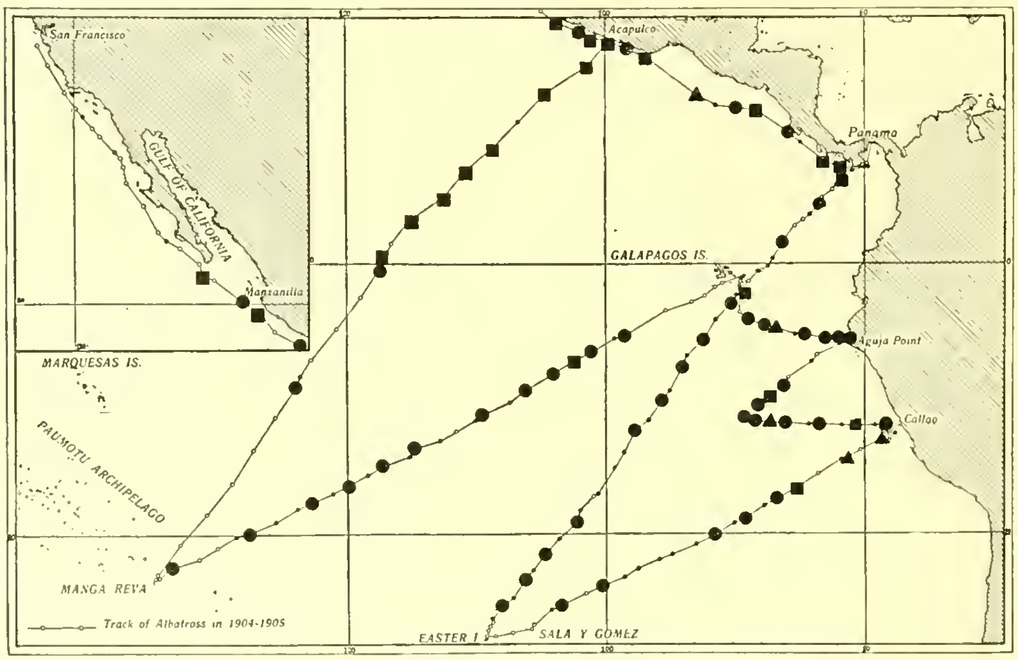

FIGURE 24.— Occurrence of *Phalacroma doryphorum* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

which this species was found, the surface temperature ranged from 67° to 84°; the average was 76.9°. At Acapulco it was 83°.

For the surface catches the following frequencies are recorded: — 7% at one station (4546), 5% at one station (4619), 3% at one station (4604), 2% at two stations (4669, 4675), 1% at eight stations (4600, 4617, 4720, 4743, 4540, 4541, 4543, 4545), and less than 1% at the remaining stations. For the catches from 100, 300, 400, or 800 fathoms to the surface the records of frequency are as follows: — 5% at one station (4663), 4% at one station (4590), 3% at five stations (4598, 4664, 4667, 4713, 4715), 2% at three stations (4675, 4689, 4699), 1% at nineteen stations (4605, 4613, 4634, 4637, 4647, 4648, 4651, 4671, 4676, 4679, 4691, 4695, 4697, 4701, 4719, 4722, 4730, 4737, 4739), and less than 1% at the remaining stations. For the catch made in Acapulco Harbor the frequency of 1% is recorded.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." Murray and Whitting (1899), who recorded it from the Atlantic, between lat. 43°4′ N. and lat. 0°16′ S., and from the Caribbean Sea, found it to occur "pretty constantly over the whole region examined." According to Cleve (1901c, 1902b, 1903b) it occurs in the Atlantic, between lat. 57° N. and lat. 39° S., and in the Caribbean Sea; only one of Cleve's several stations is located north of lat. 48° N., and this station, lat. 57° N., long. 14° W., is in the Gulf Stream. Hensen (1911) found it at a fairly great number of stations in various parts of the tropical and subtropical regions of the Atlantic. Lemmermann (1899a), Karsten (1906), and Stüwe (1909) recorded it from the Guinea Current; Lohmann (1920) from the Brazil Current, lat. 15° S., long. 34° W.; Jörgensen (1923) from the Bay of Cadiz and off the southwest coast of Portugal. From the Mediterranean there are the following records. Jörgensen (1923) found it at a very great number of stations "throughout the whole of the Mediterranean." Cleve (1903b) recorded it at lat. 37° N., long. 2° W.–8° E.; Pavillard (1905, 1909, 1915a, 1916) in the Gulf of Lyons; Nathansohn (1908, 1909, 1910a) off Monaco; Forti (1922) in the Ligurian Sea; Schröder (1900a) at Naples; Entz (1902b, 1905), Schröder (1911), and Schiller (1912), in the Adriatic Sea. Cleve (1900b, 1903b) and Ostenfeld and Schmidt (1901) found it in the Red Sea; Ostenfeld and Schmidt (1901) and Schröder (1906a) in the Gulf of Aden; Cleve (1901a, 1903b) and Schröder (1906a) in the Arabian Sea; Cleve (1901a) and Karsten (1907) in the Indian Ocean; Schröder (1906a) near Singapore; Schmidt (1901) in the Gulf of Siam; Okamura (1912) in Japanese waters; and Lemmermann (1899a) in the Pacific Ocean at lat. 6° N., long. 111° W. and lat. 12° N., long. 117° W.

Most of the records referred to in the last paragraph were from surface hauls. The only records of closing-net hauls published as yet are the following by Karsten (1907):— Station 227, lat. 2°56′ S., long. 67°59′ E., 1000–800 m.; Station 228, lat. 2°38′ S., long. 65°59′ E., 420–350 m.; Station 229, lat. 2°38′ S., long. 63°37′ E., 1600–1400 m.; Station 239, lat. 5°42′ S., long. 43°36′ E., 120–105 m.; Station 268, lat. 9°6′ N., long. 53°41′ E., 105–88 m. and 63–46 m.

All the specimens recorded were reported as "living."

According to these authors, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations		Salinity	Range	Number and Mean of Observations	
Murray and Whitting (1899)	60°–85°							
Cleve (1901a)		79.1°–86.7°				34.77–34.69		
Cleve (1901c)		57.9°–82.8°	55	71.6°		33.88–38.48	41	35.96
Cleve (1902b)	68.1°						11	36.12
Cleve (1903b)		60.3°–84.5°	14	75.9°		35.97–40.70	14	37.08
Ostenfeld & Schmidt (1901)	72.1°–80.1°							
Stüwe (1909)	68.5°–75.2°							

Of the authors who have contributed toward our knowledge of the distribution of this species only Stein (1883), Pavillard (1916), Okamura (1912), Forti (1922), and Jörgensen (1923) give descriptions or drawings by means of which their determinations of this species may be judged.

This species appears to be one of the most common representatives of Dinophysoidae (Jörgensen, 1923, p. 17). It is eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. Occasionally it is carried by warm currents into cooler regions (Cleve, 1901e). According to the Expedition records it is the most common species of this tribe and is almost evenly distributed throughout the area investigated. Although it probably has its optimum habitat in deeper waters, within the levels of photosynthesis, it is rather frequent at the surface. *Phalacroma doryphorum*, *P. rapa*, *P. cuneus*, and *P. favus* occur more frequently in the surface catches than any other species of Phalacroma; the numbers of surface records are 26, 22, 13, and 6, respectively; there are more surface records of *P. doryphorum* than of any other species of Phalacroma.

Phalacroma circumsutum Karsten

Figure 23: 6

Phalacroma circumsutum Karsten, 1907, p. 421, pl. 53, fig. 8. Steuer, 1910, p. 476, 478, fig. 246a; 1911, p. 252, fig. 214a. Jörgensen, 1923, *partim*, p. 17, 43.
?Dinophysis galea Pouchet, 1883, *partim*, p. 426, fig. G: 2.

Diagnosis: — Body obovate in lateral outline, deepest somewhat in front of middle; length: depth, 1.20–1.23: 1. Posterior cingular list 0.24–0.26 the length of body from apex. Cingular lists without ribs, sometimes inclined anteriorly at 10°–30°. Left sulcal list: distance between R_1 and R_3 is 0.33–0.38 the length of body; R_2 is 0.20–0.22, R_3 is 0.42–0.55 the greatest depth of body; margin acuminate at R_3 at angle of 35°–70°; R_3 inclined posteriorly at 25°. With acute, almost equilaterally triangular posterior sail supported by strong central rib, which is 0.43 the greatest depth of body, placed somewhat ventrally to antapex and inclined ventrally at 15°–20°; angle at tip of sail, 50°. Left sulcal list and posterior sail connected by list with minimum width 0.3–0.5 the width of transverse furrow, with or without parasagittal list along dorsal side of hypotheca. Theca finely and closely areolate. Length, 75.7–80.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, with the body obovate in lateral outline, deepest somewhat in front of the middle and 1.20–1.23 times longer than deep. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is 0.87–0.90 as deep as the hypotheca, highest in the center, of moderate convexity or rather flat, and moderately or but slightly elevated above the anterior cingular list. The transverse furrow is flat or but slightly convex; and its width is 0.50–0.60 the greatest height of the epitheca. The posterior cingular list is 0.24–0.26 the length of the body from the apex. The hypotheca is symmetrical; its ventral, posterior, and dorsal margins are confluent; the ventral and dorsal margins are of moderate convexity; the posterior margin is strongly convex. The posterior part of the body is strikingly narrower than the anterior.

The cingular lists are subequal, and either subhorizontal or inclined anteriorly at about 10°–30°; their width about equals or somewhat exceeds the width of the transverse furrow; and they appear to lack ribs and other structural differentiation. The right sulcal list extends almost to the posterior main rib of the left sulcal list; its anterior half is about as wide as the cingular lists, *i.e.*, it is decidedly narrower than the left sulcal list; posteriorly the list decreases gradually in width. The left sulcal list is of moderate length and rather wide posteriorly. The distance between the anterior and the posterior main ribs is 0.33–0.38 the length of the body. The anterior main rib is 0.18–0.19, the fission rib 0.20–0.22, and the posterior main rib 0.42–0.55 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The free margin of this list is gently concave or almost straight between the anterior main rib and the fission rib, as well as between the fission rib and the posterior main rib; at the posterior main rib it is more or less acuminate and forms an angle of 35°–70°; behind the posterior main rib it is gently concave. The main ribs of this list are of moderate strength and none of them is club-shaped or otherwise modified; the anterior main rib and the fission rib are straight or almost so, the posterior main rib is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.45 the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of about 25°. Disregarding the three main ribs, this list appears to lack structural differentiation. On the right valve there is an acute, almost equilaterally triangular posterior sail supported by a strong rib which arises somewhat ventrally to the antapex and ends at the tip of the sail. This rib has a ventral inclination of 15°–20°, and its length is about 0.43 the greatest depth of the body; *i.e.*, it is about as long as or somewhat shorter than the main rib of the left sulcal list. The margins of this sail are almost straight or slightly curved, and the angle at its tip is about 50°. The posterior sail and the left sulcal list are connected by a short, but well-developed list, which at its narrowest place is about 0.3–0.5 as wide as the transverse furrow. The connecting list and the posterior sail, disregarding the main rib of the latter, appear to lack structural differentiation. The type specimen (Karsten, 1907, pl. 53, fig. 8) had an apparently structureless parasagittal list extending, on the dorsal side of the hypotheca, from the posterior cingular list to the posterior sail but not forming a direct continuation of the latter; this list was widest posteriorly and decreased gradually in width anteriorly; its greatest width about equaled that of the transverse furrow.

The structure of the theca is about the same as in *Phalacroma doryphorum*; *i.e.*, the wall is finely and closely areolate and furnished with scattered pores.

Megacytic stages have not been seen.

Dimensions: — Length of body, 75.7 μ. Greatest depth of body, 61.5 μ. Type specimen (Karsten, 1907, pl. 53, fig. 8): Length of body, 80.0 μ. Greatest depth of body, 66.7 μ.

Variations: — Very little is known about the variability of this species. The Expedition specimen differs from the type mainly in being slightly smaller (75.7 μ as compared with 80.0 μ), in having a slightly higher epitheca and a somewhat longer posterior main rib in the left sulcal list, and in lacking a parasagittal list along the dorsal side of the hypotheca. The specimen represented by Pouchet's (1883) figure G: 2, of *Dinophysis galea* has been disregarded because of the impossibility of being certain that his figure represents *P. circumsutum*.

Comparisons: — In spite of the several differences mentioned in the last section between the type of *Phalacroma circumsutum* and the Expedition specimen, the determination of the last seems justifiable. The differences in the size of the body, in the height of the epitheca and in the length of the posterior main rib of the left sulcal list appear of little systematic importance, since they are within the range of variation established for the closely-related species, *P. doryphorum*. The "parasagittal list" along the dorsal side of the hypotheca in the type of *P. circumsutum* may be the intercalary zone not yet resorbed following binary fission. It should be noted that this list does not form a direct continuation of the posterior sail as it does in *P. limbatum*, *P. pulchrum*, and in other species of this genus. Furthermore, in the closely related *P. doryphorum*, Pavillard (1916, p. 53) frequently found specimens "en voie de reconstitution portant encore des fragments irréguliers de la zone intercalaire le long de la ligne de suture."

Phalacroma circumsutum is structurally very similar to *P. doryphorum* (see Karsten, 1907, p. 426; and Jörgensen, 1923, p. 17), differing mainly in having the left sulcal list and the posterior sail connected by a rather wide sail; in addition, the posterior main rib of its left sulcal list is not club-shaped. See also *P. doryphorum*, p. 178.

Synonymy: — *Phalacroma circumsutum* Jörgensen (1923) evidently includes two systematic units. Jörgensen (1923, p. 17) writes as follows: "Besides a larger form, answering to Karsten's figure, with protracted lower end of left longitudinal fin (at the supporting spine) and large, somewhat ventrally directed terminal spine, there occurred in the 'Thor' material also a smaller and divergent form, with downward trending terminal spine, and slightly prominent corner of left longitudinal fin, shape of cell in profile broader in proportion, and epitheca higher." Of these two "forms" the larger probably should be assigned to *P. circumsutum* Karsten; the smaller, which is figured (Jörgensen, 1923, fig. 18), belongs to *P. pulchrum* Kofoid and Michener.

Of the four specimens represented by Pouchet (1883) under the name of *Dinophysis galea*, one (Pouchet, 1883, fig. G: 2) resembles *P. circumsutum* in the shape of its body and in having its large, triangular posterior sail connected with the left sulcal list by a rather wide sail. It differs from this species in having the left sulcal list relatively narrow posteriorly, in having two instead of one posterior main rib in this list, in lacking a central rib in its posterior sail, and in having its posterior sail directed posteriorly instead of posteroventrally. Jörgensen (1923, p. 37) assigns this specimen to *P. doryphorum*. This identification is contradicted by the fact mentioned above that, according to Pouchet's (1883) drawing, this specimen had the posterior sail connected with the left sulcal list by a fairly wide sail and by the shape of the left sulcal list. It may be noted in this connection that Pavillard (1916) found *P. doryphorum* to be common in the Gulf of Lyons, which is the type locality of *Dinophysis galea;* on the other hand, he never recorded *Phalacroma circumsutum* from these waters in spite of very intensive investigations. This fact, of course, seems to support Jörgensen's (1923) identification above mentioned. Pouchet's figure must be considered as insufficient for certainty of specific assignment until the question as to the occasional occurrence in *P. doryphorum* of a connection between the left sulcal list and the posterior sail is settled and until the variability of the left sulcal list and of the posterior sail in *P. circumsutum* has been further investigated.

The four specimens figured by Pouchet (1883) under the name of *Dinophysis galea* belong to four different species, two of which (fig. G: 1, 4) are referable to Ornithocercus, one (fig. G: 2) to Phalacroma, and one (fig. G: 3) to Ceratocorys. Since of these four figures, figure G: 2 appears to be the most accurate, it is suggested that it represent *D. galea*. This name antedates both *doryphorum* and *circumsutum*.

Occurrence: — This species is recorded at only one of the 127 stations. This station (4638) is on the second line of the Expedition and in the Panamic Area. The depth is 300–0 fathoms, the surface temperature 75°, and the frequency 1% (one specimen).

Karsten (1907), who found this species in the Indian Ocean, did not give any information as to the type locality. Jörgensen (1923) recorded it from a few stations in the Mediterranean (the Thor Expedition) and from the Guinea Current (the German South Pole Expedition). With regard to Jörgensen's (1923) data, see above.

This species, which is eupelagic, appears to be very rare and limited to tropical, subtropical, and warm-temperate waters.

PHALACROMA CUNEOLUS, sp. nov.

Figure 22: 1, 2, 3, 5, 7

Diagnosis: — Body subobovate in lateral outline; epitheca moderately convex to rather flat; ventral margin of hypotheca may form broadly rounded corner at R_3 of left sulcal list; deepest somewhat behind girdle; length: depth, 1.10–1.28: 1. In dorsal view cuneate; hypotheca acute to subacute posteriorly, its side contours gently concave or gently undulating; length: width, 1.44: 1. Posterior cingular list 0.22–0.33 the length of body from apex. Cingular lists may be somewhat inclined anteriorly. Left sulcal list of moderate length and width; distance between R_1 and R_2 0.45–0.52 the length of body; R_2 is 0.13–0.20, and R_3 is 0.26–0.31 the greatest depth of body; margin forms angle of 70°–100° at R_3; R_3 inclined posteriorly at 40°–55°. With rather narrow, triangular posterior sail, located on antapex and directed posteriorly; 0.18–0.31 the greatest depth of body in length, and 0.40–0.80 as wide as long; often connected with left sulcal list by narrow list. Theca finely and closely areolate. Length, 59.0–74.0 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subobovate in lateral outline, with moderately convex to almost flat epitheca, with the posterior portion of the hypotheca more or less narrowly rounded, with the ventral margin of the hypotheca sometimes broadly rounded-angular at the posterior main rib of the left sulcal list, and with the greatest depth somewhat behind the girdle. The ratio between the length and the depth of the body is 1.16 (1.10–1.28): 1. The longitudinal axis is perpendicular to the girdle, or it has a slight posteroventral inclination.

The epitheca is 0.88 (0.86–0.90) as deep as the hypotheca, evenly and moderately convex to rather flat, highest in the center, and moderately to rather slightly elevated above the anterior cingular list. The transverse furrow is flat, or slightly concave or convex, and its width is 0.60–1.10 the greatest height of the epitheca. The posterior cingular list is 0.26 (0.22–0.33) the length of the body from the apex. Some specimens (Figure 22: 3) have the hypotheca subsymmetrical. In these specimens the dorsal and ventral margins of the hypotheca are of moderate to gentle convexity, sometimes with almost even curvature, sometimes more or less flattened posteriorly; the postmargin is confluent with the dorsal and ventral margins, subrectangular, gently convex or almost straight dorsally and ventrally, and strongly rounded at the antapex. Other specimens, the type (Figure 22: 1), which are somewhat asymmetrical, have the dorsal margin of the hypotheca of about the same shapes as the subsymmetrical specimens, but the ventral margin is more or less irregular, being broadly rounded-angular at the posterior main rib of the left sulcal list; the postmargin is subrectangular, rather narrowly rounded at the antapex, and its ventral portion is gently convex to straight, or even slightly concave. Between these two types of hypotheca, transitional forms are to be found (Figure 22: 2). In dorsoventral view the body is cuneate, widest at the girdle, and about 1.44 times longer than wide. The epitheca is broadly rounded to rather flat; the hypotheca is acute to subacute posteriorly, and its side contours are gently undulating, as in the type specimen (Figure 22: 5), or gently concave or convex.

The cingular lists are subhorizontal or somewhat (10°–25°) inclined anteriorly, subequal, and about as wide as or slightly wider than the transverse furrow; their structure is unknown. The right sulcal list (observed in only one of the specimens; Figure 22: 3) extends to a point about halfway between the fission rib and the posterior main rib of the left sulcal list; it is subtriangular in shape, decreasing gradually in width posteriorly, and anteriorly about half as wide as the transverse furrow. The left sulcal list is of moderate length and width. The distance between the anterior and posterior main ribs is 0.47 (0.45–0.52) the length of the body. The anterior main rib is 0.16 (0.13–0.18), the fission rib 0.16 (0.13–0.20), and the posterior main rib 0.29 (0.26–0.31) the greatest depth of the body. Between the anterior and posterior main ribs the free margin of this list is straight, gently convex or concave, or slightly irregular (Figure 22: 1); at the posterior main rib it forms an angle of about 90° (70°–100°). When this list is not connected with the posterior sail, its margin behind the posterior main rib is straight, or slightly concave or convex. The main ribs of this list are of moderate strength, straight or almost so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.33 (0.29–0.40) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 40°–55°. It is not known whether this list has any structure besides the three main ribs. On the right valve there is an acute, rather narrow, triangular posterior sail, which is located on the antapex and directed posteriorly. When fully developed its length is 0.18–0.31 the greatest depth of the body, and it is, at the base, 0.40–0.80 as wide as long. Its margins are almost straight, or gently convex, concave, or sigmoid, and the angle at its tip is 20°–40°. Its structure is unknown. In some specimens (Figure 22: 3) the posterior sail is separated from the left sulcal list by a distance that about equals or even exceeds its basal width. In other specimens (Figure 22: 1, 2) these two structures are connected by a rather narrow list.

The thecal wall is finely and closely areolate. Porulation was not observed.

Megacytic stages were seen.

The dimensions of five specimens were measured.

Dimensions: — Length of body, 59.0–74.0 μ (average, 64.2 μ; type, 60.3 μ). Greatest depth of body, 51.3–58.0 μ (average, 54.3 μ; type, 51.3 μ).

Variations: — This species is rather strikingly variable in the following characters: the shape and relative height of the epitheca, the shape of the ventral margin of the hypotheca, the shape of the side contours of the hypotheca in dorsoventral view, the development of the list connecting the left sulcal list with the posterior sail, and the inclination of the cingular list.

The structurally closest-known relative of *Phalacroma cuneolus* is *P. pugiunculus*. These two species agree rather closely in the shape of the body in lateral view, in the shape and relative size of the left sulcal list, and in the shape, direction, and relative size of the posterior sail. The outline of *P. pugiunculus* in dorsoventral view is unknown. The latter species can be distinguished from the former by its smaller size (49–53 μ as compared with 59–74 μ). The position of these two species is not readily established because of their simplicity. We have placed them preliminarily with *P. mucronatum, P. doryphorum,* and *P. circumsutum* on account of the general resemblance in the shape of the body in lateral view and because of the presence of a posterior sail.

The outline of the body of *Phalacroma cuneolus* in dorsoventral view is suggestive of *P. cuneus* and *Dinophysis expulsa* and their near relatives. However, this similarity probably is due to convergence and can hardly be considered as an indication of close relationships.

Occurrence: — *Phalacroma cuneolus* is recorded at only one (4711, type locality) of the 127 stations, on the fourth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 75°. The frequency is less than 1% (six specimens).

9. Praetextum Group. The single member of this group, viz., *Phalacroma praetextum*, differs so strikingly from the remaining species of Phalacroma in having a ventral cribriform plate on the hypotheca that it is made the type of a new subgenus, Ethmophalacroma, subgen. nov.

Phalacroma praetextum Kofoid and Michener

Plate 4, fig. 6, 7. Figure 25: 4, 5

Phalacroma praetexta Kofoid & Michener, 1911, p. 291.

Diagnosis: — Body rounded subbiconical in lateral outline, slightly broader posteriorly than anteriorly; deepest at girdle, 1.12 times longer than deep. In dorsal view subbiconical, with broadly rounded apices, and 1.17 times longer than wide. Posterior cingular list 0.51–0.53 the length of body from apex. Cingular lists about half as wide as transverse furrow, reticulated. Left sulcal list 0.34 the length of body, subtriangular, gradually decreasing in width posteriorly; anteriorly about as wide as transverse furrow; R_1 and R_2 weak, straight, and simple, R_3 absent. On ventral side of hypotheca a dumbbell-shaped, cribriform plate extending from girdle to antapex. Theca with heavy and rather wide-meshed reticulation; about fifteen polygons border the girdle posteriorly. Length, 61–62 μ.

Eastern tropical Pacific.

Description: — A rather small species, the body of which is rounded subbiconical in lateral outline, slightly broader posteriorly than anteriorly, and deepest at the girdle. The ratio between the length and the depth of the body is 1.12: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about as deep as or slightly deeper than the hypotheca, highest in the center, subconical, gently convex dorsally and ventrally, evenly and fairly broadly convex anteriorly, with the dorsal, anterior, and ventral margins confluent, and very prominent above the anterior cingular list. The transverse furrow is somewhat concave and its width is about 0.22–0.27 the greatest height of the epitheca. The posterior cingular list is 0.51–0.53 the length of the body from the apex. The hypotheca has almost the same shape as the epitheca but is somewhat more rounded; its posterior portion, therefore, is somewhat broader than the anterior portion of the epitheca; see the description of the structure of the theca. In dorsoventral view the body is subbiconical, with fairly broadly rounded apices, and with the side contours of the epitheca and of the hypotheca almost straight or slightly concave; it is widest at the girdle, and about 1.17 times longer than wide; see below, the description of the structure of the theca.

The cingular lists are subhorizontal, subequal, and about half as wide as the transverse furrow. Along the base of the anterior of these lists there is a series of ribs anastomosing into a row of polygons in the same way as for *Phalacroma cuneus*

Schütt (1895, pl. 3, fig. 14:2); the number of these polygons and the structure of the posterior cingular list are unknown. The sulcus is about half as long as the hypotheca. The flagellar pore is at the junction of the cingulum and the sulcus. On the ventral side of the left valve a fairly small pore is found near the sagittal suture, just behind the anterior cingular list. The right sulcal list is about half as long as the left sulcal list; posteriorly it gradually decreases in width, or its ventral margin is gently sigmoid, convex anteriorly and concave posteriorly; its greatest width somewhat exceeds half the width of the transverse furrow. The left sulcal list is 0.34 the length of the body, subtriangular, gradually decreasing in width posteriorly; anteriorly it is about as wide as the transverse furrow; it has two fairly weak, straight, and simple ribs, both of which are located in the anterior half of the list; the posterior main rib is absent (Plate 4, fig. 7). There are no accessory lists or sails.

On the ventral side of the hypotheca, just to the left of the sulcus, there is a dumbbell-shaped area, extending on both sides of the sagittal suture from the posterior cingular list to the antapex. Due to the fact that it is bordered by the posterior cingular list and by the sulcus, its anterior half is truncate and somewhat asymmetrical. The constriction in the middle is rather slight. This area, which has a maximum width of about 0.33 the dorsoventral diameter of the transverse furrow, is characterized by a structure quite different from that of the remaining portion of the theca. It has a faint reticulum of very small polygons, and in the center of each or at any rate of most of these polygons there is an exceedingly fine pore. In other words, this area has the structure of a cribriform plate. It is not known whether this area is permanent, or whether it is temporary and formed just before fission. The first alternative, which appears the more plausible, is suggested by the relative position of this area to the girdle, by the absence of an intercalary zone from the dorsal side of the body and from the ventral side of the epitheca, by the peculiar shape and structure of this area, and by the fact that an area of this kind was found in both the specimens. If this area is of an intercalary nature, then the non-megacytic specimens probably have the ventral margin of the hypotheca resembling that of *Phalacroma reticulatum*, and the posterior portion of their hypotheca is somewhat narrower than in the specimens described above.

The thecal wall has a heavy reticulum of rather large polygons, except in the cribriform plate described in the last paragraph. Most of the polygons are subuniform in size, and on each valve about fifteen of them border the posterior margin of the girdle. Each valve of the epitheca has about fifty-eight and each valve of the hypotheca about seventy-six polygons. In the transverse furrow there are two rows of polygons, each row with fourteen to sixteen polygons on each valve; near the junction of the cingulum and the sulcus these two rows may merge into a single row. Except in the cribriform plate, pores have not been seen.

With regard to megacytic stages, see p. 190.

The dimensions of one specimen, the type, were measured.

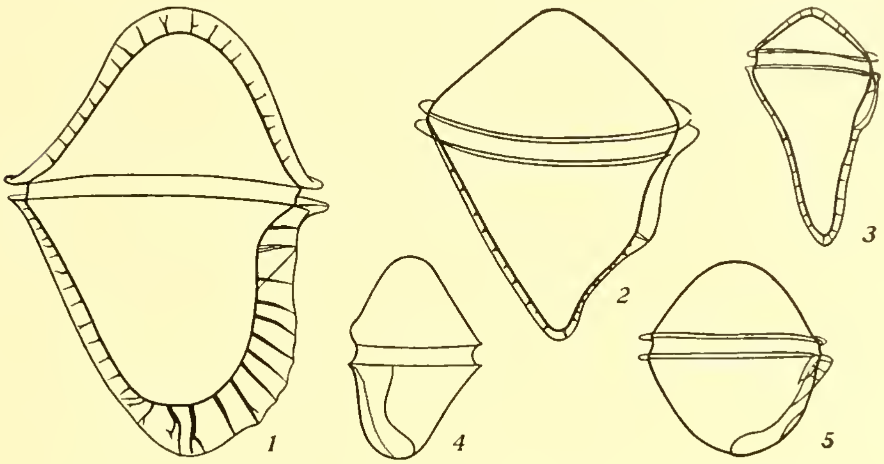

FIGURE 25.— 1, *Phalacroma fimbriatum* Kofoid and Michener, right lateral view of type specimen. × 430. Station 4613 (300–0 fathoms). 2, *Phalacroma reticulatum* Kofoid, right lateral view of type specimen. × 430. Station 4740 (300–0 fathoms). 3, *Phalacroma turbineum* Kofoid and Michener, right lateral view of type specimen. × 430. Station 4681 (300–0 fathoms). 4, 5, *Phalacroma praetextum* Kofoid and Michener; 4, oblique ventral view of detached left valve; 5, right lateral view of type specimen. × 430. Station 4742 (300–0 fathoms).

Dimensions: — Length of body, 61–62 μ (type, 61 μ). Greatest depth of body, 53.3 μ (type).

Comparisons:—The small size, the subcircular shape of the body in lateral view, the subequatorial position of the girdle, the relatively slight development of the cingular and sulcal lists, and the absence of accessory lists and sails are fundamental primitive features, which place this species among the most primitive living representatives of Phalacroma. On the other hand, the surface structure of the theca is better developed than in most species of the genus, and the cribriform plate of the hypotheca is unique and places the species in a rather isolated position. The species therefore appears to be a representative of a short evolutionary branch which split off at an early stage in the phylogenetic differentiation of the genus.

Phalacroma praetextum approaches *P. fimbriatum*, *P. reticulatum*, and *P. turbineum* in the tendency of its epitheca and hypotheca to taper toward the apices, and in the heavy and coarse reticulation of its thecal wall. However, in most respects it differs more or less strikingly from these three species, and it must be regarded as an open question whether or not the three characters mentioned above are indicative of a close relationship. *Phalacroma praetextum* resembles *P. apicatum* in the subbiconical shape of the body in dorsoventral view, in the reticulated structure of the anterior cingular list, and in the absence of posterior angularity in the free margin of the left sulcal list. *Phalacroma praetextum* is easily distinguished from all the known species by the large cribriform plate of its hypotheca.

Occurrence: — *Phalacroma praetextum* has thus far been recorded at only one (4742, the type locality) of the 127 stations, on the sixth line of the Expedition, in the South Equatorial Current, from 300–0 fathoms, and at a surface temperature of 77°. The frequency is less than 1% (two specimens).

10. Reticulatum Group. On account of the striking difference between the left sulcal list of the three members of this group, viz., *Phalacroma fimbriatum*, *P. reticulatum*, and *P. turbineum*, and that of the typical members of Phalacroma, it appears advisable to give this group the rank of a subgenus: Retephalacroma, subgen. nov., with *P. turbineum* the type.

Phalacroma fimbriatum Kofoid and Michener

Plate 2, fig. 1. Plate 4, fig. 4. Figure 25: 1

Phalacroma fimbriata Kofoid & Michener, 1911, p. 289.

Diagnosis: — Body subbiconical in lateral view, with well-rounded apices, deepest at girdle, 1.35–1.40 times longer than deep. In dorsal view biconical, subacute anteriorly, narrowly rounded posteriorly; but slightly narrower than in lateral view. Posterior cingular list 0.43 the length of body from apex. Each cingular list with twelve branched ribs on each valve. Margin of right sulcal list widely angular in the middle. Two parasagittal lists encircle body; the right one, which is much wider than the left, merges so completely into left sulcal list that the boundary between these two lists cannot be established. Right parasagittal list widest and of nearly uniform width on ventral and posterior sides of hypotheca, where it is 0.14–0.20 the greatest depth of body; on dorsal side of hypotheca and on epitheca it is about half this width. Parasagittal lists with numerous ribs, some of which are irregular and branched. Theca with heavy reticulation, forming large polygons; about ten polygons border girdle posteriorly. Length, 118 μ.

Eastern tropical Pacific.

Description: — A large species, the body of which is subbiconical in lateral outline, with well-rounded apices, and deepest at the girdle. The ratio between the length and the depth of the body is 1.35–1.40:1. The longitudinal axis has a very slight posteroventral inclination.

The epitheca is about as deep as the hypotheca, highest in the center, subconical, gently concave or almost straight dorsally and ventrally, evenly and well rounded anteriorly, with the dorsal, anterior, and ventral margins confluent, and very prominent above the anterior cingular list. The transverse furrow is somewhat concave, and its width is about 0.19 the greatest height of the epitheca. The posterior cingular list is about 0.43 the length of the body from the apex. The hypotheca has a very slight posteroventral inclination; its dorsal margin is gently concave or almost straight; its ventral margin is sigmoid, rather strikingly concave anteriorly, and gently and evenly convex posteriorly; its postmargin is evenly and fairly broadly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is biconical, subacute anteriorly and narrowly rounded posteriorly; the side contours of the epitheca and hypotheca are gently concave; the ratio between the length and the width is about 1.45–1.50:1.

The cingular lists are subhorizontal, subequal, and about as wide as or somewhat wider than the transverse furrow; each of them has on each valve about twelve rather strong, branched, and nearly equidistant ribs. The sulcus is about 0.40 the length of the hypotheca. The flagellar pore is slightly more than a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a rather small pore is found on the sagittal suture just in front of the anterior cingular list. The right sulcal list is about 0.22 the length of the body; the anterior half of this list is about 0.14 as wide as the body, and its free margin is gently concave or almost straight; the posterior half decreases gradually in width posteriorly, and its free margin is gently concave or nearly straight and forms a very wide but distinct angle with the free margin of the anterior half of this list. Two parasagittal lists encircle the body. The right one, which is much wider than the left, merges so completely into the left sulcal list that the boundary between these two lists cannot be established with certainty. For the sake of convenience in describing these structures, it is assumed that the first rib of this compound list behind the fission rib (easily recognized in the type specimen as it is split lengthwise) corresponds to the posterior main rib of the left sulcal list, and that it marks the posterior boundary of the last-mentioned list. Defined in this way, the left sulcal list is about as long as the right sulcal list, and has four simple, and almost straight and equidistant ribs. Three of these ribs would correspond to the three main ribs; the fourth, which is placed between the anterior main rib and the fission rib, would be an accessory structure. The width of the left sulcal list is almost uniform throughout the entire length and about equals 0.14–0.15 the greatest depth of the body. From the posterior main rib of the left sulcal list to the antapex, the right parasagittal list is of nearly uniform width, about 0.14–0.20 the greatest depth of the body; anterodorsally to the antapex this list gradually becomes narrower, and its average width on the dorsal side of the hypotheca is only about 0.07 the greatest depth of the body. The right parasagittal list of the hypotheca has about twenty-six fairly strong and almost equidistant ribs, most of which are simple and almost straight, a few irregular, or irregular and branched. The left parasagittal list of the hypotheca extends from the fission rib of the left sulcal list to the posterior cingular list on the dorsal side of the body; it is very narrow, at most about half as wide as the transverse furrow; its ribbing is unknown. The two parasagittal lists of the epitheca are of about the same width and structure; from the apex, where their width about equals 0.09 the greatest depth of the body, they slightly decrease in width toward the girdle; each of them has about twenty almost equidistant ribs, a few of which are branched.

The thecal wall has a heavy reticulum of rather large polygons, mainly subuniform, ten of which on each valve border the posterior margin of the girdle. Each valve of the epitheca has about forty and each valve of the hypotheca about sixty-seven polygons. The transverse furrow is divided by cross-ridges into rectangular fields, of which there are about twelve or thirteen on each valve. The whole theca has numerous scattered pores, about ten to twenty in each polygon. On the left valve of the hypotheca there is the unique feature of a large postcingular plate, bordered by a heavy ridge (Plate 2, fig. 1).

The type specimen is megacytic.

The dimensions of the type specimen were measured.

Dimensions: — Length of body, 118 μ (140 μ, with the parasagittal lists included). Greatest depth of body, 83 μ.

Comparisons: — The systematic position of *Phalacroma fimbriatum* is somewhat uncertain. In the size of the body, the shape of the body in dorsoventral view, and in the structural differentiation of the thecal wall, both in the reduction in number of polygons, and in the increase in their size and in the weight of the reticulations, this species is one of the most advanced members of the genus, and with regard to the development of the parasagittal lists it may be considered as the most advanced in the genus. On the other hand, in the position of the girdle it is very primitive. Its closest structural relatives possibly may be *P. reticulatum* and *P. turbineum;* see these two species, the sections on comparisons (p. 197, 200). These three species differ strikingly from one another in the shape of the body in lateral view and in the parasagittal lists.

With regard to the possible relationship between *Phalacroma fimbriatum* and *P. praetextum*, see p. 191.

Occurrence: — *Phalacroma fimbriatum* has been recorded at only one (4613, the type locality) of the 127 stations, on the first line of the Expedition, in the Panamic Area, from 300–0 fathoms, at a surface temperature of 80°. The frequency is less than 1% (one specimen).

Phalacroma reticulatum Kofoid

Plate 4, fig. 3, 5. Figure 25: 2; 26

Phalacroma reticulata Kofoid, 1907a, p. 195, pl. 12, fig. 72. Kofoid & Michener, 1911, p. 291. Pavillard, 1923a, p. 879.

Diagnosis: — Body biconical in lateral view, narrowly rounded anteriorly, narrowly rounded to subacute posteriorly, deepest at girdle, 1.25–1.30 times deeper than long. In dorsal view biconical, subacute anteriorly, acute posteriorly, and 1.65 times longer than wide. Posterior cingular list 0.40–0.45 the length of body from apex. Cingular list somewhat narrower than transverse furrow and apparently without ribs. Left sulcal list about 0.33 the length of the body; fairly narrow; its maximum width is 0.08 the greatest depth of body; with one rib near posterior end; free edge gently sigmoid, concave anteriorly and convex posteriorly. With a narrow parasagittal list on the hypotheca; this list forms a direct continuation of left sulcal list and extends to posterior cingular list. Theca with heavy and wide-meshed reticulation; about seven or eight polygons border girdle posteriorly. Length, 100–115 μ.

Eastern tropical Pacific.

Description: — A rather large species, the body of which is biconical, top-shaped in lateral outline, narrowly rounded anteriorly, subacute to acute posteriorly, and deepest at the girdle. The ratio between the length and the depth of the body is 1.25–1.30: 1. The longitudinal axis is about perpendicular to the girdle or but slightly deflected posteroventrally.

The epitheca is about as deep as or but slightly deeper than the hypotheca, highest in the center, and very prominent above the anterior cingular list; its dorsal and ventral margins are almost straight or gently convex, and about perpendicular to each other; anteriorly the epitheca is narrowly rounded. The transverse furrow is flat or somewhat convex or concave, and its width is 0.15–0.20 the greatest height of the epitheca. The posterior cingular list is 0.40–0.45 the length of the body from the apex. The hypotheca is conical, narrowly rounded or even subacute (Figure 25: 2) posteriorly; its dorsal margin (from the girdle to the antapex) is slightly and evenly convex or almost straight; its ventral margin (from the girdle to the antapex) is either gently and almost evenly convex, or it is gently undulating, concave anteriorly and posteriorly, and convex in the middle (Figure 25: 2). In dorsoventral view the body is biconical, top-shaped, widest at the girdle, and 1.65 times wider than long; anteriorly it is narrowly rounded, posteriorly it is acute; the side contours of the epitheca are almost straight and nearly perpendicular to each other; those of the hypotheca are gently sigmoid, concave anteriorly and convex posteriorly.

The cingular lists are subhorizontal, subequal, somewhat narrower than the transverse furrow, and apparently without ribs. The sulcus is about half as long as the hypotheca. The right sulcal list is low, extends to the posterior rib of the left sulcal list, and is reticulated posteriorly. The left sulcal list is about 0.33 the length of the body, and fairly narrow, its maximum width being about 0.08 the greatest depth of the body; its free edge is gently sigmoid, concave anteriorly and convex posteriorly. Near its posterior end this list has a short, straight, and simple rib of moderate strength; with the exception of this rib, this list appears to lack structural differentiation. On the right valve of the hypotheca there is a narrow parasagittal list, which forms a direct continuation of the left sulcal list and extends to the posterior cingular list; this parasagittal list is of almost uniform width throughout, somewhat narrower than the cingular lists, and is furnished with a moderate number (15–20) of simple ribs. There are no accessory lists or sails on the left valve of the hypotheca and on the epitheca.

The thecal wall has a heavy reticulum of relatively large polygons. Generally speaking, the polygons increase in size from the two apices toward the girdle, and on each valve about seven or eight of them border the posterior margin of the girdle. Each valve of the epitheca has a total of about twenty-four and each valve of the hypotheca about thirty-five to forty polygons. The transverse furrow is divided by cross-ridges into a number of rectangular fields, about ten fields on each valve. Pores were not seen.

Megacytic stages were not recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 100–115 μ (type, 100 μ). Greatest depth of body, 77–84 μ (type, 77 μ).

Variations: — The shape of the hypotheca is rather variable. In some specimens the hypotheca is subacute posteriorly, and its ventral margin (from the girdle to the antapex) is gently undulating, concave anteriorly and posteriorly, and convex in the middle. In other specimens the hypotheca is narrowly rounded posteriorly, and its ventral margin is gently and almost evenly convex.

Comparisons: — The structurally closest-known relative of *Phalacroma reticulatum* is *P. turbineum*. This relationship is especially indicated by the biconical, top-like shape of the body, by the heavy and coarse reticulation of the

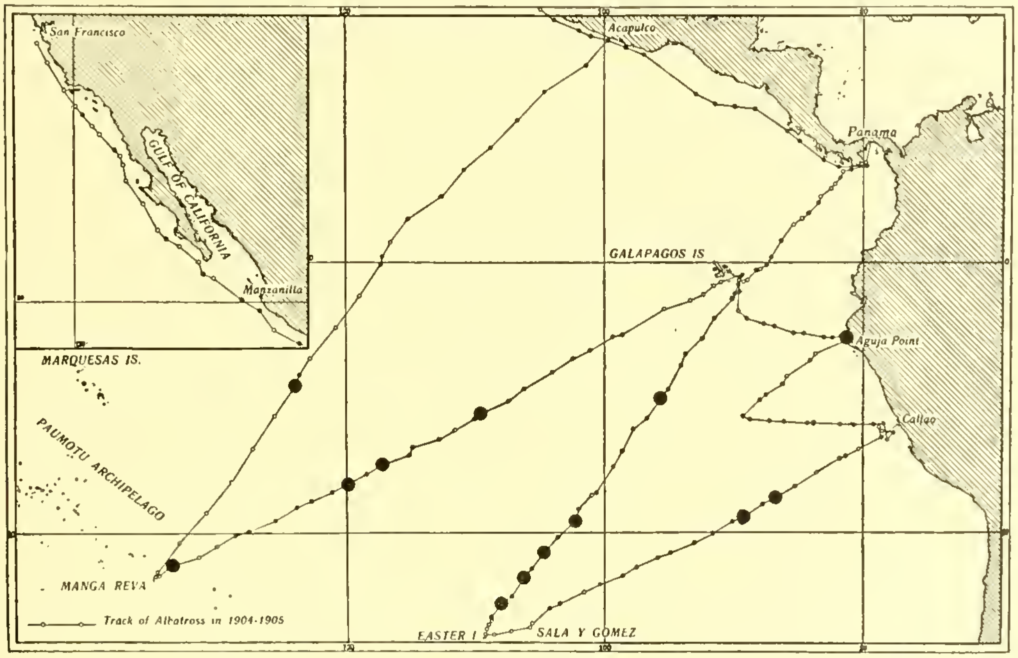

FIGURE 26.— Occurrence of *Phalacroma reticulatum* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

thecal wall, and by the presence of parasagittal lists. *Phalacroma reticulatum* is more advanced than *P. turbineum* in size, but in most other characters it appears to be more primitive; for instance, its body is relatively deeper, its hypotheca is relatively shorter, the reticulation of its thecal wall is less coarse, and it has only one parasagittal list on the hypotheca, while *P. turbineum* has two such lists on the epitheca as well as on the hypotheca.

Phalacroma fimbriatum may be fairly closely related to *P. reticulatum*. This relationship, which is less evident than that mentioned in the last paragraph, is indicated by the biconical, top-like shape of the body in dorsoventral view, by the heavy reticulation of the thecal wall, and by the presence of parasagittal lists.

When compared with *P. fimbriatum*, *P. reticulatum* is less advanced with regard to the size of the body, and in the number, size, and structural differentiation of the parasagittal lists, and it is more advanced in the top-like shape of its body in lateral view, in the position of its girdle, and in the coarser reticulation of its thecal wall.

With regard to the possible relationship between *Phalacroma reticulatum* and *P. praetextum*, see the last species, the section on comparisons.

Occurrence: — *Phalacroma reticulatum* is recorded at thirteen of the 127 stations. There are 0, 1, 2, 5, 4, and 1 stations on the six lines of the Expedition. Of these thirteen stations, one (4655) is in the Peruvian Current; three (4695, 4697, 4699) in the Easter Island Eddy; nine (4679, 4681, 4701, 4709, 4724, 4730, 4732, 4739, 4740) in the South Equatorial Drift. At one station (4655) the species is recorded from 400–0 fathoms; at one (4681) from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these thirteen stations at the surface was 68°–81°; the average was 74.4°.

At one station (4699) the frequency is 1 %; in the remaining cases it is less.

The species was first recorded by Kofoid (1907a) from Station 4740 of the Expedition; it was found in the Mediterranean by Pavillard (1923a).

The most outstanding peculiarities of the distribution of this species in the Eastern Pacific are the absence of surface records and the fact that all the record stations except one are located either in the South Equatorial Drift or in the Easter Island Eddy.

PHALACROMA TURBINEUM Kofoid and Michener

Plate 2, fig. 3. Plate 4, fig. 1, 2. Figure 25: 3

Phalacroma turbinea KOFOID & MICHENER, 1911, p. 291.

Diagnosis: — Body biconical in lateral outline, rather broadly rounded anteriorly, narrowly rounded posteriorly; deepest at girdle, 1.84 times deeper than long. In dorsal view of similar shape but somewhat wider. Posterior cingular list about 0.23 the length of body from apex. Cingular lists about half as wide as transverse furrow, with few ribs. Right sulcal list with T-shaped rib. Left sulcal list small, 0.38–0.39 the length of body, and with maximum width 0.12–0.13 the greatest depth of body; free margin gently and evenly convex; with cross-rib somewhat in front of its middle and submarginal rib along its entire length. Two parasagittal lists encircle body; the one on right valve of hypotheca continues left sulcal list; maximum width about equaling that of cingular lists; with moderate number of short ribs. Theca with heavy and very wide-meshed reticulum; five polygons border girdle posteriorly. Length, 69.5 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is biconical, top-shaped in lateral outline, rather broadly rounded anteriorly, narrowly rounded posteriorly, and deepest at the girdle. The ratio between the length and the depth of the body is about 1.84: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about as deep as the hypotheca, highest in the center, and very prominent above the anterior cingular list; its dorsal and ventral margins are almost straight, or gently concave or convex; anteriorly it is fairly broadly rounded. The transverse furrow is somewhat concave, and its width is about 0.40 the greatest height of the epitheca. The posterior cingular list is about 0.23 the length of the body from the apex. The hypotheca is elongated and conical; posteriorly it is narrowly rounded; its dorsal margin (from the girdle to the antapex) is gently undulating, convex anteriorly and posteriorly, and concave in the middle; its ventral margin (from the girdle to the antapex) also is gently undulating, but it is concave anteriorly and posteriorly and convex in the middle. In dorsoventral view the body has about the same shape as in lateral view, but it is somewhat wider; the ratio between the length and the width is about 1.50: 1; the side contours of the hypotheca are evenly and moderately concave.

The cingular lists are subhorizontal, subequal, about half as wide as the transverse furrow, and have a few (about seven or eight on each valve) simple, straight cross-ribs. The sulcus is relatively short, about 0.26 the length of the hypotheca. The flagellar pore is at the junction of the cingulum and the sulcus. A large pore is to be found in the transverse furrow, just in front of the flagellar pore. The right sulcal list is about 0.20 the length of the body, subtriangular, and decreases gradually in width posteriorly; its maximum width about equals half the width of the transverse furrow; along its entire free edge runs a marginal rib, from the middle of which arises a cross-rib to the base of the list. The left sulcal list is small; its length is 0.38–0.39 the length of the hypotheca, and its maximum width is 0.12–0.13 the greatest depth of the body; its free margin is gently and evenly convex; it has a weak cross-rib somewhat in front of its middle and a submarginal rib along its entire length; with the exception of these two ribs, this list appears to lack structural differentiation. Two parasagittal lists encircle the body; the one on the right valve of the hypotheca forms a direct continuation of the left sulcal list. On the average the parasagittal lists are about twice as wide on the posterior half of the shell as on the anterior half, and their maximum width about equals that of the cingular lists; each of them has a moderate number of short, simple ribs, approximately six on the epitheca and eighteen on the hypotheca. On the ventral side of the body the distance between the two parasagittal lists about equals the width of the transverse furrow; on the dorsal side of the body it is about 2.5 times as wide at the girdle, and from the girdle it decreases gradually toward the apices.

The cingular and the parasagittal lists arise from narrow but well-marked ridges, which are connected by similar cross-ridges. These cross-ridges divide the transverse furrow and the zone between the parasagittal lists into rectangular fields. The number of rectangular fields in the transverse furrow is about seven or eight on each valve; most of these fields have a fine, central pore. The number of rectangular fields in the zone between the parasagittal lists is about five or six on the epitheca, and seventeen or eighteen on the hypotheca; in these fields no pores were found. The rest of the thecal wall has a heavy reticulum of very large polygons. Generally speaking, the polygons increase in size from the two apices toward the girdle, and on each valve five of them border the posterior margin of the girdle. Each valve of the epitheca has about ten, and each valve of the hypotheca about twenty-nine polygons. Pores were not seen in the polygons.

The nucleus is large and rounded; its diameter is about 0.5 the greatest depth of the body. It lies at the level of the girdle, is filled with beaded chromatin, and contains some spheroidal structures.

With regard to megacytic stages, see the section on comparisons, below.

The dimensions of the type specimen were measured.

Dimensions: — Length of body, 69.5 μ. Greatest depth of body, 37.8 μ.

Variations: — The two specimens were very similar.

Comparisons: — In the specimens of this species examined the two parasagittal lists are separated from the sagittal suture by a broad zone. In premegacytic specimens of other species of this genus with two parasagittal lists, these lists are located near the sagittal suture (*cf. P. limbatum*, Plate 3, fig. 3); in megacytic specimens of these species on the other hand, they are separated from this suture by the broad intercalary zone (*cf. P. fimbriatum*, Plate 2, fig. 1). The zone between the parasagittal lists in *P. turbineum* has the same position, relative size, and shape (being wider on the dorsal side of the body than on the ventral) as the intercalary zone. On the other hand, it has not the juvenile structural appearance that usually characterizes the intercalary zone but is furnished with cross-ridges which are as well developed as the ridges on the remaining portion of the thecal wall. For this reason we consider the question open as to whether or not the Expedition specimens are megacytic.

This beautiful and characteristic species is structurally most closely related to *Phalacroma reticulatum* (see p. 197). It may also be fairly closely related to *P. fimbriatum*, but this relationship is less evident. The last two species resemble each other in the biconical, top-like shape of the body in dorsoventral view, in the development of two parasagittal lists extending around the body, and in the heavy reticulation of the thecal wall. *Phalacroma fimbriatum* is much more advanced than *P. turbineum* in the size of the body and in the size and structural differentiation of the parasagittal lists. On the other hand, *P. turbineum* is more advanced than *P. fimbriatum* in the elongated, conical shape of the hypotheca seen in lateral view, in the position of the girdle, and in the coarser reticulation of the thecal wall. Indeed, the polygons of the thecal reticulation are relatively larger than in any other known species of this genus.

With regard to the possible relationship between *Phalacroma turbineum* and *P. praetextum*, see p. 191.

Occurrence: — *Phalacroma turbineum* is recorded at two of the 127 stations. One of these two stations (4681) is on the third line of the Expedition and in the South Equatorial Drift; the other (4715) is on the fourth line and in the Galapagos Eddy. Both records refer to hauls from 300–0 fathoms.

The temperature of these two stations at the surface was 68° and 75°, respectively; the average was 71.5°.

The frequency is less than 1% (one specimen at each station).

Dinofurcula, gen. nov.

Phalacroma Kofoid, *partim* (1906c, 1907a).

Diagnosis: — Body molariform in lateral outline, with two long, narrow, and acute to narrowly rounded posterior processes; strongly compressed bilaterally; its length 1.57–1.83 the depth of midbody. Epitheca 0.62–0.78 the greatest depth of midbody, low. Transverse furrow narrow, of subuniform width throughout, and gently concave to flat. Posterior cingular list 0.14–0.26 the length of body from apex. Shortest distance from curvature between posterior processes to posterior cingular list 0.26–0.61 the greatest depth of midbody. Distance between tips of posterior processes 0.80–0.93 the greatest depth of midbody. Cingular lists subhorizontal, subequal, slightly wider to slightly narrower than transverse furrow, and ribbed. Sulcal lists about as wide as or somewhat narrower than the cingular.

Type. — *Dinofurcula ultima* Kofoid.

Distribution: — Up till the present time, species of this planktonic genus have been found only in the eastern warm-temperate and tropical Pacific.

Representatives of Dinofurcula are recorded at six of the 127 stations of the Expedition. Four of these six stations (4655, 4659, 4661, 4671) are within the

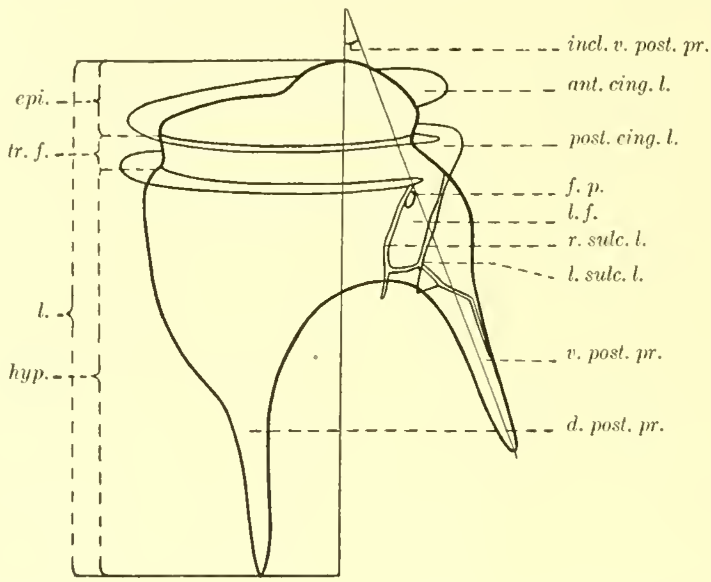

Figure 27.— Diagram of measurements in Dinofurcula. Measurements are made in straight lines. Proportions are measured as if all parts were in the same plane, *i.e.*, as they appear in drawings. Longitudinal axis of body is perpendicular to girdle. The length of body is distance between the two perpendiculars to longitudinal axis that pass through apex of body and tip of dorsoposterior process. The depth of body is measured perpendicularly to longitudinal axis. The greatest height of epitheca is the shortest distance from apex of body and base of anterior cingular list. The depth of epitheca is measured along base of anterior cingular list. The width of transverse furrow and of cingular lists is measured dorsally. The position of posterior cingular list is expressed in the ratio between the shortest distance from apex of body to the mentioned list and the length of body. The inclinations of the posterior processes are the angles between the longitudinal axis of the body and the long axis of these processes.

Abbreviations: — *ant. cing. l.*, anterior cingular list; *d. post. pr.*, dorsoposterior process; *epi.*, epitheca; *f.p.*, flagellar pore; *hyp.*, hypotheca; *incl. v. post. pr.*, inclination of ventroposterior process; *l.*, length of body; *l. f.*, longitudinal furrow; *l. sulc. l.*, left sulcal list; *post. cing. l.*, posterior cingular list; *r. sulc. l.*, right sulcal list; *tr. f.*, transverse furrow; *v. post. pr.*, ventroposterior process.

Peruvian Current; two (4681, 4711) are outside this current, but undoubtedly within its sphere of influence.

The genus has not been found as yet in the surface waters. All the records refer to hauls from 300 (400, 800)–0 fathoms. Data based on hauls made with closing nets are not available.

Both the species known seem to be rare. The frequency is less than 1% at all the six stations mentioned.

Dinofurcula ultima (Kofoid)

Plate 5, fig. 4, 6. Figure 28: 1

Phalacroma ultima Kofoid, 1906c, p. 95; 1907a, p. 195, pl. 12, fig. 68.

Diagnosis: — Body broadly molariform in lateral view; its length 1.57–1.60 the greatest depth of midbody. Epitheca 0.78 the greatest depth of midbody; with rounded ventral hump, which is somewhat higher than width of transverse furrow. Ventroposterior process inclined posteroventrally at 21°–23°. Sulcus runs on right face of body and extends to dorsal side of base of ventroposterior process. Except on posterior processes, theca is finely reticulated. Length, 61.3–63.6 μ.

Eastern tropical and subtropical Pacific.

Description: — A medium-sized and rather broad species, the body of which is molariform in lateral outline. The ratio between the length of the body and the greatest depth of the midbody is 1.57–1.60: 1. The epitheca is about 0.78 as deep as the midbody; dorsally it is low, but ventrally it forms a large rounded hump, which includes the ventral half of the epitheca and is about twice as high as the width of the transverse furrow or somewhat less. The transverse furrow, which is concave, forms a descending left spiral, and its distal end is displaced posteriorly about half its width. The posterior cingular list is about 0.24–0.26 the length of the body from the apex. The hypotheca is deepest just behind the girdle. The dorsal margin is rather strikingly sigmoid, being gently convex, almost straight or even slightly concave anteriorly (Figure 28: 1), and moderately concave posteriorly. The ventral margin is also sigmoid, being gently to moderately convex anteriorly and slightly concave posteriorly. The posterior processes are almost straight, slender, slightly tapering, and subacute distally; the ventral one is inclined posteroventrally at about 21°–23°; the dorsal either is subparallel to the longitudinal axis of the body or it has a slight posteroventral inclination. The curvature between the posterior processes is comparatively deep and broad, and the shortest distance between this curvature and the posterior cingular list is about 0.26–0.29 the greatest depth of the midbody and 0.13–0.16 the length of the body. The distance between the tips of the posterior processes is 0.80–0.86 the greatest depth of the midbody. In dorsoventral view the ventroposterior process is inclined to the right; the two posterior processes diverge from each other at an angle of about 20°. The greatest transdiameter of the body is located just behind the transverse furrow and equals about 0.38 the greatest dorsoventral diameter of the midbody.

The cingular lists are subhorizontal, subequal, and about as wide as or somewhat wider than the transverse furrow; each of them has on each valve about fifteen to seventeen straight, simple, and almost equidistant ribs. The sulcus runs on the right face of the body toward the dorsal side of the base of the ventroposterior process; it extends to the posterior margin of the midbody, and is nearly as wide as the transverse furrow. The flagellar pore is located just behind the girdle on the right (dorsal) side of the sulcus. The right (dorsal) margin of the sulcus has a low ridge or list, which continues as a short spine beyond the postmargin of the midbody. The left sulcal list extends to the posterior end of the sulcus and is throughout its entire length about as wide as the posterior cingular list; posteriorly it is rectangular (Plate 5, fig. 6); its structure is unknown.

Except on the posterior processes, the thecal wall is finely reticulate. The meshes are subequal and irregular, and on each valve about thirty-five to forty-five meshes border the girdle anteriorly. The suture between the valves seems to follow the left sulcal list to a point near the postmargin of the midbody, from whence it turns abruptly toward the ventral margin of the ventroposterior process.

The dimensions of two specimens were measured.

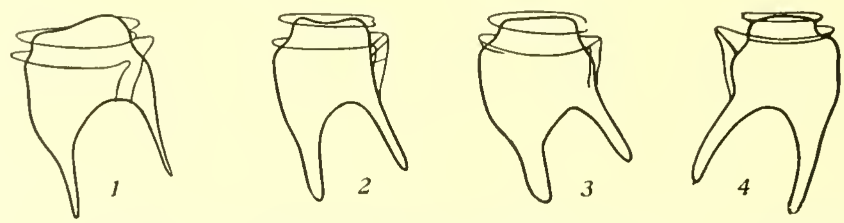

FIGURE 28.— 1, *Dinofurcula ultima* (Kofoid), right lateral view. × 430. Station 4661 (300–0 fathoms). 2, 3, 4, *Dinofurcula ventralis*, gen. et spec. nov. 2, 3, in right lateral view; 4, left lateral view of type specimen. × 430. 2, from Station 4659 (300–0 fathoms); 3, from Station 4655 (400–0 fathoms); 4, from Station 4681 (800–0 fathoms).

Dimensions: — Length of body, 61.3–63.6 μ (type, 61.3 μ). Greatest depth of midbody, 39.0–39.7 μ (type, 39.0 μ). Distance between tips of posterior processes, 32.3–34.0 μ (type, 34.0 μ).

Variations: — The specimens examined are strikingly similar.

Comparisons: — *Dinofurcula ultima* is easily distinguished from *D. ventralis* by having a large, rounded hump on the ventral side of the epitheca and by the lateral position of the sulcus.

Occurrence: — *Dinofurcula ultima* is recorded at three of the 127 stations. There are 0, 2, 0, 1, 0, and 0 stations on the six lines of the Expedition. Of these three stations, two (4661, 4671) are in the Peruvian Current, and one (4711) is in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these three stations at the surface was 66°–75°; the average was 70.0°.

The frequency is in all the cases less than 1%.

Dinofurcula ventralis, sp. nov.

Figure 28: 2, 3, 4

Diagnosis: — Body rather narrowly molariform in lateral view; its length 1.60–1.83 the greatest depth of midbody. Epitheca 0.62–0.74 the greatest depth of midbody, lower than transverse furrow, not, or but slightly higher ventrally than dorsally. Ventroposterior process inclined posteroventrally at 30°–36°. Sulcus runs along ventral margin of midbody to ventral side of base of ventroposterior process. Length, 56.5–60.7 μ.

Eastern tropical and subtropical Pacific.

Description: — A medium-sized and rather narrow species, the body of which is molariform in lateral outline. The ratio between the length of the body and the greatest depth of the midbody is 1.74 (1.60–1.83): 1. The epitheca is relatively narrow, 0.68 (0.62–0.74) as deep as the midbody, and low, 0.45-0.80 the width of the transverse furrow; sometimes (Figure 28: 4) it is gently convex and highest in the center, sometimes (Figure 28: 3) flattened and highest ventrally, and sometimes (Figure 28: 2) gently concave in the middle and of equal height dorsally and ventrally. The transverse furrow is concave, and, according to available data, its distal end is not displaced posteriorly. The posterior cingular list is 0.18 (0.14–0.22) the length of the body from the apex. The greatest depth of the hypotheca is variable in position; sometimes it is located near the middle of the midbody, sometimes near the bases of the posterior processes, and sometimes near the distal ends of these processes. The dorsal margin either (Figure 28: 2, 3) is sigmoid, being gently convex or almost straight anteriorly and gently to moderately concave posteriorly; or it is (Figure 28: 4) gently undulating. In some specimens (Figure 28: 2) the ventral margin is gently and almost evenly concave; in others (Figure 28: 3, 4) it is more or less strikingly convex anteriorly. The posterior processes sometimes are almost straight, and sometimes (Figure 28: 4) slightly curved toward each other. The ventral of them, which usually is very slender, tapers very slightly and is subacute to more or less rounded distally. The dorsal one, usually somewhat wider than the ventral, also is somewhat tapering, and subacute to more or less rounded distally; in one specimen (Figure 28: 3) the average width of this process about equaled the width of the transverse furrow, but usually it is somewhat less. The ventroposterior process is inclined posteroventrally at about 30°–36°; the dorsoposterior either is subparallel to the longitudinal axis of the body, or it has a slight posteroventral inclination. In one specimen, the type, the tip of each of these processes had a very small spinule. The curvature between the posterior processes is fairly deep and wide, and the shortest distance between this curvature and the posterior cingular list is 0.53 (0.47–0.61) the greatest depth of the midbody and 0.30 (0.28–0.33) the length of the body. The distance between the tips of the posterior processes is 0.88 (0.80–0.93) the greatest depth of the midbody.

The cingular lists are subequal, somewhat narrower than the transverse furrow, and subhorizontal or somewhat inclined anteriorly; their structure is unknown. The sulcus runs on the right face of the body, near the ventral margin, to the ventral side of the base of the ventroposterior process. The extension and width of the right sulcal list are unknown. The left sulcal list extends to the posterior end of the sulcus; anteriorly it is about as wide as or even somewhat wider than the transverse furrow, and it decreases gradually in width posteriorly; its structure is not known with entire certainty, but it appears to have one to three ribs in its anterior half. The structure of the theca is unknown.

The dimensions of three specimens were measured.

Dimensions: — Length of body, 56.6–60.7 μ (average, 58.4 μ; type, 60.7 μ). Greatest depth of midbody, 31.1–36.0 μ (average, 33.6 μ; type, 33.7 μ). Distance between tips of posterior processes, 28.8–31.1 μ (average, 29.6 μ; type, 31.1 μ).

Variations: — While *Dinofurcula ultima* appears to be fairly constant in size and structure, this species is comparatively variable. The following characters are the most variable: the depth and the shape of the epitheca, the depth of the midbody, the shape of the ventral margin of the hypotheca, and the width of dorsoposterior process.

Comparisons: — This species is established on outline drawings of three specimens in lateral view. The shape of the body in dorsoventral view, the structure of the cingular lists and of the theca are unknown, and knowledge of the sulcal lists is incomplete. The species is readily distinguished from *Dinofurcula ultima* by the lack of the large ventral hump on the epitheca and by the ventral position of the sulcus.

Occurrence: — *Dinofurcula ventralis* is recorded at three of the 127 stations. There are 0, 2, 1, 0, 0, and 0 stations on the six lines of the Expedition. Of these three stations, two (4655, 4659) are in the Peruvian Current, and one (4681), the type locality, is in the South Equatorial Drift. The depth records are 400, 300, and 800 fathoms to the surface, respectively.

The temperature range of these three stations at the surface was 65°–69°; the average was 67.3°.

The frequency is in every case less than 1%.

DINOPHYSIS Ehrenberg

Dinophysis EHRENBERG, 1840a, p. 124. GRIFFITH & HENFREY, 1856, p. 211. DIESING, 1866, p. 98. FROMENTEL, 1874, p. 196. KENT, 1881, p. 458. BERGH, 1881b, p. 226. BÜTSCHLI, 1885, p. 941, 1010. DELAGE & HÉROUARD, 1896, p. 385. SCHÜTT, 1896, p. 27. PAULSEN, 1908, p. 12. MEUNIER, 1919, p. 79. JÖRGENSEN, 1923, p. 18. LEBOUR, 1925, p. 79.
Dynophysis VAN OYE, 1921, p. 209, 212, 214 (*lapsus pennae*).

Diagnosis:—Body usually subovate, subcircular, subellipsoidal, subobovate, subreniform, subtrapeziform, or subtrapezoidal in lateral outline, or very elongated with one or two posterior peduncles; ratio between length and depth usually somewhere between 1.1 : 1 and 1.6 : 1 but may be as low as 0.97 : 1 or as high as 5.3 : 1; on the whole somewhat more compressed bilaterally than in Phalacroma. Epitheca always low, as evidenced by the fact that posterior cingular list is never more than 0.28 the length of body from apex; ratio between its depth and depth of hypotheca 0.30–0.86 : 1. Transverse furrow narrow, of subuniform width throughout, flat or but slightly convex or concave; its width subequal to or but slightly greater or smaller than height of epitheca. Cingular lists may be subhorizontal but usually with more or less pronounced anterior inclination; anterior 1.0–4.0 the width of transverse furrow and sometimes ribbed; posterior usually somewhat narrower than anterior and without ribs in most species. Right sulcal list small, usually subtriangular, and ends at or slightly in front of or behind R_2 of left sulcal list. Left sulcal list usually subtrapeziform, somewhat wider posteriorly than anteriorly, with pronounced posteroventral angle, and with three ribs, one (R_1) in front and one (R_3) behind fission rib (R_2); R_2 somewhat behind girdle; length of this list ranges from 0.41 to 0.84 the length of hypotheca; R_2 usually 0.20–0.35, seldom as little as 0.11 or as much as 1.25 the depth of body; for R_3 the corresponding values are 0.30–0.60 and 0.00, 1.33; margin seldom rounded posteroventrally. Sometimes with accessory lists and sails.

TYPE. — *Dinophysis acuta* Ehrenberg.

Organology: — The *body* (*theca*) in Dinophysis is diverse in shape; usually, however, its shape is fairly simple, and only in one group of species, *viz.*, in the CAUDATA group, does it show pronounced elongation and protuberances. When seen laterally, it generally is somewhat asymmetrical, but symmetrical species also have been recorded (*e.g., D. sphaerica,* Figure 31:3). In dorsoventral view it appears always to be symmetrical. Sometimes (*D. triacantha,* Figure 42:2) the *longitudinal axis* (*l.a.,* Figure 29) is perpendicular to the girdle, but in most species it is inclined either posterodorsally or posteroventrally. While in Phalacroma only one species has been recorded as yet in which this axis is inclined posterodorsally, this inclination is found rather frequently in Dinophysis. In the species with the most pronounced posterodorsal deflection of this axis, viz., *D. collaris* (Plate 5, fig. 2), an inclination of 10°–15° was found. The maximum posteroventral inclination as yet established is 30° (*D. caudata,* Figure 44). The inclination is very variable even within the species.

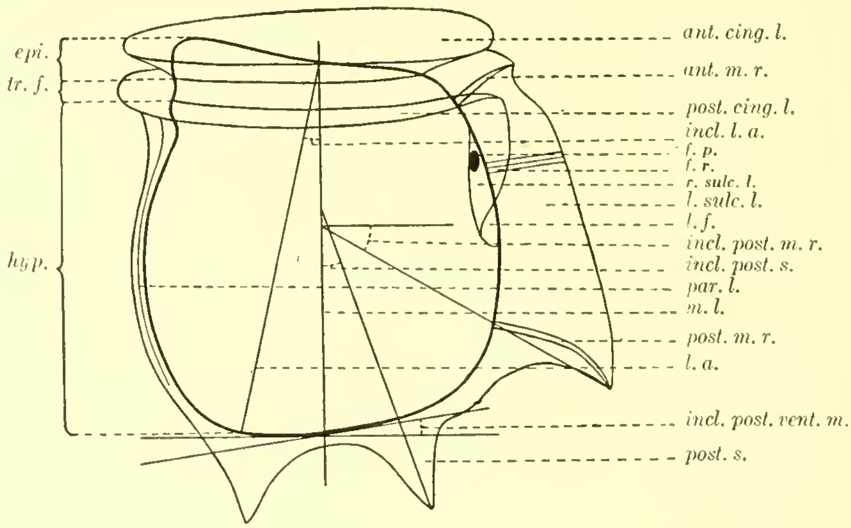

FIGURE 29.—*Dinophysis collaris* Kofoid and Michener, right lateral view. Station 4671 (300–0 fathoms). Terminology and methods of making measurements of Phalacroma and Dinophysis.

Terminology:—The midline is the perpendicular to girdle which is equidistant from dorsal and ventral margins of body at place of greatest depth of body. When longitudinal axis of body is not inclined, it coincides with midline. In specimen represented by this Figure the longitudinal axis of body is inclined *posterodorsally* and the posteroventral margin of body, *dorsoposteriorly,* according to our terminology. The anterior main rib (R_1) is the rib at junction of left sulcal list and posterior cingular list. The fission rib (R_2) is the rib of left sulcal list at place where this list is divided in binary fission. The posterior main rib (R_3) is the rib of left sulcal list near posterior end of this list or, in the case of two or more ribs in this region, the best developed of these. Ventral margin of left sulcal list is the free edge of this list between R_1 and R_3; posterior margin of this list is the free edge behind R_3.

Methods of making measurements:—Measurements are made in straight line, if not otherwise stated. Proportions of theca are measured as if all parts were in the same plane, *i.e.,* as they appear in drawings. The length of body is the distance from apex to antapex. The depth of body is measured parallel to girdle. The inclination of longitudinal axis of body is the angle between this line and midline. The greatest height of epitheca is the shortest distance between apex and base of anterior cingular list. The depth of epitheca is measured along base of anterior cingular list. The width of transverse furrow is measured along dorsal outline, when body is seen in lateral view. The length of longitudinal furrow is measured from posterior cingular list. The inclination of posteroventral margin of body is the angle between this margin and a line parallel to girdle. The widths of cingular lists are measured dorsally, when organism is seen in lateral view. The inclination of these lists is the angle between their dorsal margin and a line perpendicular to midline. The position of posterior cingular list is expressed in the ratio between the shortest distance from apex to the mentioned list and the length of body. The length of left sulcal list is measured from the base of R_1 to the posterior point of base of this list; if R_1 is absent and if this list is continued by parasagittal list, the measurement is made from the posterior cingular list to the base of R_3. The inclination of R_3 is the angle between a line parallel to girdle and the line through tip and base of R_3. The length of posterior sail is measured from the tip to the middle of base of this structure. The inclination of posterior sail is the angle between the midline and the line through the tip and the middle of base of posterior sail.

Abbreviations: — *ant. cing. l.*, anterior cingular list; *ant. m. r.*, anterior main rib; *epi.*, epitheca; *f. p.*, flagellar pore; *f. r.*, fission rib; *hyp.*, hypotheca; *incl. l. a.*, inclination of longitudinal axis; *incl. post. m. r.*, inclination of posterior main rib; *incl. post. s.*, inclination of posterior sail; *incl. post. vent. m.*, inclination of posteroventral margin; *l. a.*, longitudinal axis; *l. f.*, longitudinal furrow; *l. sulc. l.*, left sulcal list; *m. l.*, midline; *par. l.*, parasagittal lists; *post. cing. l.*, posterior cingular list; *post. m. r.*, posterior main rib; *post. s.*, posterior sail; *r. sulc. l.*, right sulcal list; *tr. f.*, transverse furrow.

When seen laterally, the *body* usually is longer than deep; in only a few species specimens are found, the body of which is deeper than long. In the species with the most elongated body (*Dinophysis miles* Cleve, 1900b, fig. 1b), the ratio between the length and the depth is about 5.3: 1 (the depth being measured just behind the dorsal peduncle); in the species with the relatively deepest body (*D. triacantha*, Figure 42: 2), the corresponding ratio is about 0.97: 1; in most species it is between 1.1: 1 and 1.6: 1. Sometimes the body is deepest in or near the middle, but usually the greatest depth has shifted posteriorly; only in exceptional cases (*D. caudata*, Figure 44: 3) the greatest depth is located in front of the middle.

In most species the *body*, seen laterally, is ovate or subovate; in some of these it is relatively deep, almost subcircular (*Dinophysis jörgenseni*, Figure 42: 6), in others more or less elongated (*D. fortii*, Figure 31: 7). The following shapes of body, seen laterally, have also been found: — subcircular (*D. triacantha*, Figure 42: 2); ellipsoidal or subellipsoidal (*D. similis*, Figure 31: 2); subovate, truncate anteriorly (*D. uracantha*, Figure 35: 3); asymmetrically subovate, flattened ventrally (*D. sacculus*, Stein, 1883, pl. 20, fig. 12); subovate, with a dorsal shoulder-like constriction at the girdle and with the ventral margin somewhat concave between the epitheca and the fission rib of the left sulcal list (*D. okamurai*, Figure 31: 5); obovate (*D. alata*, Jörgensen, 1923, fig. 45); subobovate with the posterior end acute or subacute (*D. acuta*, Stein, 1883, pl. 20, fig. 13); short sausage-shaped and straight or gently sigmoid (*D. sacculus*, Stein, 1883, pl. 20, fig. 10, 11); reniform (*D. reniformis*, Pavillard, 1905, pl. 3, fig. 10); elongated, subacute posteriorly, with the dorsal margin evenly convex, and with the ventral margin more or less angular at the posterior main rib of the left sulcal list and fairly straight in front of this rib (*D. schröderi*, Figure 31: 6); subtrapeziform, protracted posterodorsally (*D. trapezium*, Figure 38: 2); rounded subtrapeziform or pitcher-shaped (*D. monacantha*, *D. urceolus*, Figure 37); narrowly subtrapezoidal (*D. dens*, Pavillard, 1916, pl. 3, fig. 1); very elongated, with the anterior portion of the body irregularly ovate and the posterior portion pedunculate (*D. caudata*, Figure 44); very elongated, with the anterior portion of the body irregularly ovate and the posterior portion pedunculate, and with a more or less developed peduncle near the middle of the dorsal side of the body (*D. tripos*, Jörgensen, 1923, fig. 38; *D. miles*, Cleve, 1900b, fig. 1). Between these shapes transitions are to be found. It also should be mentioned in this connection that the lateral outline of the body often is strikingly variable even within the species; the most extreme examples of such variations are to be found in *D. caudata* (Jörgensen, 1923, fig. 30–37).

The *body* is compressed bilaterally in all the species in which the dorsoventral outline is known; it should be remembered, however, that this character has not been recorded as yet in most of the species. Sometimes the compression is moderate, *e.g.*, in *Dinophysis schütti*, in which the ratio between the length and the transdiameter is about 1.45: 1; sometimes it is very pronounced as in *D. collaris* (Plate 5, fig. 2, 8) and *D. caudata* (Stein, 1883, pl. 21, fig. 1, 7), in which this ratio is about 3: 1 and 7–8: 1, respectively. The dorsoventral outline usually is narrowly ovate, ellipsoidal (*D. schütti*, Figure 40: 7), or lenticular (*D. acuta*, Stein, 1883, pl. 20, fig. 17). When lenticular, its lateral contours sometimes are subparallel (Meunier, 1919, pl. 3, fig. 40, 48) or even slightly concave (*D. schröderi*) in the middle. Sometimes (*D. collaris*, Plate 5, fig. 8) it is narrowly obovate with the side contours almost straight and gently converging posteriorly; sometimes (*D. caudata*, Stein, 1883, pl. 21, fig. 6, 7) the side contours are subparallel anteriorly and gently converging posteriorly. A cuneate outline has been found in one species only, viz., in *D. cuneiformis* (Meunier, 1910, pl. 14, fig. 32), in which it is widest at the girdle and acute posteriorly. This circumstance is especially noteworthy since a cuneate dorsoventral outline is fairly frequent in the closely related genus Phalacroma.

One of the most characteristic features of Dinophysis, when compared with Phalacroma, is the small size of the *epitheca* (*epi.*, Figure 29). The epitheca is always very low, which is evident from the fact that the posterior cingular list never is located farther from the apex than about 0.28 the length of the body (*Dinophysis exigua*, Figure 30); in most species this list is only about 0.10–0.20 the length of the body from the apex. Its depth does not exceed 0.86 the greatest depth of the hypotheca (*D. hastata*, Figure 33: 3) and sometimes (*D. schütti*, Figure 40: 5, 6) does not amount to more than 0.30 the greatest depth of the hypotheca; in most species this ratio varies between 0.40: 1 and 0.60: 1. As a rule the greatest height of the epitheca is in or near the center, but sometimes it has shifted dorsally (*D. hastata*, Figure 33: 1) or slightly ventrally (*D. uracantha*, Figure 35: 2). The outline of the epitheca in lateral view usually is gently and almost evenly convex, but sometimes it is fairly strongly convex (*D. uracantha*, Figure 35: 2), flat (*D. uracantha*, Figure 35: 3), or even gently concave (*D. collaris*, Plate 5, fig. 2; *D. urceolus*, Figure 37: 1). In most species the epitheca is not visible, in lateral view, above the anterior cingular list; sometimes (*D. collaris*, Plate 5, fig. 2) it is barely visible.

In consequence of the small height of the epitheca, the *transverse furrow* (*tr. f.*, Figure 29) is always situated near the anterior end of the body. Its distal portion is not displaced posteriorly, *i.e.*, it does not form a spiral about the body; and it always crosses the lateral faces of the body in an almost straight line. Its width is moderate and subject to but slight variations, being either subequal to or somewhat greater or slightly smaller than the greatest height of the epitheca. Its floor is flat or but slightly concave or convex.

The length of the *longitudinal furrow* is unknown in most species, but judging by the length of the right sulcal list it usually does not exceed 0.3 the length of the hypotheca. Only in exceptional cases (*Dinophysis ellipsoides* Kofoid, 1907b, pl. 33, fig. 56) this furrow is as long as 0.55 the length of the hypotheca. Anteriorly it does not extend beyond the girdle, *i.e.*, into the epitheca, and it is at most but slightly impressed.

The *lists of the furrows* are not excessively developed. They arise from low and narrow basal ridges (Plate 5, fig. 3, 7), and are hyaline and generally exceedingly delicate.

In some species the *cingular lists* (*ant. cing. l.*, *post. cing. l.*, Figure 29) are subequal, but usually the width of the anterior exceeds that of the posterior; frequently this difference is fairly slight, but the anterior may be several times wider than the posterior (*Dinophysis okamurai*, Figure 31:5). The anterior may be open or closed ventrally; the posterior is always open ventrally. The anterior cingular list usually is between 1.5 and 2.5 times wider than the transverse furrow and between 0.15 and 0.30 the greatest depth of the body. Sometimes, however, its width is subequal to that of the transverse furrow and only about 0.13 the greatest depth of the body (*D. hastata*, Figure 32: 15); or it may be as much as 4.0 times the width of the transverse furrow and 0.50 the greatest depth of the body (*D. swezyi*, Plate 5, fig. 9; *D. schütti*, Figure 40: 1). The posterior cingular list sometimes (*D. acuminata*, Jörgensen, 1923, fig. 25) is so reduced in width that hardly anything but its basal ridge is present. In most species these lists are funnel-shaped, *i.e.*, inclined anteriorly at an angle of between 20° and 60°; but both of them may be subhorizontal (*D. monacantha*, Figure 37:2, 3). Their inclination either is about the same or, and this seems to be the rule, the inclination of the anterior slightly exceeds that of the posterior. It should be remembered, however, that the pressure of the cover-glass is likely to change the inclination of these lists. Sometimes (Pavillard, 1916, pl. 3) both these lists appear to lack structural differentiation, except for one or two ribs dorsally and ventrally on each valve near the sagittal suture; sometimes (*D. jörgenseni*, Plate 5, fig. 7) the posterior list is undifferentiated while the anterior is ribbed; sometimes (*D. collaris*, Plate 5, fig. 2) both of them are ribbed. The ribs usually are rather strong, straight, simple, and nearly equidistant; but they may be more or less irregular and branched (*D. jörgenseni*, Plate 5, fig. 7), or they may even anastomose into a reticulum (Stein, 1883, pl. 20, fig. 20); sometimes some of them are incomplete (Jörgensen, 1923, fig. 46, 47). When both lists are ribbed, the number of ribs in the anterior list is either subequal to or somewhat larger or smaller than that of the posterior. In most cases each list has on each valve between ten and twenty ribs, but as many as twenty-five have been observed (*D. hastata*).

The *sulcal lists*, which form a direct continuation of the posterior cingular list, run about parallel to each other on either side of the longitudinal furrow. The entire right sulcal list and the posterior portion of the left belong to the right valve, while the anterior portion of the left sulcal list belongs to the left valve.

The *right sulcal list* (*r. sulc. l.*, Figure 29) is subject to but slight differentiation. In most species it is rather constant in size and shape, but in some (*e.g.*, in *Dinophysis hastata*) it exhibits about the same range of variation as within the genus as a whole. Usually it extends to or slightly beyond the fission rib of the left sulcal list, and only exceptionally it is decidedly shorter (*D. pusilla*, Jörgensen, 1923, fig. 44) or extends as far back as to the posterior main rib of the left sulcal list (*D. ellipsoides*, Kofoid, 1907b, pl. 33, fig. 56). In most species it is subtriangular to rounded triangular, about as wide as the transverse furrow anteriorly, and decreasing gradually in width posteriorly. Sometimes (*D. hastata*, Figure 32:5, 9) it is of subuniform width throughout the greater portion of its length, fairly strongly rounded posteriorly, and about as wide as the transverse furrow anteriorly; sometimes it is gently sigmoid, concave anteriorly, convex posteriorly (*D. jörgenseni*, Figure 42:3). No structural differentiation has been observed. Its ventral margin is always free.

The *left sulcal list* (*l. sulc. l.*, Figure 29), on the other hand, shows a rather striking differentiation within the genus and is also fairly variable in some of the species (*Dinophysis swezyi*, Figure 39). For the sake of convenience in describing this list, it may first be mentioned that in nearly all the species it has three well-developed cross-ribs, which are named the anterior main rib, the fission rib, and the posterior main rib. The anterior main rib (*ant. m. r.*, Figure 29) is located anteriorly, at the junction of this list and the posterior cingular list; the fission rib (*f. r.*, Figure 29), at the place where the list is divided in binary fission, *i.e.*, at the sagittal suture and usually somewhat in front of the middle of the list; the posterior main rib (*post. m. r.*, Figure 29), near the posterior end of the list. Frequently the anterior main rib and the fission rib are subequal; when different, the fission rib usually is the longer, but sometimes (*D. uracantha*, Figure 35: 2) it is slightly shorter. On the whole, the length of the fission rib is much more variable than that of the anterior main rib. The usual range of variation for the anterior main rib is from 0.20 to 0.30 the greatest depth of the body, but this ratio may be as small as 0.13: 1 (*D. hastata*) or as large as 0.50: 1 (*D. caudata*). For the fission rib the corresponding values are 0.20 and 0.35, and 0.11: 1 (*D. hastata*) and 1.25: 1 (*D. schütti*). As a rule, the posterior main rib is the longest of these three ribs; indeed, in exceptional cases (*D. uracantha*, Figure 35: 2) it may be as much as five times longer than the fission rib. Its usual range of variation is from 0.30 to 0.60 the greatest depth of the body; but sometimes (*D. schütti*) this ratio is as large as 1.33: 1, or the rib is more or less reduced in length (*D. okamurai*, Figure 31: 5) or even absent (*D. similis*, Figure 31: 1, 2). In most species the length of this list is between 0.50 and 0.70, and the distance from its anterior to its posterior main rib between 0.40 and 0.60 the length of the hypotheca. Sometimes, however, these ratios are only 0.41: 1 and 0.33: 1 (*D. caudata*, Jörgensen, 1923, fig. 30; see also *D. sacculus*, Stein, 1883, pl. 20, fig. 11) or as much as 0.84: 1 and 0.68: 1 (*D. schütti*, Figure 40). Usually this list is subtrapeziform, wider posteriorly than anteriorly, with a pronounced postero-ventral angle, and with the ventral and posterior margins straight, or gently convex, concave, or sigmoid. From this fundamental and presumably primitive type a great number of variants have evolved. Most variable is the postero-ventral portion of the list. Sometimes this portion is more or less acuminate (*D. nias*, Figure 42: 1), the angle of its margin ranging from 5° to about 50°, or acuminate and recurved (*D. jörgenseni*, Figure 42: 8); sometimes it is subrect-angular (*D. caudata*, Figure 44: 5, 6) or even rounded (*D. similis*, Jörgensen, 1923, fig. 29). The shape of this portion of the list depends on the length, shape, and inclination of the posterior main rib. When this rib is well developed, the postero-ventral margin of the list is angular, and the rib ends at or near the vertex of the angle; when the rib is more or less reduced in length or absent, this margin is rounded; when the rib is long and straight or long and strongly concave posteriorly, this portion of the list is acuminate or acuminate and recurved, respectively. The ventral margin of the list, *i.e.*, the free margin between the anterior and posterior main ribs, is also very variable, and its shape depends largely on the relative length of the fission rib. When this rib is of moderate length, this margin is almost straight, or gently convex, concave, or sigmoid. When the rib is long, the margin is straight or gently convex, concave, or sigmoid between the anterior main rib and the fission rib, angular at the fission rib, and more or less strikingly concave between the fission rib and the posterior main rib; as a rule, the last-mentioned concavity is most pronounced just behind the fission rib (*D. swezyi*, Figure 39). The posterior margin of the list, *i. e.*, the free margin behind the posterior main rib, as previously mentioned, usually is almost straight, or gently concave, convex, or sigmoid, but it may be strongly concave (*D. acuta*, Jörgensen, 1923, fig. 20), convex (*D. caudata*, Figure 44: 4), or sigmoid (*D. jörgenseni*, Figure 42: 8); and sometimes (*D. swezyi*) it forms a more or less narrowly rounded or even acute accessory lobe, the height of which is 0.25–0.11 the greatest depth of the body. The last condition is, in a sense, an initial step in the development of a parasagittal list (see *D. trapezium*, Figure 38: 2, 3). The free margin of this list usually extends to the tip of the fission rib and of the posterior main rib, but in one species (*D. schütti*, Figure 40) it frequently terminates at some distance from these tips, leaving the distal portions of the ribs free; the length of the free portions may even slightly exceed half the length of the ribs. Sometimes (*D. recurva*, Pavillard, 1916, pl. 3, fig. 6) the ventral margin of the list is recurved to the right (see also Bergh, 1881b, p. 220). The anterior main rib always is unbranched, of moderate strength, and tapering distally; and, as a rule, it is straight or but slightly curved. The fission rib, which (always?) is double, *i.e.*, made up of two members, one on either side of the suture (*D. jörgenseni*, Plate 5, fig. 3, 7), frequently is straight or almost so, and tapers distally; sometimes, however, this rib is gently sigmoid (*D. jörgenseni*, Plate 5, fig. 7) or gently concave posteriorly (*D. swezyi*, Plate 5, fig. 9); and it may be more or less club-shaped distally (*D. schütti*, Figure 40: 1). The posterior main rib, which usually is more or less concave posteriorly but may be straight or almost so, is club-shaped distally more frequently than is the fission rib; furthermore, while the fission rib in most species is subparallel to the transverse furrow, the posterior main rib generally is characterized by a posterior inclination of between 20° and 55°; only in exceptional cases (*D. caudata*, Figure 44) this list and the transverse furrow are subparallel. In some species this list appears to lack structural differentiation except for the main ribs; in others it may have a number of short, secondary ribs (*D. swezyi*, Plate 5, fig. 9), or a more or less developed reticulation (*D. collaris*, Plate 5, fig. 2; *D. caudata*, Stein, 1883, pl. 21, fig. 1, 2). It also should be mentioned that in *D. swezyi* (Plate 5, fig. 9) the accessory posterior lobe has a rib extending to the margin of the lobe.

Some of the primitive, as well as some of the highly differentiated species have no lists except the cingular and sulcal lists. Others have *accessory*, "*parasagittal*" lists (*par. l.*, Figure 29) along the sagittal suture. On the whole, these structures are less developed in Dinophysis than in Phalacroma (see p. 43). For instance, the epitheca always lacks parasagittal lists in Dinophysis, and *D. collaris* is the only known species of its genus in which the left valve has a parasagittal list; furthermore, in all but a few species, *e.g.*, *D. alata*, *D. monacantha*, these structures are limited to the posterior portion of the body. Usually the right parasagittal list is represented only by a subtriangular or wedge-shaped posterior sail, which is situated either on the midline or displaced somewhat dorsally (*D. uracantha*, Figure 35) or ventrally (*D. hastata*). Sometimes (*D. uracantha*, Figure 35:2) this sail is directed posteriorly, sometimes it is somewhat deflected dorsally (*D. schütti*, Figure 40) or ventrally (*D. hastata*, Figure 32). When fully developed, its length usually is about 0.35–0.85 the greatest depth of the body, but it may be decidedly shorter (*D. hastata*, Figure 32: 13) or in exceptional cases (*D. schütti*, Figure 40: 1) as long as about 1.35 the greatest depth of the body. The ratio between its length and its basal width ranges from 1.0: 1 to 4.0: 1 and the angle at its tip from 10° to 50°. In nearly all species this sail is distinctly separated from the left sulcal list, and only seldom (*D. hastata*, Figure 32: 8) specimens are found in which these structures are so close that a connection may exist. In some species two posterior sails are developed. When this is the case, these sails either are free, *i.e.*, connected neither with each other nor with the left sulcal list (*D. nias*, Figure 42: 1); or the dorsal posterior sail is free and the ventral connected with the left sulcal list (*D. triacantha*, Figure 42: 2); or again, the sails are connected with each other but not with the left sulcal list (*D. jörgenseni*, Figure 42: 7); or, once more, they may be connected with each other as well as with the left sulcal list (*D. jörgenseni*, Plate 5, fig. 7). The lists connecting the posterior sails with each other and with the left sulcal list sometimes are very narrow, barely distinguishable, and sometimes (*D. jörgenseni*, Plate 5, fig. 7) their minimum width is not less than 0.18 the greatest depth of the body. The posterior sail may lack structural differentiation (*D. hastata*, Figure 32: 14), but usually it is supported by a central rib, by marginal ribs, by both central and marginal ribs, or by a reticulum of ribs (*D. hastata*, Figure 32: 1, 12, 11; *D. collaris*, Plate 5, fig. 2). The central rib may be simple, split lengthwise (*D. swezyi*, Plate 5, fig. 9), bifurcate or trifurcate proximally (*D. schütti*, Figure 40: 1, 2, 3), or it is more or less broken up in a reticulum (*D. hastata*, Figure 32: 3, 5, 7); furthermore, sometimes it tapers distally, and sometimes (*D. schütti*, Figure 40: 1) it is club-shaped distally. As mentioned previously, the right parasagittal list very seldom extends along the dorsal side of the hypotheca. When the dorsal portion of this list is developed, it usually is of subuniform width throughout, about half as wide as the transverse furrow or less, and without structural differentiation or with a number of cross-ribs. In *D. alata* (Jörgensen, 1923, fig. 45), however, it is large, crescent-shaped, and its greatest width is not less than 0.19 the greatest depth of the body. Sometimes (*D. collaris*, Plate 5, fig. 2) the dorsal portion of the right parasagittal list is connected with the posterior sail, sometimes (*D. alata*) it is not. The left parasagittal list, which is developed in *D. collaris* only, is of subuniform width throughout and very narrow, about half as wide as the transverse furrow or less. It should be mentioned that the parasagittal lists along the dorsal side of the hypotheca appear to remain undeveloped during a comparatively long period following binary fission.

The *flagellar pore* (*f. p.*, Figure 29) is a fairly large opening, located in the longitudinal furrow, *i.e.*, on the right valve, and usually just behind or about a girdle-width behind the posterior cingular list. In *Dinophysis miles* (Weber-van Bosse, 1901, pl. 17, fig. 4) it is somewhat farther displaced posteriorly. Its shape, as a rule, is subcircular or slightly elongated, and its greatest diameter does not exceed the width of the transverse furrow. In no species of Dinophysis have pores been recorded which correspond to those found, for instance, in *Phalacroma pulchrum* and *P. giganteum* (Plate 3, fig. 1, 2) on the ventral side of the left valve, near the sagittal suture, and just in front of the anterior cingular list. It is not impossible, however, that such pores do exist in Dinophysis.

Both *flagella* arise in the flagellar pore and are well developed. The transverse flagellum (Schütt, 1895, pl. 1, fig. 5: 1 and 6: 1, 2) lies in the girdle and encircles the body from the left around to the right. The longitudinal flagellum (Schütt, 1895, pl. 1, fig. 5: 1; 6: 1, 2; 7: 1), which is about as long as the body or somewhat shorter, passes posteriorly between the sulcal lists.

The structure of the *thecal wall* is less variable than in Phalacroma. In most species there is a fairly great number of pores and poroids (Schütt, 1895, p. 21, 22) more or less uniformly scattered all over the theca; in others such structures have not been observed. Sometimes the theca appears to lack structural differentiation except for the pores and poroids, but usually it is characterized either by areolation or by reticulation. The areoles (Pavillard, 1916, pl. 3) are small, rounded, and more or less closely set pits, resembling the poroids, with which they are connected by transitional structures (Schütt, 1895, p. 22). The meshes of the reticulation always are rather small or of moderate size; in *Dinophysis jörgenseni* and *D. swezyi* (Plate 5, fig. 7, 9), which are characterized by larger meshes than most of the other species of this genus, about twelve to twenty meshes border the posterior margin of the transverse furrow. The ridges between the areoles and meshes sometimes are so fine that the structure hardly can be distinguished, sometimes (*D. alata*, Jörgensen, 1923, p. 33, fig. 45) they are rather heavy. In most species the areolation or reticulation covers the whole thecal surface, in others (*D. jörgenseni*, Plate 5, fig. 7) the regions nearest to the sagittal suture remain more or less undifferentiated. It should be remembered that the new valve of a recently divided specimen is thin and almost without structure, while in old specimens the thecal wall is relatively heavy and its structural peculiarities are well developed. In a few species (Stein, 1883, pl. 20, fig. 10, 14; pl. 21, fig. 1) small, wart-like structures are to be found at the posterior end of the theca.

With regard to the shape and structure of the *intercalary* zones of the megacytic specimens and of the ridge of adherence in *Dinophysis caudata*, *D. tripos*, and *D. miles*, see p. 51, 218.

The *protoplasmic contents* are coarsely granular, and hyaline or of a pale yellowish green or brownish color. The *nucleus*, which usually is located in the dorsal, posterodorsal, or posterior portion of the body (Schütt, 1895, pl. 1, fig. 4: 3; 7: 1; 6: 2), is rather large, ellipsoidal, ovoidal, or spheroidal, and has moniliform chromatin reticulum. Probably in all species there are one or two large *pusules*, which open by more or less slender canals into the flagellar pore (Schütt, 1895, pl. 1, fig. 4: 2). When *chromatophores* are present, they usually are rod-shaped or granular, and yellow, brown, or reddish brown in color (Schütt, 1895, pl. 1, fig. 4: 1, 2; 6: 2). In some forms the chromatophores are arranged in groups, named *chromatospheres* by Schütt (1895, p. 65). *Metaplasmic inclusions* of various kinds, *e.g.*, globules of fats and oils, also have been found (see Schütt (1895) and Bütschli (1885)).

The *length of the body* is very variable within the species as well as within the genus. For the genus as a whole the variation in length thus far established ranges from 28.9 μ (*Dinophysis exigua*) to 107.0 μ (*D. caudata*).

Reproduction: — Binary fission of the free-swimming individuals is the only known mode of reproduction in Dinophysis as well as in Phalacroma, and it presumably takes place in about a similar manner in both these genera; see Plate 5, fig. 3, and p. 51. Bergh (1886, p. 80–82, pl. 5, fig. 11, 12) describes and figures specimens of *Dinophysis acuta* with the sulcal lists in a state of reorganization following binary fission.

In *Dinophysis caudata* the two schizonts, for some time following binary fission, remain attached to each other by an accessory ridge along the posterior portion of the dorsal margin of the anterior part of the hypotheca. The duration of this attachment is not known. The ridge of adherence, which appears to be resorbed fairly soon after the separation of the schizonts, sometimes (Figure 44: 6) is narrow and sometimes (Figure 44: 2) rather wide; in some specimens it lacks structural differentiation, in others it has an areolation resembling that of the thecal valves. The schizonts of the closely related *D. tripos* adhere to each other by a ridge extending almost to the tip of the dorsal peduncle (Jörgensen, 1923, fig. 38, 39). *Dinophysis miles*, in which this phenomenon is further developed and which is characterized by the extreme elongation of the dorsal peduncle, has the small ridge of adherence near the tip of the dorsal peduncle. In this species as many as eight specimens have been found to form a wheel-like colony. The specimens of this colony have their dorsal peduncles directed toward the center, like the spokes of a wheel, and all of them turn their ventral sides from the center (Weber-van Bosse, 1901, pl. 17, fig. 3). Except in the three species just mentioned, this phenomenon has not been observed in Dinophysis; probably it is limited to the Caudata group. Its significance is not known, but it may be interpreted as an adaptation to flotation. It is of interest in this connection that the members of the Caudata group are the only ones in Dinophysis in which the buoyancy has been increased by a profound modification of the shape of the body.

The "chain" figured by Weber-van Bosse (1901, pl. 17, fig. 3) is interesting also because of the unequal sizes of the component specimens. It shows that the pronounced differences in the size of the body which are so characteristic a feature in many species of Dinophysis and related genera might be brought about by a comparatively small number of rapidly repeated binary fissions.

A more or less striking increase in the size of the body preceding binary fission and accompanied by the formation of intercalary bands along the sagittal margins of the two valves has been observed in Dinophysis. However, this phenomenon appears to occur less frequently in this genus than in Phalacroma (see p. 52). It has been found only in the following of the forty-one presumably valid species: *Dinophysis acuta* (Stein, 1883), *D. hastata* (Pavillard, 1915a, 1916, and Albatross Exped.), *D. norvegica* (Meunier, 1910), *D. punctata* (Stein, 1883, pl. 20, fig. 8), *D. recurva* (Pavillard, 1916), *D. sacculus* (Pavillard, 1916), and in the specimen figured as *D. sphaerica* by Stein (1883, pl. 20, fig. 6).

Distribution: — There are more distributional data on Dinophysis than on any other genus of Dinophysoidae. This is largely due to the fact that several species are relatively frequent in the northern European waters, which have seen submitted to very extensive and oft-repeated investigations. Unfortunately, the great majority of these data lack descriptions and figures by means of which the determinations of species may be checked (see p. 224). For this and other reasons, *e.g.*, the looseness of the concept of species held by several of the investigators, the general distribution of many of the species must be regarded as rather uncertain. On the other hand, the distribution of the genus as a whole is probably fairly well established.

Dinophysis is marine, almost exclusively eupelagic, occurs in all seas, but most of its species are restricted to waters of tropical, subtropical, and warm-temperate nature or origin. As examples of species occurring in the cold waters of the far north, *D. acuminata*, *D. acuta*, *D. arctica*, *D. cuneiformis*, *D. granulata*, *D. norvegica*, *D. semen*, *D. sphaerica*, *D. ventricosa*, and *D. vertex* may be mentioned. These species have been found either on the west coast of Norway or in the Arctic Ocean. Most of them probably are endogenetic (see Aurivillius, 1898a) in these waters; some are eurythermal and more or less widely distributed; some appear to be stenothermal, cold-water forms. It also may be mentioned that Aurivillius (1899, p. 32, 33) found representatives of this genus as far to the north as lat. 80° 31′ N. One of the species recorded by Aurivillius (1899) from lat. 80° 31′ N., viz., *D. sphaerica*, was taken by the Valdivia Expedition (Karsten, 1905) in the Antarctic Ocean as far to the south as lat. 63° 32′ S. All the species of Phalacroma found as yet in the cold waters of the far north and the far south are small, rotund, and simply organized. The species of Dinophysis in the colder waters, are also, typically, of the simpler, less highly specialized types, but some of the more or less luxuriant representatives of this genus, *e.g.*, *D. hastata* and *D. schütti*, are occasionally carried by currents from the warm regions into the cold (Ostenfeld, 1900). Only a few species are known to be endogenetic in brackish waters, viz., *D. acuta*, *D. baltica*, and *D. granulata*, which have been found in the less saline regions of the Baltic Sea. Other species have been recorded from the brackish regions of the Baltic, but since their specific determinations are very uncertain the list is restricted to the three species just mentioned (see Jörgensen, 1912, p. 10, 11). It may be added that Oye (1921) found *D. acuta* to be the only species of this genus occurring in the brackish waters at Batavia (Java).

The genus is found in surface waters, but the optimum habitat of most of its species appears to be the deeper levels of photosynthesis. However, the vertical distribution of the genus is very incompletely known, since but few records based on catches made with closing nets are available. The following records from Karsten's (1905, 1906, 1907) reports on the phytoplankton of the VALDIVIA Expedition are the only ones published at the present writing. *Dinophysis ovum* was found in catches from 35–15 m. and 55–35 m. at Station 145; *D. hastata* and *D. uracantha* in a haul from 80–60 m. at Station 169; *D. caudata*, in a catch from 200–100 m. at Station 67. *Dinophysis sphaerica* was taken at the following stations: — Station 151, 100–10 m. and 300–200 m.; Station 152, 80–60 m.; Station 169, 60–40 m. All the species recorded were reported as "living."

Many of the species appear to be more or less rare, but some of them, *e.g.*, *D. miles*, *D. acuta*, and *D. caudata*, have been taken in rather large numbers; see Schröder (1906a, p. 333), who recorded *D. miles* as very common ("cc"), Lohmann (1908a, p. 148), and Jörgensen (1923, p. 27). It should be remembered in this connection that Hensen (1911, p. 164) has found this genus to pass "wohl recht leicht durch die Netzmaschen."

Representatives of Dinophysis were found at eighty-nine (70.0%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These eighty-nine stations are distributed over the whole area covered by the Expedition in the following manner (Plate 25): —

	Number of Stations and Occurrences	Number and % of Occurrences		
				%
California Current	4571, 4574, 4580, 4583	4	4	100
Mexican Current	4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4545, 4546	13	12	92.3
Panamic Area	4609, 4611, 4613, 4615, 4617, 4619, 4631, 4634, 4637, 4638, 4639, 4640, 4644	17	13	76.5
Peruvian Current	4647, 4648, 4649, 4650, 4651, 4652, 4655, 4657, 4659, 4660, 4663, 4664, 4665, 4667, 4668, 4669, 4670, 4671, 4673, 4675, 4676, 4678	27	22	85.2
Easter Island Eddy	4689, 4691, 4695, 4697, 4699	10	5	50
Galapagos Eddy	4713, 4715, 4716	4	3	75
South Equatorial Drift	4679, 4680, 4681, 4683, 4687, 4701, 4705, 4707, 4709, 4711, 4717, 4719, 4720, 4721, 4722, 4724, 4727, 4728, 4730, 4732, 4734, 4736, 4737, 4739, 4740, 4741	45	26	57.8
South Equatorial Current	4742	3	1	33.3
Equatorial Counter Current	4542	2	1	50
North Equatorial Current	4544	2	1	50

At sixty-four of these eighty-nine stations Dinophysis was taken in vertical hauls and at thirty-six stations in surface hauls. Most of the records from vertical hauls are from 300–0 fathoms, some are from 800, 400, 150, 100–0 fathoms. Vertical hauls were made at sixty-eight of the 127 stations. The genus thus was found at not less than 94.2% of the stations at which vertical hauls were made.

Disregarding the stations at which only surface catches were made, the record stations are distributed over the area covered by the Expedition in the following manner:—

	Number of Stations	Number and % of Occurrences	
			%
California Current	4	4	100
Mexican Current	5	5	100
Panamic Area	6	6	100
Peruvian Current	22	19	86.4
Easter Island Eddy	5	5	100
Galapagos Eddy	2	2	100
South Equatorial Drift	23	22	95.6
South Equatorial Current	1	1	100

There were no vertical hauls made in the Equatorial Counter Current or in the North Equatorial Current.

Surface catches and Salpa stomachs of specimens taken in surface waters (eighty-one surface catches and twenty-four samples of Salpa stomachs) were examined from eighty-two stations. The genus, as previously mentioned, was taken in surface hauls at thirty-six stations, *i.e.*, at 43.9% of all the surface stations. Taking into consideration the surface stations only, these thirty-six record stations are distributed in the following manner:—

	Numbers of Stations and Occurrences	No. of Stations	Number and % of Occurrences	
				%
California Current	4571, 4574, 4580, 4583	4	4	100
Mexican Current	4588, 4592, 4596, 4600, 4604, 4545, 4546	9	7	77.8
Panamic Area	4611, 4615, 4619, 4631, 4638, 4639, 4640, 4644	13	8	61.5
Peruvian Current	4649, 4650, 4657, 4659, 4660, 4666, 4669, 4676, 4678	20	9	45
Easter Island Eddy	0000	5	0	0
Galapagos Eddy	4716	2	1	50
South Equatorial Drift	4680, 4709, 4720, 4727	23	5	21.7
South Equatorial Current	0000	2	0	0
Equatorial Counter Current	4542	2	t	50
North Equatorial Current	4544	2	1	50

On account of the prevalence of Dinophysis in deeper waters, the table showing the distribution and the frequency of the record stations at which *vertical* hauls were made should be used as an indicator of the horizontal distribution of this genus in the area investigated by the Expedition. This table shows that the genus is almost evenly distributed throughout this area. In the region with the lowest percentage of record stations, *viz.*, the Peruvian Current, it was taken at not less than 86.4% of the stations with vertical hauls; and in the California Current, Mexican Current, Panamic Area, Easter Island Eddy, Galapagos Eddy, and South Equatorial Current it occurred at all the stations with vertical hauls. The even distribution of this genus is evident not only from the distribution and frequency of the record stations but also from the distribution and frequency of the records of species (Plate 25). Of the five most frequent species, *D. hastata*, *D. jörgenseni*, *D. schütti*, and *D. uracantha* (Figure 34, 43, 41, 36) were found to be more or less evenly distributed throughout the area investigated; *D. caudata*, on the other hand, was found to have a rather peculiar distribution; almost all its record stations are located in the coastal currents (Figure 45).

The surface record stations of Dinophysis are very unevenly distributed. While this genus was found at not less than twenty-eight (60.9%) out of the forty-six surface stations in the California Current, Mexican Current, Panamic Area, and Peruvian Current, it did not occur at more than six (20.0%) out of the thirty surface stations in the South Equatorial Drift, the Easter Island Eddy, and the Galapagos Eddy. However, this is due to the fact that not less than twenty-eight (63.7%) out of the forty-four surface records are of *D. caudata*, a species occurring almost exclusively in the coastal currents. If this species is disregarded, the genus occurred at seven (15.2%) out of the forty-six surface stations in the coastal regions and at six (20.0%) out of the thirty surface stations in the South Equatorial Drift, the Easter Island Eddy, and the Galapagos Eddy.

There are 170 records of species of Dinophysis from vertical catches. Out of these 170 records 1 (0.6%; Station 4659) showed a frequency of 12%; 1 (0.6%; Station 4571) 9%; 1 (0.6%; Station 4650) 3%; 11 (6.5%; Stations 4574, 4598, 4609, 4638, 4651, 4655, 4671, 4675, 4676, 4689, 4695) 2%; 34 (20.0%; Stations 4571, 4580, 4587, 4590, 4613 [2 records], 4617, 4634, 4637, 4638 [2 records], 4647, 4648, 4657, 4663 [2 records], 4667, 4670, 4671, 4679, 4681 [2 records], 4689, 4699, 4701, 4715 [2 records], 4722, 4724, 4734, 4737, 4740 [2 records], 4742) 1%; 122 (71.8%) showed a frequency of less than 1%.

There are forty-four records of species from surface catches. Out of these forty-four records 1 (2.3%; Station 4571) showed a frequency of 72%; 1 (2.3%; Station 4611) 29%; 1 (2.3%; Station 4649) 11%; 1 (2.3%; Station 4669) 10%; 1 (2.3%; Station 4639) 9%; 1 (2.3%; Station 4615) 6%; 1 (2.3%; Station 4640) 5%; 1 (2.3%; Station 4720) 4%; 3 (6.8%; Stations 4657, 4659, 4676) 3%; 3 (6.8%; Stations 4644, 4650, 4544) 2%; 8 (18.2%; Stations 4574, 4588, 4592, 4619, 4666

[2 records], 4716, 4542) 1%; 22 (50.0%) showed a frequency of less than 1% or did not have the frequency established. Of these records all but one (*Dinophysis sphaerica*, 4%, Station 4720) showing a frequency of 2% or more refer to *D. caudata*.

As will be seen from a comparison between the last two paragraphs and the corresponding paragraphs in the section on the distribution of the genus Phalacroma, the number of records of species as well as the average frequency of the individual species is less in Dinophysis than in Phalacroma. Only one species of Dinophysis, viz., *D. caudata*, was found to be relatively frequent in the material of the Expedition.

Coincident occurrence of different species of Dinophysis in catches from 300 (800, 400, 150, 100)–0 fathoms is recorded at the following of the sixty-four stations mentioned above: — six species occurred coincidently at five stations (7.8%; Stations 4679, 4691, 4701, 4711, 4730); five species at three stations (4.7%; Stations 4638, 4681, 4732); four species at seven stations (10.9%; Stations 4637, 4659, 4676, 4697, 4705, 4713, 4722); three species at ten stations (15.6%; Stations 4605, 4613, 4650, 4651, 4652, 4671, 4699, 4715, 4717, 4740); two species at twenty-eight stations (43.8%; Stations 4571, 4574, 4580, 4583, 4587, 4590, 4594, 4598, 4609, 4634, 4647, 4655, 4663, 4665, 4667, 4673, 4675, 4683, 4687, 4689, 4695, 4709, 4721, 4724, 4734, 4737, 4739, 4742).

Coincident occurrence of different species of this genus in surface catches is recorded at the following of the thirty-six surface stations mentioned above: — three species occurred coincidently at two stations (5.5%; Stations 4588, 4676); two species at four stations (11.1%; Stations 4583, 4596, 4666, 4545).

At the thirty-six surface stations just mentioned, there are records of only seven of the twenty species of this genus found in the material of the Expedition. The number of surface records of each of these seven species is as follows: — *Dinophysis caudata*, twenty-eight records, one of which is from a Salpa stomach; *D. hastata*, eight records; *D. exigua*, two records, one of which is from a Salpa stomach; *D. sphaerica*, two records, one of which is from a Salpa stomach; *D. uracantha*, two records, one of which is from a Salpa stomach; *D. jörgenseni*, one record; *D. schütti*, one record. Thus not less than thirty-six (81.8%) out of the forty-four surface records refer to two species only, one of which, *D. caudata*, seems to be predominantly a surface species.

The fact that Dinophysis was found to be somewhat evenly distributed throughout the area investigated by the Expedition leads to the inference that it is fairly evenly distributed throughout all the tropical and subtropical seas.

It may also be mentioned that only seven out of the forty-one presumably valid species of this genus have been found only in the material of the Expedition.

Historical Discussion and Systematics

Dinophysis was the first genus of the tribe Dinophysoidae to be established. It was founded for two new species, *D. acuta* and "*D. michaelis*" (= *D. limbata*), by Ehrenberg (1840a, p. 124), who gave it but a short and superficial diagnosis. Diagnoses of this genus have also been published by Griffith and Henfrey (1856, p. 211; 1875, p. 253; 1883, p. 264), Diesing (1866, p. 98), Fromentel (1874, p. 196), Kent (1881, p. 458), Bergh (1881a, p. 5; 1881b, p. 226), Bütschli (1885, p. 1010), Delage and Hérouard (1896, p. 385), Schütt (1896, p. 27), Paulsen (1908, p. 12), Meunier (1919, p. 79), Jörgensen (1923, p. 18), and Lebour (1925, p. 79). Most of these generic diagnoses are partial and inadequate; the one by Paulsen (1908) is the best. A short discussion of this genus was given by Claparède and Lachmann (1858, p. 406). Fairly lengthy descriptions and discussions were published by Bergh (1881b, p. 218) and by Gourret (1883, p. 74); Bergh's (1881b) account is comparatively good, while the one by Gourret (1883) is characterized by numerous imperfect observations and misinterpretations.

Besides the two specific names of Dinophysis established by Ehrenberg (1840a), the following specific and subspecific names of this genus are to be found in the literature:—

D. atlantica Ehrenberg (1854)
D. norvegica Claparède & Lachmann (1858)
D. ventricosa Claparède & Lachmann (1858)
D. acuminata Claparède & Lachmann (1858)
D. rotundata Claparède & Lachmann (1858)
D. ovata Claparède & Lachmann (1858)
D. laevis Claparède & Lachmann (1858)
D. norvegiana Claparède & Lachmann, Moss (1877)
D. arctica Mereschowsky (1878)
D. caudata Kent (1881)
D. acuta Ehrenberg var. *geminata* Pouchet (1883)
D. galea Pouchet (1883)
D. hastata Stein (1883)
D. sphaerica Stein (1883)
D. sacculus Stein (1883)
D. uracantha Stein (1883)
D. homunculus Stein (1883)
D. jourdani Gourret (1883)
D. allieri Gourret (1883)
D. inaequalis Gourret (1883)
D. tripos Gourret (1883)
D. acuacuta Bergh, Balbiani (1884b)
D. semicarinata Grenfell (1887)
D. armata Daday (1888)
D. laevis Stein, Daday (1888)
D. lenticula Bergh, Daday (1888)
D. vermiculata Pouchet (1894)
D. ovum Schütt (1895)
D. ocuta Hjort & Gran (1899)
D. ovalis Claparède & Lachmann, Ostenfeld (1899)
D. vanhöffeni Ostenfeld (1899)
D. granulata Cleve (1899e)
D. rudgei Murray & Whitting (1899)
D. schütti Murray & Whitting (1899)
D. rotundata Claparède & Lachmann var. *laevis* (Claparède & Lachmann) Jörgensen (1899)
D. homunculus Stein var. *allieri* (Gourret) Lemmermann (1899a)
D. homunculus Stein var. *incurva* Lemmermann (1899a)
D. homunculus Stein var. *tripos* (Gourret) Lemmermann (1899a)
D. miles Cleve (1900b)
D. truncata Cleve (1900f)
D. schröteri (Forti, 1901), described as *Heteroceras schröteri*
D. aggregata Weber-van Bosse (1901)

D. acuminata Claparède and Lachmann var. *granulata* (Cleve) Jörgensen (1901)
D. miles Cleve var. *aggregata* (Weber-van Bosse) Lemmermann (1901a)
D. miles Cleve f. *maris rubri* Ostenfeld & Schmidt (1901)
D. miles Cleve f. *indica* Ostenfeld & Schmidt (1901)
D. homunculus Stein var. *pedunculata* Schmidt (1901)
D. intermedia Cleve (1902b)
D. sphaericaca Entz (1902b)
D. acuta Ehrbg. var. *steini* Lemmermann (1902a)
D. acuminata Claparède and Lachmann f. *reniformis* Pavillard (1905)
D. miles Cleve f. *maris jonii* Schröder (1906a)
D. pavillardi Schröder (1906a)
D. homunculus Stein var. *appendiculata* Zacharias (1906)
D. homunculus Stein var. *carinata* Zacharias (1906)
D. triacantha Kofoid (1907a)
D. ellipsoides Kofoid (1907b)
D. diegensis Kofoid (1907b)
D. diegensis f. *curvata* Kofoid (1907b)
D. nias Karsten (1907)
D. norvegica Claparède & Lachmann f. *crassior* Paulsen (1907)
D. norvegica Claparède & Lachmann f. *debilior* Paulsen (1907)
D. ovum Schütt var. *baltica* Paulsen (1908)
D. schröderi Pavillard (1909)
D. cuneiformis Meunier (1910)
D. vertex Meunier (1910)
D. semen Meunier (1910)
D. apiculata Meunier (1910)
D. homunculus Stein var. *gracilis* Schröder (1911)
D. collaris Kofoid & Michener (1911)
D. expulsa Kofoid & Michener (1911)
D. rugosa Kofoid & Michener (1911)
D. bihastata Hensen (1911)
D. bipes Hensen (1911)
D. hormunculus Hensen (1911)
D. hornunculus Hensen (1911)
D. pluripes Hensen (1911)
D. porosa Hensen (1911)
D. sphaeroidea Hensen (1911)
D. tripes Hensen (1911)
D. geminata (Pouchet) Kofoid & Ridgen (1912a)
D. norvegica Claparède & Lachmann var. *crassicornis* Smyth (1912)
D. dens Pavillard (1915b)
D. miles Cleve f. *schröteri* (Forti) Ostenfeld (1915)
D. pedunculata (Schmidt) Ostenfeld (1915)
D. homunculus Stein var. *ventricosa* Pavillard (1916)
D. diegensis Kofoid var. *caudata* Pavillard (1916)
D. intermedia Pavillard (1916)
D. lenticula Pavillard (1916)
D. acuta Ehrenberg var. *sculpta* Jörgensen (1923)
D. alata Jörgensen (1923)
D. caudata Kent var. *abbreviata* Jörgensen (1923)
D. caudata Kent var. *allieri* (Gourret) f. *speciosa* Jörgensen (1923)
D. caudata Kent f. *marmarae* Jörgensen (1923)
D. caudata Kent f. *pontica* Jörgensen (1923)
D. caudata Kent f. *subdiegensis* Jörgensen (1923)
D. hastata Stein var. *phalacromides* Jörgensen (1923)
D. hastata Stein var. *uracanthides* Jörgensen (1923)
D. intermedia Pavillard f. *pachyderma* Jörgensen (1923)
D. kofoidi Jörgensen (1923)
D. punctata Jörgensen (1923)
D. pusilla Jörgensen (1923)
D. tripos Gourret f. *brevicauda* Jörgensen (1923)
D. uracantha Stein var. *mediterranea* Jörgensen (1923)
D. fortii Pavillard (1923a)
D. hastata Stein var. *parvula* Lindemann (1923)
D. homunculus Stein var. *latus* Lindemann (1923)
D. rotundata Claparède & Lachmann var. *intermedia* Lindemann (1923)
D. schütti Murray & Whitting var. *uracanthoides* Forti & Issel (1924)

In the present paper the following new names have been introduced:—*D. baltica*, *D. caudata*, *D. acutiformis*, *D. exigua*, *D. jörgenseni*, *D. monacantha*, *D. okamurai*, *D. recurva*, *D. reniformis*, *D. similis*, *D. swezyi*, *D. trapezium*, and *D. urceolus*.

Among the species enumerated above, *Dinophysis rotundata* Claparède and Lachmann (1858), *D. laevis* Claparède and Lachmann (1858) (*D. rotundata* var. *laevis* of Jörgensen (1899)), *D. ovata* Claparède and Lachmann (1858), and *D. expulsa* Kofoid and Michener (1911) have been transferred to Phalacroma (see p. 59). On the other hand, *Dinophysis rotundata* Claparède and Lachmann var. *intermedia* Lindemann (1923) apparently belongs to Dinophysis; its specific allocation is uncertain, and the subspecific name, though preoccupied, is retained temporarily until the systematic status of this form is determined. *Dinophysis jourdani* Gourret (1883) and *D. armata* Daday (1888) are identical and belong to Ceratocorys, according to Kofoid (1910a) and Jörgensen (1911). *Dinophysis galea* Pouchet (1883) includes four different species, none of which belongs to Dinophysis. *Dinophysis intermedia* Cleve (1902b) should be transferred to Histioneis. *Dinophysis rugosa* Kofoid and Michener (1911) is the type of Histiophysis.

Dinophysis bihastata, *D. bipes*, *D. pluripes*, *D. porosa*, *D. sphaeroidea*, and *D. tripes*, all of Hensen (1911), are *nomina nuda*, and there is no information published as yet as to their organization. *Dinophysis ocuta* Hjort and Gran (1899) and *D. norvegica* Claparède and Lachmann var. *crassicornis* Smyth (1912), which also are *nomina nuda*, evidently are due to slips of the pen and are intended for *D. acuta* Ehrenberg and *D. norvegica* Claparède and Lachmann var. *crassior* Paulsen, respectively; see Ostenfeld (1916b, p. 13). *D. norvegiana* Claparède and Lachmann, Moss (1877), *D. acuacuta* Bergh, Balbiani (1884b), *D. laevis* Stein, Daday (1888), *D. lenticula* Bergh, Daday (1888), *D. sphaeriaca* Entz (1902b), and *D. hormuneculus* and *D. hornuneculus* Hensen (1911) also are due to slips of the pen and stand for *Dinophysis norvegica* Claparède and Lachmann, *D. acuta* Ehrenberg, *Dinopyxis laevis* Stein, *Diplopsalis lenticula* Bergh, *Dinophysis sphaerica* Stein, and *Dinophysis homunculus* Stein, respectively. The name *Dinophysis oralis* Claparède and Lachmann, Ostenfeld (1899) is due to an error and should be *D. ovata* Claparède and Lachmann.

A fairly great number of the names mentioned in the first two paragraphs of this section are synonyms. The reasons why *D. caudata* has so many synonyms are that Kent's (1881) original description was not accompanied by any figures and was disregarded until recently; that three investigators, Pouchet (1883), Stein (1883), and Gourret (1883), described and named this species almost simultaneously but independently of each other; and that this species is characterized by an exceptionally great variability (see p. 314).

Dinophysis tripos Gourret (1883), which some investigators refer to *D. caudata* but which is considered as a distinct species, has the following synonyms: *D. tripos* f. *brevicauda* Jörgensen (1923), *D. homunculus* var. *appendiculata* Zacharias (1906), *D. homunculus* var. *incurva* Lemmermann (1899a), and *D. homunculus* var. *tripos* (Gourret) Lemmermann (1899a).

Dinophysis diegensis Kofoid (1907b), of which there are two varieties, var.

curvata Kofoid (1907b) and var. *caudata* Pavillard (1916), *D. caudata* Kent f. *subdiegensis* Jörgensen (1923), and *D. caudata* f. *acutiformis* nobis have a rather uncertain systematic status. Indeed, it is not impossible that all these forms are established on specimens of *D. caudata* degenerated in coastal waters, but this cannot be proven. *Dinophysis kofoidi* Jörgensen (1923) is a synonym of *D. subdiegensis,* while *D. caudata* f. *acutiformis* is a new name applied to the form previously established by Pavillard (1916) under the name *D. homunculus* var. *ventricosa.* Pavillard's name *ventricosa* had to be discarded since it was antedated by *D. ventricosa* Claparède and Lachmann (1858). If Pavillard's (1916) variety *caudata* is a distinct systematic unit, then, of course, its name must be changed.

Dinophysis miles Cleve (1900b), which is a close relative of *D. caudata* and *D. tripos,* comprises two rather different varieties, viz., *D. miles miles* (Cleve, 1900b, fig. 1a) and *D. miles* f. *schröteri* (Forti) Ostenfeld (1915). These two forms probably are specifically distinct, but this question cannot be settled as yet. *Dinophysis miles miles* is identical with *D. miles* f. *maris rubri* Ostenfeld and Schmidt (1901). *Heteroceras schröteri* Forti (1901), *Dinophysis aggregata* Weber-van Bosse (1901), *D. miles* f. *indica* Ostenfeld (1901), and *D. miles* var. *aggregata* (Weber-van Bosse) Lemmermann (1901a) are synonyms of *D. miles* f. *schröteri.* Another variety of *D. miles,* established by Schröder (1906a) under the name of *D. miles* f. *maris jonii,* has not been figured or sufficiently described as yet, and thus must be classified as uncertain.

Dinophysis acuta Ehrenberg (1840a) and *D. norvegica* Claparède and Lachmann (1858), which are very similar but nevertheless undoubtedly specifically distinct, have been badly confused. *Dinophysis acuta,* the type of the genus, was described from the Bay of Kiel, but the form to which its name has been applied in most of the recent papers possibly does not occur in the Baltic (Ostenfeld, 1913a, p. 307), or if it does occur there, it is allogenetic, appearing as a rare guest only (Jörgensen, 1912, p. 11). On the other hand, the form which has been called *D. norvegica* by most authors is common and certainly endogenetic in the southwestern portion of the Baltic. Ehrenberg's (1840a) description and figure of *D. acuta* would be too poor for certainty of specific identification if both these forms were frequent in the Bay of Kiel, but the fact that only one of them occurs there constantly and in relatively great abundance and the fact that all the remaining species of Dinophysis found in the Baltic are strikingly different from *D. acuta* as figured by Ehrenberg makes it necessary to accept Ehrenberg's data and apply the name *D. acuta* to the one of the two species that is endogenetic in the Bay of Kiel (see Aurivillius, 1898a, p. 104, and Jörgensen, 1923, p. 18). In other words, *D. acuta* Ehrenberg should be applied to the form figured as *D. acuta* by Bergh (1881b, pl. 15, fig. 49, 50) and by Lohmann (1908a, p. 201, fig. 51) and under the name of *D. norvegica* var. *debilior* by Paulsen (1907, fig. 1b). On the other hand, *D. norvegica* Claparède and Lachmann is identical with the form figured by Paulsen (1907, fig. 1a) as *D. norvegica* var. *crassior*. *Dinophysis acuta* Jörgensen (1899, pl. 1, fig. 2), which by most authors has been treated as the type of *D. acuta* Ehrenberg, almost certainly is a synonym of *D. ventricosa* Claparède and Lachmann (1858, pl. 20, fig. 20) (see Jörgensen, 1899, p. 28). Furthermore, *D. acuta* var. *steini* Lemmermann (1902a), which is founded on *D. acuta* Stein (1883, pl. 20, fig. 14–17), probably is a synonym of *D. acuta* Ehrenberg, while *D. acuta* Stein (1883, pl. 20, fig. 20) is referable to *D. ventricosa* Claparède and Lachmann. *D. acuta* var. *sculpta* Jörgensen (1923) probably is based on an old, thick-walled specimen of *D. ventricosa*.

Dinophysis hastata var. *phalacromides* Jörgensen (1923), var. *uracanthides* Jörgensen (1923), var. *parvula* Lindemann (1923), and *D. uracantha* var. *mediterranea* Jörgensen (1923) are treated as synonyms of *D. hastata* Stein (1883); it should be mentioned, however, that the scope of the last species is very uncertain, and that the present arrangement is tentative. Whether *D. schütti* var. *uracanthoides* Forti and Issel (1924) is a distinct systematic unit or a modification of *D. schütti* is uncertain. Schröder's (1906a) elevation of *D. acuminata* Claparède and Lachmann f. *reniformis* Pavillard (1905) to the rank of species seems to be justified. However, the name used by him, viz., *D. pavillardi*, should be replaced by *D. reniformis;* see also Jörgensen (1923, p. 22). Instead of *D. lenticula* Pavillard (1916), which must be discarded since it is antedated by *D. lenticula* Bergh, Daday (1888), we suggest the name *D. recurva*, nom. nov. *D. vanhöffeni* Ostenfeld (1899) and *D. apiculata* Meunier (1910) are of somewhat uncertain allocation, but most probably they are identical with *D. ovata* Claparède and Lachmann.

Dinophysis acuminata Claparède and Lachmann (1858), *D. arctica* Mereschowsky (1878), and *D. granulata* Cleve (1899e) have been badly confused, and an attempt to unravel their synonymies will meet with great difficulties. For the present all of them should be treated as specifically distinct. *Dinophysis arctica* is a valid species according to Paulsen (1911b, p. 304); and *D. granulata* is specifically distinct according to Jörgensen (1912, p. 10, 11). *Dinophysis acuminata* Claparède and Lachmann var. *granulata* (Cleve) Jörgensen (1901) thus becomes a synonym. See also (p. 230) the treatment of *D. michaelis* Ehrenberg.

Dinophysis acuminata Claparède and Lachmann was described from the west coast of Norway. The type, as figured, is characterized especially by being much broader posteriorly than anteriorly and by having a small, triangular antapical protuberance somewhat ventrally to the midline of the body. Under this name Jörgensen (1899) gave a short description and fairly good figures of a form which he had found in hundreds of specimens on the west coast of Norway; the three specimens figured, however (1899, pl. 1, fig. 7–9), differ strikingly from the type as figured by Claparède and Lachmann (1858, pl. 20, fig. 17); they are about as wide anteriorly as posteriorly or even slightly narrower posteriorly than anteriorly, and they have some small, rounded protuberances in the middle of the postmargin of the body. In a later paper Jörgensen (1912) points out that *D. acuminata* is very variable and that there is, on the west coast of Norway, a form that agrees fairly well ("viel besser, und ziemlich genau") with the type specimen. Paulsen (1912, p. 261) considers it possible that it will prove necessary to divide *D. acuminata* into two or more species. These facts seem to indicate, first, that *D. acuminata* at the present time is a collective species and, second, that the form described and figured by Jörgensen (1899, pl. 1, fig. 7–9) is specifically distinct from the type. The last circumstance is the more confusing since many modern investigators evidently have treated Jörgensen's (1899) figures as if they had been drawn from cotypes.

Levander (1900a, p. 15, fig. 1) described and figured a form from the Gulf of Finland which he called "Dinophysis sp. (? *ovum* Schütt)." Later this form was treated by Paulsen (1908) under the name *D. ovum* Schütt var. *baltica*. The question as to whether this form is specifically distinct or only a brackish-water modification of *D. ovum* is, of course, impossible to settle at present. However, these two forms differ in so many respects that they should be considered as different species until it has been proven that they are genetically identical. The most important differences are to be found in the size of the body, in the shape of the transverse furrow and of the epitheca, and in the width and shape of the cingular and sulcal lists. The name of this species should be *Dinophysis baltica* Paulsen. It may be mentioned in this connection that *D. baltica* has been recorded only by Levander. Thus it was not found in the Finnish waters by Jörgensen (1912), who, on the other hand, recorded *D. granulata* Cleve, a species that is strikingly similar to *D. baltica* and that has never been recorded by Levander. Are *D. baltica* and *D. granulata* Jörgensen (1912) identical?

Dinophysis cuneiformis, *D. semen*, and *D. vertex* Meunier (1910), which are of somewhat uncertain systematic status, have in the present paper been treated as valid species. *Dinophysis cuneiformis* recalls *D. acuta* Ehrenberg, and *D. semen* shows a great resemblance to *D. granulata* Cleve.

Due to insufficient data, *Dinophysis michaelis* Ehrenberg (1840a) cannot be determined at the present time; it may be identical either with *D. acuminata* Jörgensen (1899) or with *D. granulata* Cleve (1899c), both of which occur in the southern portion of the Baltic (Jörgensen, 1912). However, it is not impossible that a careful examination of rich material from the type locality, the Bay of Kiel, will allow the identification of this species with a fair degree of accuracy. Judging by the information published, it appears most probable that this species is identical with *D. rotundata* Lohmann (1908a, p. 201, fig. 43) and with *D. granulata* Jörgensen (1912). With regard to the name *D. michaelis,* Ehrenberg (1840a, p. 151) writes as follows: "Der erste Beobachter dieses Thierchens ist Dr. Michaelis in Kiel, unter dessen Zeichnungen, die er mir durchsehen liess, diese Form bereits war. Ich habe deshalb diesen Specialnamen vorgezogen." The name *D. limbata* had evidently been used by Ehrenberg (1840a) in his manuscript and engraved (his Plate 4, fig. 15) before he saw Dr. Michaelis's drawings, which appear to have determined the change in the text from *limbata* to *michaelis.* However, in the above-mentioned paper the name *michaelis* precedes *limbata* and thus has priority.

Dinophysis atlantica Ehrenberg (1854) and *D. vermiculata* Pouchet (1894) also must be regarded as impossible to determine with a fair degree of certainty at the present time. The first species was considered by Jörgensen (1923) as possibly identical with *D. intermedia* [*fortii*]; the other is closely connected with *D. acuta* Ehrenberg, *D. norvegica* Claparède and Lachmann, and *D. ventricosa* Claparède and Lachmann.

At present there are forty-one presumably valid species of Dinophysis, one presumably valid subspecies, and four species and six subspecies of more or less uncertain status. The valid species and subspecies are as follows: —

D. acuminata Claparède & Lachmann (1858)
D. acuta Ehrenberg (1840a)
D. alata Jörgensen (1923)
D. arctica Mereschowsky (1878)
D. baltica Paulsen (1908) nobis
D. caudata Kent (1881)
D. collaris Kofoid & Michener (1911)
D. cuneiformis Meunier (1910)
D. dens Pavillard (1915b)
D. ellipsoides Kofoid (1907b)
D. exigua, sp. nov.
D. fortii Pavillard (1923a)
D. granulata Cleve (1899c)
D. hastata Stein (1883)
D. jorgenseni, sp. nov.
D. miles Cleve (1900b)
D. miles Cleve f. *schröteri* (Forti) Ostenfeld (1915)
D. monacantha, sp. nov.
D. nias Karsten (1907)
D. norvegica Claparède & Lachmann (1858)
D. okamurai, sp. nov.
D. ovum Schütt (1895)
D. punctata Jörgensen (1923)
D. pusilla Jörgensen (1923)
D. recurva, sp. nov.
D. reniformis Pavillard (1905)
D. rudgei Murray & Whitting (1899)
D. sacculus Stein (1883)
D. schröderi Pavillard (1909)
D. schütti Murray & Whitting (1899)
D. semen Meunier (1910)
D. similis, sp. nov.
D. sphaerica Stein (1883)
D. swezyi, sp. nov.

D. trapezium, sp. nov.
D. triacantha Kofoid (1907a)
D. tripos Gourret (1883)
D. truncata Cleve (1900f)
D. uracantha Stein (1883)
D. urceolus, sp. nov.
D. ventricosa Claparède & Lachmann (1858)
D. vertex Meunier (1910)

The species and subspecies of more or less uncertain status are as follows: —

D. atlantica Ehrenberg (1854)
D. caudata Kent f. *acutiformis*, f. nov.
D. caudata Kent var. *subdiegensis* Jörgensen (1923)
D. diegensis Kofoid (1907b)
D. diegensis Kofoid var. *caudata* Pavillard (1916)
D. diegensis var. *curvata* Kofoid (1907b)
D. michaelis Ehrenberg (1840a)
D. miles Cleve f. *maris jonii* Schröder (1906a)
D. schütti Murray & Whitting var. *uracanthoides* Forti & Issel (1924)
D. vermiculata Pouchet (1894)

Nearly all the published descriptions of species and subspecies are short and incomplete, and most of them have no or but few data of variation for consideration. The descriptions published by Kofoid (1907a) and by Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper. Thus most of the species are very incompletely known, and considerable work will be necessary for a truly scientific delimitation of these units. Especially urgent at the present time is a thorough revision of the species occurring in the waters of northern Europe. As will be seen from the account given above, most of these species were established when protozoölogy was still in its infancy; nevertheless nobody, except Jörgensen (1899), has even attempted a revision. Furthermore, the synonymies of these Nordic species will cause great difficulties, since most of the planktonologists have not been specialists in dinoflagellates and so have applied superficial and unsatisfactory criteria in their determinations of this group.

Pavillard (1916) divided Dinophysis into five sections, which he designated by the names of the representative species, viz., Homunculus, Acuta, Sacculus, Hastata, and Sphaerica. The species included in these sections are as follows: — Homunculus: — *D. homunculus*, *D. homunculus* var. *ventricosa*, *D. diegensis* var. *caudata*, and *D. tripos*. Acuta: — *D. dens*, *D. acuta*, *D. vertex*, *D. ovum*, *D. intermedia*, and *D. schröderi*. Sacculus: — *D. sacculus*, *D. pavillardi*, and *D. lenticula*. Hastata: — *D. hastata*, *D. uracantha*, and *D. schütti*. Sphaerica: — *D. sphaerica*. Jörgensen (1923) divided this genus into the following sections: — Acutae: — *D. acuta*, *D. intermedia*, *D. atlantica*, *D. schröderi*, and *D. dens*. Ovum: — *D. sacculus*, *D. reniformis*, *D. acuminata*, *D. ovum*, *D. lenticula*, and *D. punctata*. Sphaericae: — *D. sphaerica*. Homunculus: — *D. caudata*, *D. caudata* f. *ventricosa*, *D. caudata* var. *subdiegensis*, *D. diegensis* and its two varieties, and *D. tripos*. Hastatae: — *D. hastata*, *D. uracantha*, *D. pusilla*, and *D. alata*. Scolops: — *D. schütti* and *D. triacantha*. Jörgensen (1923) gave his six sections short diagnoses, while Pavillard (1916) did not attempt any characterization of his.

Claparède and Lachmann (1858), Bergh (1881b), Gourret (1883), Stein (1883), and Bütschli (1885) attempted to homologize the different structures in Dinophysoidae and Peridinioidae. Of these attempts the one by Gourret (1883) is characterized by many and peculiar misinterpretations; *e.g.*, the main ribs of the left sulcal list and the central rib of the posterior sail in Dinophysis were homologized with the horns in Ceratium; and the sulcus in Dinophysis was considered to be on the right side of the body. The first detailed description of the sulcal lists was given by Bergh (1881b), who in a later paper (1886) gave the first clear and correct account of the position of these structures relative to the thecal valves. Bergh (1881b) also studied the structure and organization of the thecal wall and of the cell-contents, but most of the knowledge in this field is due to Bütschli (1885) and Schütt (1895, 1899). A few remarks on the adaptive value of the furrows and lists in Dinophysis were made by Francé (1923). With regard to the interpretation of the megacytic specimens, see page 62. Pouchet (1894, p. 175, 176) interpreted megacytic stages as prefission stages.

Contributions to our knowledge of the distribution of Dinophysis are to be found in the following papers, not specifying those previously mentioned in this section: — Abshagen (1908), Apstein (1893, 1902, 1905a, 1912), Aurivillius (1896a, b, 1899), Bergh (1881a), Bigelow (1915), Brandt (1898), van Breemen (1905), Breitfuss (1904, 1912), Broch (1908, 1910a,[1] b), Büse (1915), Bygrave (1911), Carazzi (1900), Carazzi and Grandori (1912), Carisso (1911),[1] Chun (1886), Clark (1905), Cleve (1894, 1897a, 1898, 1899a, b, 1900a, c, d, e, 1901a, e, 1902a, 1903a, b, 1905a, b), Cleve, Ekman, and Pettersson (1901), Cori and Steuer (1901), Cunha and Fonseca (1917), Czapek (1909), Dalla Torre (1889), Dixon and Joly (1898),[1] Driver (1907), Ehrenberg (1840b), Entz (1884, 1902a, b, 1905, 1907), Faria and Cunha (1917), Forti (1906, 1922), van Goor (1923), Gough (1906, 1907), Gräf (1909), Gran (1900, 1902,[1] 1915), Gruber (1884, 1888), Hensen (1887, 1890, 1895, 1911), Herdman and Riddell (1913), Herdman, Thompson, and Scott (1897), Hjort and Gran (1899, 1900), Imhof (1886), Jörgensen (1905), Karsten (1905, 1906), Kraefft (1908), Lauterborn (1894a), Lebour (1917a, b), Lemmermann (1900a, 1901a, 1905a), Levander (1894a, b, c,[1] 1901a, b, 1913, 1914), Lindemann (1924, 1925), Linko (1904, 1906, 1907), Lloyd (1925), Lohmann (1901, 1902, 1920), Mangin (1906, 1912, 1913, 1915), Mereschowsky (1879), Merkle (1910), Mielck (1911), Minkevich (1899), Möbius (1887, 1888a, 1893), Nathansohn (1908, 1909, 1910a), Nordgaard (1899, 1910), Okamura (1907,[1] 1912[1]), Ostenfeld (1895, 1898a, b, 1900, 1902, 1903, 1906, 1909, 1913a), Ostenfeld

[1] Contains figures by which the identifications may be verified.

and Paulsen (1904, 1911), van Oye (1921), Paulsen (1904, 1909, 1911a, b,[1] 1912), Pavillard (1912), Petersen (1897), Pouchet and Guerne (1885), Rauschenplat (1900), Redeke and van Breeman (1903), Reinhard (1910), Schiller (1911a, b, 1912), Schröder (1900a, b, 1906b, 1909), Schütt (1890, 1893), Schussnig (1914), Steuer (1910), Storrow (1913), Stüwe (1909), Tempère (1898), Vanhöffen (1897a,[1] b), Walther (1893), Whitelegge (1891), Wright (1907), and Zernow (1904). Of these papers only the following contain figures by means of which the accuracy of the determinations may be judged: — Broch (1910a), Carisso (1911), Dixon and Joly (1898), Gran (1902), Levander (1894c), Okamura (1907, 1912), Paulsen (1911b), and Vanhöffen (1897a). Forti (1922) reproduced previously published figures. Due to the great difficulties in the determination of several species and to the broad concept of species held by many investigators, much of the data on the distribution should be accepted tentatively.

References to Dinophysis or minor contributions to our knowledge of this genus are also found in Balbiani (1884a, c), Beauregard and Galippe (1880), Bergh (1882, 1884), Bles (1892), Brandt (1883), Bütschli (1885a), Buhigas (1918), Calkins (1902), Chun (1897), Daday (1884), Dakin (1908), Doflein (1909, 1911, 1916), Dogiel (1906), Entz (1909), Forti and Issel (1923), Goldschmidt (1907), Gran (1905, 1908, 1912a, b), Hensen (1891), Hjort (1911), Klebs (1884, 1885), Lawessan (1882), Lankester (1885), Lebour (1922), Leuckart (1861), Maggi (1874, 1880a, b), Nathansohn (1910b), Oltmanns (1922), Pavillard (1915a), Pouchet (1882, 1885a), Pritchard (1845, 1861), Stein (1878), Torrey (1902), Wallengren and Hennig (1911), West (1916), and Willey and Hickson (1909). Pavillard (1923a) gives a critical review of Jörgensen's (1923) important paper on this group.

It may also be mentioned that Gourret (1883, p. 74) rejected Amphidinium as a distinct genus and united it with Dinophysis.

The following typographical errors in the spelling of the name Dinophysis have been found by us: — Dixophysis Kofoid and Michener (1911) and Dynophysis van Oye (1921).

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

The species of Dinophysis are limited largely to tropical, subtropical, and warm-temperate waters of low buoyancy. Nevertheless, most of them are characterized by the fact that the body (theca) is more or less simple in shape, such as lenticular (Figure 35: 1, 6), bilaterally flattened, ellipsoidal (Figure 32: 13),

[1] Contains figures by which the identifications may be verified.

ovoidal (Figure 31: 7), obovoidal (Figure 32: 6), etc. Only in one group of species, viz., in the CAUDATA group, *e.g.*, in *D. caudata* and *D. miles*, does the body show adaptations to flotation in the form of pronounced elongation and protuberances. In *D. miles*, a species occurring in tropical seas, the capacity of flotation is further increased during the period of binary fission by the fact that the schizonts form a wheel-like colony, a phenomenon that facilitates the remaining of the asymmetrical specimens in the horizontal position in which they offer a maximum surface of resistance (Weber-van Bosse, 1901, pl. 17, fig. 3). In *D. caudata* two specimens have been found to adhere to each other for some time following binary fission. The species that have a body more or less simple in shape maintain themselves in the upper strata of the sea by the same means as those found in Phalacroma (see p. 64). It may be mentioned, however, that in Dinophysis the anterior cingular list is, on the average, somewhat wider, that in some species (Plate 5, fig. 7) the left sulcal list and the posterior sail (or sails) are very large, and that the parasagittal lists along the dorsal margin of the body very seldom are present. Just as in Phalacroma, the species of Dinophysis that are endogenetic in cold waters (*D. acuminata*, *D. acuta*, *D. arctica*, *D. cuneiformis*, *D. granulata*, *D. norvegica*, *D. semen*, *D. sphaerica*, *D. ventricosa*, and *D. vertex*) are characterized by the relatively small size of their lists. With regard to the spiral swimming the same adaptations are found in Dinophysis and Phalacroma.

All the external characters have been considered and utilized in the establishment of the species; nevertheless, as in Phalacroma, a number of the specific separations should be regarded as tentative. This is true not only among the species of relatively simple organization, such as the members of the ACUTA group, but also among the highest-developed forms, *e.g.*, the representatives of the CAUDATA and HASTATA groups. It is due to the profound fluctuations that sometimes occur in several of the most important characters, *e.g.*, in the size and shape of the body and in the size, shape, and structure of the left sulcal list and of the posterior sail (or sails). As examples of striking variations in the size of the body, *Dinophysis hastata* and *D. uracantha* (Figure 32, 35) may be mentioned; profound variations in the shape of the body are well illustrated by *D. hastata*, *D. swezyi*, and *D. caudata* (Figure 32, 39, 44); variations in the shape of the left sulcal list by *D. swezyi* (Figure 39); variations in the shape and structure of the posterior sail by *D. hastata* (Figure 32). Jörgensen (1923, fig. 30–37) gives a good illustration of the wide amplitude of variation that might characterize a species of this genus. *Dinophysis hastata*, although highly differentiated, includes specimens that have the habitus characteristics of Dinophysis and specimens that look like rather typical representatives of Phalacroma (Figure 33). The characters most variable within the species are those which have also been most profoundly modified within the genus as a whole, and it is largely upon them that the subdivisions of the genus have been founded.

In the descriptions of the species the same (five) principles have been applied as in Phalacroma.

Of the eight principles followed in the diagnoses of the species of Phalacroma, 1, 2, 3, 6, 7, and 8 are followed also in Dinophysis. If not otherwise mentioned, the epitheca is not visible above the anterior cingular lists, and the cingular lists are more or less funnel-like (inclined anteriorly) and subequal or the anterior is but slightly wider than the posterior; furthermore, the anterior cingular list is ribbed and the posterior is without ribs. The methods of measuring lengths, proportions, and angles are shown in Figure 29.

Subdivisions. Relationships among the Species

Dinophysis, like Phalacroma, exhibits a marked diversity of structural types, proceeding from small, simple, and undifferentiated forms such as *Dinophysis exigua* (Figure 30), closely related to the members of the primitive Rotundatum group of Phalacroma, to highly specialized ones such as *Dinophysis miles* (Cleve, 1900b, fig. 1a) and *D. jörgenseni* (Figure 42: 3–8). On the other hand, while the species of Phalacroma without very great difficulty can be arranged into several groups, all of which probably represent different evolutionary lines, Dinophysis does not readily yield to a similar analysis. Accordingly, the forty-one presumably valid species of the latter cannot with certainty be divided into more than three groups. Two of these include quite heterogeneous elements, and a further subdivision is desirable. However, attempts in this direction have not proved successful. The reason for this failure is largely the independent materialization in the various evolutionary lines of "tendencies" that were inherent in, but not morphologically expressed by, the simpler common ancestors. In other words, the obstacles were the same as in the genus Histioneis.

The three groups recognized in Dinophysis are as follows: —

1. Acuta group: — *D. exigua*, sp. nov., *D. punctata* Jörgensen, *D. semen* Meunier, *D. granulata* Cleve, *D. recurva*, nom. sp. nov., *D. arctica* Mereschowsky, *D. acuminata* Claparède and Lachmann, *D. baltica* (Paulsen) nobis, *D. sphaerica* Stein, *D. similis*, sp. nov., *D. ovum* Schütt, *D. okamurai*, sp. nov., *D. reniformis* (Pavillard) nobis, *D. sacculus* Stein, *D. ellipsoides* Kofoid, *D. dens* Pavillard, *D. truncata* Cleve, *D. fortii* Pavillard, *D. vertex* Meunier, *D. ventricosa* Claparède and

Lachmann, *D. norvegica* Claparède and Lachmann, *D. schröderi* Pavillard, *D. acuta* Ehrenberg, and *D. cuneiformis* Meunier (Figure 30; Jörgensen, 1923, fig. 28; Meunier, 1910, pl. 3, fig. 47, 48; Cleve, 1899c, pl. 4, fig. 7; Pavillard, 1916, pl. 3, fig. 6; Mereschowsky, 1879, pl. 11, fig. 19; Claparède and Lachmann, 1858, pl. 20, fig. 17; Paulsen, 1908, fig. 17; Figure 31: 3, 4 and 1, 2; Schütt, 1895, pl. 1, fig. 6, Figure 31: 5; Pavillard, 1905, pl. 3, fig. 10; Stein, 1883, pl. 20, fig. 10; Kofoid, 1907b, pl. 33, fig. 56; Pavillard, 1916, pl. 3, fig. 1; Cleve, 1900f, fig. 7; Pavillard, 1916, pl. 3, fig. 4; Meunier, 1910, pl. 14, fig. 29, 30; Claparède and Lachmann, 1858, pl. 20, fig. 20; Paulsen, 1907, fig. 1a; Figure 31: 6; Paulsen, 1907, fig. 1b; Meunier, 1910, pl. 14, fig. 31, 32).

2. Hastata group: — *D. pusilla* Jörgensen, *D. hastata* Stein, *D. alata* Jörgensen, *D. rudgei* Murray and Whitting, *D. uracantha* Stein, *D. urceolus*, sp. nov., *D. monacantha*, sp. nov., *D. trapezium*, sp. nov., *D. swezyi*, sp. nov., *D. collaris* Kofoid and Michener, *D. schütti* Murray and Whitting, *D. nias* Karsten, *D. jörgenseni*, sp. nov., and *D. triacantha* Kofoid (Jörgensen, 1923, fig. 44; Figure 32, 33; Jörgensen, 1923, fig. 45; Murray and Whitting, 1899, pl. 31, fig. 9; Figure 35, 37: 1 and 2, 3; 38: 2, 3; 39; 38: 1, 40, 42: 1, and 3–8 and 2).

3. Caudata group: — *D. caudata* Saville-Kent, *D. tripos* Gourret, and *D. miles* Cleve (Figure 44; Jörgensen, 1923, fig. 38, 39; Cleve, 1900b, fig. 1a).

1. Acuta group (for references, see above): — Body of somewhat varying shapes, usually ellipsoidal, ovate to subovate in lateral outline, never with posterior peduncle. Accessory sails and lists not present.

The twenty-four species referred by us to this group have been arranged above, as far as possible, according to similarities. The series begins with small, simple, ellipsoidal, and usually symmetrical forms (*Dinophysis exigua*, *D. punctata*, *D. semen*, *D. granulata*, and *D. recurva*; Figure 30; Jörgensen, 1923, fig. 28; Meunier, 1910, pl. 3, fig. 47, 48; Cleve, 1899c, pl. 4, fig. 7; Pavillard, 1916, pl. 3, fig. 6), and ends with moderately large forms, the bodies of which are somewhat asymmetrical and elongated, and narrowly rounded to subacute posteriorly (*D. vertex*, *D. ventricosa*, *D. norvegica*, *D. schröderi*, *D. acuta*, and *D. cuneiformis;* Meunier, 1910, pl. 14, fig. 29, 30; Claparède and Lachmann, 1858, pl. 20, fig. 20; Paulsen, 1907, fig. 1a; Figure 31: 6; Paulsen, 1907, fig. 1b; Meunier, 1910, pl. 14, fig. 31, 32). Between these extremes we have a practically continuous series of intermediate forms (*D. arctica*, *D. baltica*, *D. ovum*, and *D. fortii;* Mereschowsky, 1879, pl. 11, fig. 19; Paulsen, 1908, fig. 17; Schütt, 1895, pl. 1, fig. 6; Pavillard, 1916, pl. 3, fig. 4). Indeed, the transitions between the members of the extreme groups as well as between the members of the intermediate group are so gradual that delimitations of species are extremely difficult. *D. acuminata* (Claparède and Lachmann, 1858, pl. 20, fig. 17) agrees fairly closely with *D. arctica*, but is characterized by one or more small protuberances on the posterior end of the body. *D. similis* (Figure 31: 1, 2), which represents a small side branch characterized by the reduction of the posterior main rib of the left sulcal list, is structurally closely related to *D. sphaerica* (Figure 31: 3, 4), which in its turn is close to *D. ovum* (Schütt, 1895, pl. 1, fig. 6). *D. okamurai* (Figure 31: 5), which presumably also is closely related to *D. ovum*, is characterized by the concavity of the anterior portion of the ventral margin of the hypotheca. *D. reniformis* and *D. sacculus* (Pavillard, 1905, pl. 3, fig. 10; Stein, 1883, pl. 20, fig. 10) as well as *D. dens* and *D. truncata* (Pavillard, 1916, pl. 3, fig. 1; Cleve, 1900f, fig. 7) form short side branches. The first two species are characterized by the slight, but distinct bending of the body, the last two by the subtrapeziform lateral outline of the body. These four species probably originated from an ancestral form resembling *D. ovum* or *D. fortii* (Pavillard, 1916, pl. 3, fig. 3, 4). *D. ellipsoides* (Kofoid, 1907b, pl. 33, fig. 56) is probably closely related to *D. reniformis*.

This group corresponds to Pavillard's (1916) sections Acuta, Sacculus, and Sphaerica, and to Jörgensen's (1923) sections Acutae, Ovum, and Sphaericae.

2. Hastata group (for references, see above): — Body of varied shapes, rounded, ovate, subovate, or rounded subtrapeziform in lateral outline, without posterior peduncle. With one or two posterior sails and sometimes with parasagittal lists along dorsal side of hypotheca.

The fourteen species of this group are arranged above, as far as possible, according to structural similarities. The first three of them, viz., *Dinophysis pusilla*, *D. hastata*, and *D. alata* (Jörgensen, 1923, fig. 44; Figure 32, 33; Jörgensen, 1923, fig. 45) are structurally, and presumably also genetically, very closely related and appear to form a natural unit. Their most characteristic common features are as follows: — (*1*) only one posterior sail is present, and this is located ventrally to the midline and directed somewhat ventrally; (*2*) the ventral margin of the left sulcal list is nearly straight or more or less convex. *D. pusilla*, which is the most primitive member of this group, is a very small form, subcircular in lateral outline, and its posterior sail is small and lacks structural differentiation. In *D. hastata* and *D. alata* the body is somewhat elongated, the longitudinal axis deflected posteroventrally, and the posterior sail is fairly large and has a central rib or a central reticulation. Of these two species *D. alata* is the more highly differentiated, in so far as it has a wide parasagittal list along the dorsal side of the hypotheca. The remaining members of this group are structurally very close to *D. pusilla*, *D. hastata*, and *D. alata*, but at the same time they presumably belong to different evolutionary lines. Of these species *D. uracantha* and *D. urceolus* (Figure 35, 37: 1) undoubtedly are very closely related. Their most important common characteristics are as follows: — (*1*) the longitudinal axis is somewhat deflected posterodorsally; (*2*) only one posterior sail is developed, and this is located somewhat dorsally to the midline and supported by marginal ribs; (*3*) the ventral margin of the left sulcal list is straight or nearly so. *D. monacantha*, *D. trapezium*, and *D. collaris* (Figure 37: 2, 3; 38: 2, 3; 38: 1) are variants of the same evolutionary type as the last two species. *D. monacantha* differs from these mainly in two respects, viz., its posterior sail is located on the midline and parasagittal lists are developed along the dorsal side of the hypotheca. *D. trapezium* is characterized especially by the fact that its left sulcal list is furnished with an accessory triangular lobe behind the posterior main rib; and *D. collaris* is distinguished from *D. trapezium* chiefly by having the accessory lobe and the posterior sail well balanced, of about the same size, shape, and structure. The last five species form in most respects a well-marked orthogenetic series. *D. swezyi* (Figure 39), which approaches *D. trapezium* in having the left sulcal list furnished with an accessory posterior lobe, differs strikingly from this as well as from the other previously discussed species in the more or less pronounced concavity of the ventral margin of its left sulcal list. In the last respect *D. swezyi* resembles *D. schütti*, *D. jörgenseni*, and *D. triacantha* (Figure 40; 42: 3–8; 42: 2), of which the last two are characterized especially by having two posterior sails, instead of one. On the other hand, in *D. nias* (Figure 42: 1), which undoubtedly is very close to *D. jörgenseni* as indicated by the fact that it has two posterior sails, the ventral margin of the left sulcal list is straight or nearly so. Finally, *D. rudgei* (Murray and Whitting, 1899, pl. 31, fig. 9) represents a small side branch, characterized by the primitive, subcircular lateral outline of the body and by the very heavy and large-meshed thecal reticulation. This branch probably split off near the base of the evolutionary scale of this group.

This group corresponds to the section Hastata of Pavillard (1916) and of Jörgensen (1923). Although it comprises at least three evolutionary lines, viz., the Pusilla, the Uracantha, and the Rudgei lines, its subdivision is hardly advisable at the present time.

3. Caudata group (Figure 44; Jörgensen, 1923, fig. 38, 39; Cleve, 1900b, fig. 1a): — Body strongly elongated, with posterior peduncle. Without accessory lists or sails.

Of the three species of this group, *Dinophysis caudata* (Figure 44) is the most primitive, and *D. miles* (Cleve, 1900b, fig. 1a) is the most advanced. *D. tripos* (Jörgensen, 1923, fig. 38, 39) is structurally and presumably also genetically intermediate between these extreme types. This group corresponds to the section Homunculus of Pavillard (1916) and Jörgensen (1923).

Each of these three groups presumably has evolved independently from small, subrotund, and structurally undifferentiated forms, such as *Dinophysis exigua* (Figure 30: 1) in three diverging lines.

1. Acuta Group: — Of the twenty-four species referred to this group, only the following were found in the material of the Expedition: *Dinophysis exigua*, *D. sphaerica*, *D. similis*, *D. okamurai*, *D. fortii*, *D. norvegica*, and *D. schröderi*. Their arrangement is indicative of relationships.

Dinophysis exigua, sp. nov.

Figure 30

Diagnosis: — Body subellipsoidal in lateral outline, deepest near the middle; length : depth, 1.08–1.14 : 1; symmetrical, or its longitudinal axis deflected posterodorsally at 1°–10°. Posterior cingular list 0.18–0.28 the length of body from apex; epitheca barely if at all visible above anterior cingular list. Cingular list inclined anteriorly at 30°–50°; the anterior sometimes somewhat wider than the posterior; structure unknown. Left sulcal list 0.50–0.60 the length of body; distance between R_1 and R_3 0.40–0.45 the length of body; R_2 is 0.15–0.17, R_3 is 0.37–0.50 the greatest depth of body; margin forms angle of 40°–55° at R_3; R_3 inclined posteriorly at 40°–50°. Structure of theca unknown, presumably not differentiated. Length, 28.9–30.4 μ.

Eastern tropical Pacific.

Description: — This is a small species, the body of which is subellipsoidal in lateral outline, deepest near the middle. The ratio between the length and the depth of the body is 1.12 (0.08–1.14) : 1. Either the body is symmetrical, or its longitudinal axis is deflected posterodorsally at 1°–10°.

The epitheca is about 0.63 (0.58–0.67) as deep as the hypotheca and highest in the center; it is evenly, and moderately to rather strongly convex, and barely, if at all, visible above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 1.0–1.5 the greatest height of the epitheca. The posterior cingular list is about 0.22 (0.18–0.28) the length of the body from the apex. The hypotheca is sometimes symmetrical (Figure 30: 1), sometimes more or less deflected posteroventrally (Figure 30: 2, 3) (see p. 240). Its dorsal, posterior, and ventral margins are moderately convex and confluent. The posterior portion of the body is not, or but slightly, deeper than the anterior.

The cingular lists are subequal, or the anterior is somewhat wider than the posterior; the anterior is about 1.0–1.5 times wider than the transverse furrow and 0.21 (0.19–0.25) the greatest depth of the body; the anterior has an anterior inclination of 30°–50°, the posterior sometimes a little less; their structure is unknown. The right sulcal list is unknown. The left sulcal list is 0.50–0.60 as long as the body, and the distance between the anterior and posterior main ribs is 0.40–0.45 the length of the body. The anterior main rib is 0.20–0.21, the fission rib 0.15–0.17, and the posterior main rib 0.42 (0.37–0.50) the greatest depth of the body; behind the last rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight; at the posterior main rib it forms an angle of 40°–55°; behind the last-mentioned rib it is gently concave or straight. The main ribs of this list are of moderate strength, and not club-shaped or otherwise modified; the two anterior are straight or nearly so, the posterior is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.29–0.40 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 40°–50°. Except for the main ribs, this list appears to lack structure. There are no accessory lists or sails. The structure of the thecal wall is unknown.

Megacytic specimens were not recorded.

The dimensions of three specimens were measured.

FIGURE 30.— *Dinophysis exigua*, sp. nov., 1, 2, in left lateral view; 3, in right lateral view. 1, from type specimen. × 430. 1, 2, from Station 4545, surface; 3, from Station 4709, stomach of Salpa.

Dimensions: — Length of body, 28.9–30.4 μ (average, 29.6 μ; type, 29.6 μ). Greatest depth of body, 25.6–28.2 μ (average, 26.6 μ; type, 25.9 μ).

Variations: — This species varies mainly in the inclination of the longitudinal axis of the body, and in the inclination and relative width of the anterior cingular list.

Comparisons: — This species is established on drawings giving the lateral outlines of three specimens from the material of the Expedition. The description given above is thus incomplete in several respects. The following important characters are unknown: — the shape of the body in dorsoventral view, the structure of the thecal wall, the structure of the cingular lists, and the shape and structure of the right sulcal list.

Dinophysis exigua is on the border line between Dinophysis and Phalacroma. It has some features that affiliate it with Dinophysis, viz., the narrowness of the epitheca, the strong anterior inclination of the cingular lists, and the postero-dorsal inclination of the longitudinal axis of the hypotheca. The last peculiarity has not been found in any of the known species of Phalacroma, but it is characteristic of some species of Dinophysis, *e.g.*, *D. uracantha*, *D. schütti*, and *D. swezyi*. Compare also the shape of the left sulcal list in *D. exigua and D. uracantha*. On the other hand, *D. exigua* is not far removed from *Phalacroma parvulum* and its small, simple, and rounded relatives.

The structurally closest-known relative of *Dinophysis exigua* probably is the species established by Ehrenberg (1840a, p. 151, pl. 4, fig. 15) under the name of *D. michaelis* and later figured by Lohmann (1908a, fig. 7: 43, p. 201) under the name of *D. rotundata;* Lohmann's as well as Ehrenberg's specimens were from the Bay of Kiel. These two species are so similar that their specific separation should be regarded as tentative. They have been separated by us, since *D. michaelis* appears to be somewhat larger (about 52 μ, according to Lohmann's figure, as compared with 28.9–30.4 μ) and narrower. Another structurally close relative is *D. lenticula* Pavillard (*non* [Bergh] Daday, 1888), which is most easily distinguished by the shape of its left sulcal list (see also *Phalacroma parvulum*, the section on comparisons).

Occurrence: — Dinophysis exigua is recorded at two of the 127 stations. Of these two stations one (4709) is on the fourth line of the Expedition and in the South Equatorial Drift; the other (4545), the type locality, is on the sixth line and in the Mexican Current. At Station 4709 one specimen was found in the stomach of a Salpa taken in a surface haul; the other record (two specimens) refers to a surface haul.

The surface temperatures of these two stations were 72° and 79°, respectively. The frequency is less than 1% in both cases.

Dinophysis sphaerica Stein

Figure 31: 3, 4

Dinophysis sphaerica Stein, 1883, *partim*, pl. 20, fig. 3, 4. Daday, 1888, p. 99, 104. *non* Schütt, 1895, p. 13, 64, 119, pl. 1, fig. 7: 1, 2. Aurivillius, 1898a, p. 256, 348, 368, 418; 1899, p. 33, 64. Lemmermann, 1899a, *partim*, p. 373; 1901a, p. 375. Murray & Whitting, 1899, p. 331, tab. 1, 2, 4–6, 8, 9. Schröder, 1900a, p. 19. Gran, 1900, p. 43. Ostenfeld & Schmidt, 1901, p. 170. Schmidt, 1901, p. 138. Entz, 1902b, p. 94; 1905, p. 111. Cleve, 1903b, p. 344. Karsten, 1905, p. 59, 62, 63; 1906,

p. 218; 1907, p. 233. ZACHARIAS, 1906, p. 530. PAULSEN, p. 13, 16, fig. 15. GRÄF, 1909, p. 139. HENSEN-OSTENFELD, 1913, p. 141. *non* PAVILLARD, 1916, p. 47, 60. JÖRGENSEN, 1923, p. 11, 23, 44, fig. 29. LEBOUR, 1925, p. 82, fig. 21c.
?*Phalacroma sphaericum* ZACHARIAS, 1906, p. 530.

Diagnosis: — Body ovate to subellipsoidal in lateral outline, deepest in or somewhat behind the middle; length: depth, 1.17–1.43: 1; symmetrical or with but slight posteroventral inclination. Anterior cingular list 1.4–1.7 times wider than transverse furrow. Left sulcal list 0.52–0.66 the length of body; distance between R_1 and R_3 0.44–0.58 the length of body; R_2 is 0.18–0.33, R_3 is 0.23–0.41 the greatest depth of body; margin forms angle of 80°–90° at R_3; R_3 inclined posteriorly at 5°–15°; besides the three main ribs this list has numerous anastomosing cross-ribs. Theca finely and closely areolate. Length, 44.5–47.0 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder regions.

Description: — This is a rather small species, the body of which is ovate to subellipsoidal in lateral outline, and deepest in or somewhat behind the middle. The ratio between the length and the depth of the body is 1.17–1.43: 1; in Stein's (1883, pl. 20, fig. 3, 4) specimens this ratio is 1.20–1.43: 1; in our specimens it is 1.17–1.31: 1. The longitudinal axis either is perpendicular to the transverse furrow, or it is inclined posteroventrally at 1°–5°.

The epitheca is 0.43–0.55 as deep as the hypotheca, of moderate convexity, highest in or near the center, and not visible above the anterior cingular list. The transverse furrow is flat or somewhat convex, and its width is 1.0–2.0 the greatest height of the epitheca. The posterior cingular list is 0.12–0.19 the length of the body from the apex. The hypotheca is symmetrical or almost so. The dorsal and ventral margins are subuniformly, and gently to moderately or rather strongly convex; or they are somewhat flattened anteriorly. The postmargin is evenly and rather strongly convex, and confluent with the dorsal and ventral margins. The posterior portion of the body may be of about the same depth as the anterior (Stein, 1883, pl. 20, fig. 3), but usually it is more or less strikingly deeper (Figure 31: 3).

The anterior cingular list is 1.4–1.7 times wider than the transverse furrow and 0.18–0.29 the greatest depth of the body; it has a well-developed funnel shape, being inclined anteriorly at 45°–60°; and on each valve it is furnished with about ten to twenty simple, straight, and almost equidistant ribs. The posterior cingular list has about the same inclination as the anterior and appears always to lack structural differentiation. In our specimens it is about as wide as or slightly narrower than the anterior, but in the specimens figured by Stein (1883, pl. 20, fig.

3, 4) it is very narrow, only about 0.25 the width of the anterior. It should be noticed, however, that Stein (1883) made this list very narrow in almost all his figures of species of Dinophysis. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is 0.58 (0.52–0.66) the length of the body, and the distance between the anterior and posterior main ribs is 0.51 (0.44–0.58) the length of the body. The anterior main rib is 0.20–0.28, the fission rib 0.18–0.33, and the posterior main rib 0.23–0.41 the greatest depth of the body; in the specimens examined by us the corresponding values are 0.20–0.22, 0.18, and 0.23–0.24, respectively; in the specimens figured by Stein (1883, pl. 20, fig. 3, 4) they are 0.25–0.28, 0.29–0.33, and 0.31–0.41, respectively. Behind the posterior main rib this list decreases sud-

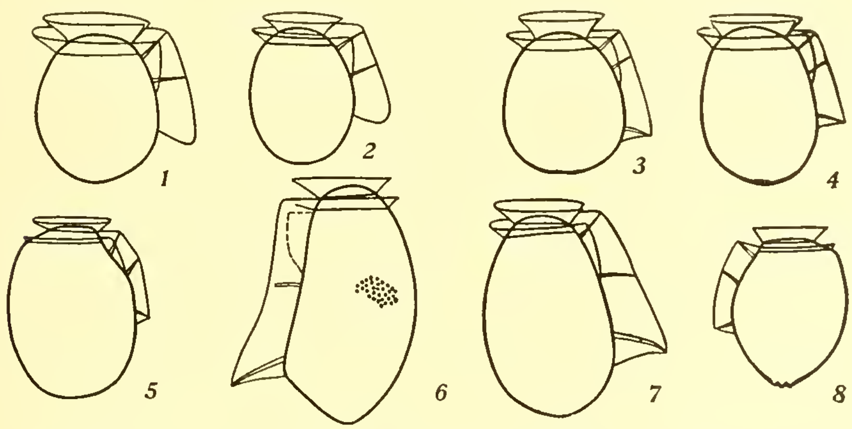

FIGURE 31.— 1, 2, *Dinophysis similis*, sp. nov., right lateral view (2, possibly somewhat tilted). × 430. 1, from Station 4701 (300–0 fathoms); 2, from Station 4691 (300–0 fathoms). 3, 4, *Dinophysis sphaerica* Stein, right lateral view. × 430. 3, from Station 4697 (300–0 fathoms); 4, from Station 4711 (300–0 fathoms). 5, *Dinophysis okamurai*, sp. nov., right lateral view of type specimen. × 430. Station 4673 (300–0 fathoms). 6, *Dinophysis schröderi* Pavillard, left lateral view; structure of thecal wall indicated only. × 430. Station 4574, surface. 7, *Dinophysis fortii* Pavillard, right lateral view. × 430. Station 4667 (300–0 fathoms). 8, *Dinophysis norvegica* Claparède and Lachmann, left lateral view. × 430. Station 4638 (300–0 fathoms).

denly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight, or gently to moderately convex; at the posterior main rib it forms an angle of 80°–90°; behind this rib it is almost straight or gently concave. The main ribs are of moderate strength, and not club-shaped or otherwise modified; the anterior two are straight or almost so; the posterior one may be straight but usually is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.38 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 5°–

15°. Besides the three main ribs, this list has numerous anastomosing cross-ribs (Stein, 1883, pl. 20, fig. 3, 4). There are no accessory lists or sails. The thecal wall is finely and closely areolate, and at least sometimes furnished with scattered pores; compare figure 3 and figure 4 of Stein's (1883) Plate 20.

Megacytic specimens have not been recorded.

The dimensions of two of our specimens and of the specimens figured by Stein (1883, pl. 20, fig. 3, 4) were measured.

Dimensions: — Our specimens: length of body, 44.5–47.0 μ. Greatest depth of body, 35.9–38.1 μ. The size of the specimens represented by Stein (1883, pl. 20, fig. 3, 4) is unknown. Judging by Stein's (1883) information about the magnifications of his figures, given in an introductory remark to the explanations of the plates, the lengths of these specimens were somewhere between 52.2 μ and 86.5 μ.

Variations: — This species, as here conceived, is rather variable. The size of the body, the shape of the hypotheca, the width of the cingular lists, and the size of the left sulcal lists are the most variable characters.

Comparisons: — *Dinophysis sphaerica*, as conceived by Stein (1883, pl. 20, fig. 3–9), is certainly not a natural systematic unit. Indeed, the five specimens figured under this name by him probably belong to at least three different species. This fact was pointed out first by Ostenfeld and Schmidt (1901) and later by Schmidt (1901), Paulsen (1908), Pavillard (1916), and Jörgensen (1923), who, in their references to Stein's (1883) figures of this species, mention only his Plate 20, figure 3 and 4 (see also *D. punctata* Jörgensen, 1923, p. 23). Although the two specimens represented by Stein's (1883) Plate 20, figure 3 and 4, are rather different, and the question as to whether or not they belong to the same species must be regarded as open, we have considered it most advisable to accept, preliminarily, the decision of Ostenfeld and Schmidt (1901). The specimen represented by Stein's (1883) Plate 20, figure 4, is regarded as the type of *D. sphaerica s. str.*

Of the two specimens found by us in the material of the Expedition and figured in the present paper, one (Figure 31: 3) shows, in the shape of its body, a rather striking resemblance to the type specimen; the other (Figure 31: 4) approaches in the same respect the specimen represented by Stein's (1883) Plate 20, figure 3. Both of our specimens differ conspicuously from Stein's (1883) specimens in their wider posterior cingular list and in their narrower left sulcal list. We are not able to judge the significance of these differences. However, it seems far from improbable that the difference in the width of the posterior cingular list is due to the incomplete observation of this structure by Stein (1883), since this list is very narrow in almost all the figures of species of Dinophysis to be found in

Stein's (1883) iconography. Reference should also be made to the rather striking similarity in the shape of the body, between one of our specimens (Figure 31 : 3) and the specimen represented by Stein's (1883) Plate 20, figure 9.

The structurally closest-known relatives of *Dinophysis sphaerica* are *D. ovum* and *D. similis*. Indeed, the specific separation of these three forms should be regarded as tentative (see *D. similis*, the section on comparisons). *D. sphaerica* differs from *D. ovum* mainly in having the anterior cingular list ribbed and in the shape of the posterior portion of the left sulcal list. From *D. similis* it differs mainly in having the posterior main rib of the left sulcal list well developed, about as long as or somewhat longer than the fission rib of this list, and in having the posteroventral portion of this list angular instead of rounded to rounded angular. Other structurally close relatives of *D. sphaerica* are *D. lenticula* Pavillard (*non* [Bergh] Daday, 1888) and *D. punctata*. *D. lenticula* differs from *D. sphaerica* mainly in lacking ribs in the anterior cingular list and in having the ventral margin of the left sulcal list strongly recurved to the right (Pavillard, 1916, pl. 3, fig. 6). *D. punctata* is characterized by its smaller size and by the faint structure of its thecal wall.

Synonymy: — The name of *Dinophysis sphaerica* was first applied by Stein (1883, pl. 20, fig. 3–9) to a compound species. Later it was used in a restricted sense by Ostenfeld and Schmidt (1901), Schmidt (1901), Paulsen (1908), Pavillard (1916), and Jörgensen (1923) (see the previous section). Of the rather great number of writers who have used this name, only the following, besides Stein (1883), give descriptions or figures by means of which their determinations of this species may be checked: — Schütt (1895), Paulsen (1908), Okamura (1912), Pavillard (1916), Jörgensen (1923), and Lebour (1925). With regard to *D. sphaerica* of Schütt (1895), Pavillard (1916), and Jörgensen (1923), see *D. similis*, the sections on comparisons and synonymy. The figures of this species given by Paulsen (1908, fig. 15) and Lebour (1925, fig. 21b) are reproductions of Stein's (1883) Plate 20, figure 3. The figure given by Okamura (1912, pl. 5, fig. 85) under the name of *D. sphaerica* is too incomplete for certainty of specific determination. However, the small size of the figured specimen, 35.8 μ, seems to indicate that *D. sphaerica* Okamura (1912) is not identical with *D. sphaerica* Stein. Zacharias (1906, p. 530) records a species from the Gulf of Naples under the name of *Phalacroma sphaericum* Stein. This is probably a *lapsus pennae* for *Dinophysis sphaerica*, a name also used by Zacharias (1906), but no data bearing on this question are available. Entz (1902b, 1905) writes *sphaeriaca* instead of *sphaerica*. Our bibliographical list of *D. sphaerica* should be regarded as rather uncertain, since the great difficulties in determining this and closely related species make errors or at least diversity in the assignments of specimens of these species very probable.

Occurrence: — *Dinophysis sphaerica* is recorded at four of the 127 stations. There are 1, 0, 0, 2, 1, and 0 stations on the six lines of the Expedition. Of these four stations, one (4619) is in the Panamic Area; one (4697) is in the Easter Island Eddy; and two (4711, 4720) are in the South Equatorial Drift. There are two records from surface waters (from Salpa stomachs; Stations 4619, 4720), and two from hauls from 300–0 fathoms (Stations 4697, 4711).

The temperature range of these four stations at the surface was 75°–79°; the average was 76.2°.

At one station (4720) the frequency is 4%, at one station (4619) 1%, and at the two remaining stations less than 1%.

Stein (1883) recorded this species "aus dem Atlantischen Meer." In the Arctic Ocean it has not been recorded more than once, viz., by Aurivillius (1899), on the north side of Spitzbergen, in Hinlopen Strait, lat. 80° 31′ N. Aurivillius (1898a) also found it on four occasions in the Skager Rak, on the west coast of Sweden. Murray and Whitting (1899) reported it from thirteen stations in the Atlantic, between lat. 44° 30′ N. and lat. 18° 20′ N., and between long. 19° W. and long. 64° W.; Gräf (1909) found it at lat. 35° 57′ N., long. 7° 50′ W. At the Cape of Good Hope it was found by Karsten (1906). From the Mediterranean it has been recorded by the following investigators: — from Naples by Daday (1888) and Zacharias (1906); from the Adriatic by Entz (1902b, 1905). In the Red Sea it was found by Ostenfeld and Schmidt (1901), and Cleve (1903b); in the Gulf of Aden, by Ostenfeld and Schmidt (1901); in the Indian Ocean, at lat. 34° 13′ S., long. 80° 30′ E., by Karsten (1907); in the Antarctic Ocean, at lat. 63° 16′ S.–63° 32′ S., long. 57° 51′ E.–54° 46′ E., by Karsten (1905); and in the Gulf of Siam, by Schmidt (1901). As stated in the last section, it is doubtful whether or not the form recorded by Okamura (1912) from Japanese waters under the name of *Dinophysis sphaerica* is referable to this species.

Karsten (1905, 1907) reported this species as taken with closing net at the following stations: — Station 151, lat. 63° 32′ S., long. 54° 46′ E., 100–10 m. and 300–100 m.; Station 152, lat. 63° 15′ S., long. 57° 51′ E., 80–60 m.; Station 169, lat. 34° 13′ S., long. 80° 30′ E., 60–40 m. All the specimens recorded were reported as living. Most of the other records mentioned above probably refer to surface hauls.

According to the writers who have contributed to our knowledge of the distribution of this species, it occurs in waters of the following temperatures and salinities. Aurivillius (1898a):— temperature: range, 54.1°–65.6°; mean of three observations, 60.2°; salinity: range, 24.0–29.5; mean of three observations, 26.3. Aurivillius (1899): — temperature, 36.4°; salinity, 33.93. Murray and Whitting (1899): — temperature: range, 58°–79°; mean of thirteen observations, 70.0°. Ostenfeld and Schmidt (1901): — temperature: range, 72.0°–80.2°; mean of four observations, 77.2°. Cleve (1903b): — temperature, 84.6°; salinity, 39.92.

Unfortunately our knowledge of the distribution of *D. sphaerica* must be regarded as rather uncertain, since this species, on account of its simple structure, is very easily confused with some closely related forms. Of the authors who have recorded this species, only Stein (1883) and Okamura (1912) give descriptions or figures by means of which their determinations may be checked. Ostenfeld and Schmidt (1901), and Schmidt (1901) refer to Stein's (1883) Plate 20, figure 3 and 4 (see above, the sections on comparisons and synonymy).

This species has been recorded from waters of very different temperatures. However, it probably is a warm-water form and not endogenetic in the Skager Rak (see Aurivillius, 1898a; Gran, 1900; and Hensen-Ostenfeld, 1913) and in the Arctic Ocean. We are not in the position to discuss the question as to whether or not it is endogenetic in the Antarctic Ocean.

Dinophysis similis, sp. nov.

Figure 31: 1, 2

Dinophysis sphaerica Schütt, 1895, p. 13, 119, *non* p. 64, pl. 1, fig. 7: 1, 2. Pavillard, 1916, p. 47, 60. Jörgensen, 1925, p. 11, 23, 44, fig. 29.

Diagnosis: — Body subcircular to ovate or subellipsoidal in lateral outline, deepest in or just behind the middle, and 1.03–1.29 times longer than deep; symmetrical or its longitudinal axis is inclined posteroventrally at about 1°–10°. Anterior cingular list 1.4–2.0 times wider than transverse furrow. Left sulcal list 0.50–0.57 the length of body, of subuniform width throughout the greater portion of its length; R_1 and R_2 subequal, 0.19–0.30 the greatest depth of body; R_3 absent or rudimentary (very short); posteroventrally this list is rounded or forms a more or less rounded angle of 50°–55°. Theca finely and closely areolate. Length, 43.0–62.0 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This is a rather small to medium-sized species, the body of which is subcircular to ovate or subellipsoidal in lateral outline, and deepest in or somewhat behind the middle. The ratio between the length and the depth of the body is 1.03–1.29: 1; in Schütt's (1895, pl. 1, fig. 7: 1) and Jörgensen's (1923, fig. 29) specimens, this ratio is 1.09: 1 and 1.03: 1, respectively; in our specimens it is 1.19–1.29: 1. The longitudinal axis either is about perpendicular to the transverse furrow (Figure 31: 1, 2), or it has a posteroventral inclination of about 1°–10°, as in the specimens figured by Schütt (1895) and Jörgensen (1923).

The epitheca is 0.42–0.54 as deep as the hypotheca, of moderate convexity, highest in or near the center, and not visible above the anterior cingular list. The transverse furrow is flat or somewhat convex, and its width is 1.5–2.0 the greatest height of the epitheca. The posterior cingular list is 0.14–0.17 the length of the body from the apex. The hypotheca either is symmetrical (Figure 31: 1, 2), or somewhat inclined posteroventrally (see above). The dorsal and ventral margins are subuniformly, and moderately to rather strongly convex; sometimes (Schütt, 1895, pl. 1, fig. 7: 1; Jörgensen, 1923, fig. 29) the ventral margin is less convex than the dorsal. The postmargin is evenly and rather strongly convex, and confluent with the dorsal and ventral margins. The posterior portion of the body may be of about the same depth as the anterior (Figure 31: 2), but usually it is more or less strikingly deeper.

The cingular lists are subequal, or the posterior is slightly narrower than the anterior; the anterior is 1.4–2.0 times wider than the transverse furrow and 0.22–0.29 the greatest depth of the body. Both these lists are funnel-shaped, being inclined anteriorly at 30°–40°. The anterior has simple, straight, and almost equidistant ribs, about 10–15 on each valve; the posterior appears always to lack structural differentiation. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as or somewhat wider than the transverse furrow. The left sulcal list is 0.50–0.57 the length of the body and of subuniform width throughout the greater part of its length. In the specimens figured by Schütt (1895) and Jörgensen (1923) the anterior main rib and the fission rib are about 0.19 the greatest depth of the body; in our specimens the corresponding value is 0.28–0.30. The posterior main rib is absent, or rudimentary and short; it is "usually indistinct, or only distinct for a short inner portion" (Jörgensen, 1923, p. 23, fig. 29). Posteriorly the left sulcal list is rounded (Jörgensen, 1923, fig. 29), or it forms a more or less rounded angle of about 50°–55°; one of our specimens (Figure 31: 2) agrees in this respect rather closely with Schütt's (1895) Plate 1, figure 7: 1; the other (Figure 31: 1) with Schütt's (1895) Plate 1, figure 7: 2. The ventral margin of this list is almost straight or gently convex. The main ribs are straight or almost so, and not club-shaped or otherwise modified. In some specimens this list is without structure except for the anterior two main ribs; sometimes (Schütt, 1895, pl. 1, fig. 7: 2) its posterior half is finely reticulated. There are no accessory lists or sails. The thecal wall is finely and closely areolate and has scattered pores.

Megacytic specimens have not been recorded.

The proportions of two of our specimens and of the specimens figured by Schütt (1895) and Jörgensen (1923) were measured.

Dimensions: — Our specimens: Length of body, 43.0–46.4 μ. Greatest depth of body, 33.2–38.5 μ. The specimen figured by Schütt (1895, pl. 1, fig. 7: 1) was 62.0 μ long and 57.0 μ deep. The type specimen, as figured by Jörgensen (1923, fig. 29) was 61.0 μ long and 59.0 μ deep. According to Jörgensen (1923, p. 24) this species is "as a rule" 57–60 μ long and 55–57 μ deep.

Variations: — Jörgensen (1923), who examined a great number of specimens, does not indicate by any statement that he had found this species to be variable. Furthermore, the specimens figured by Schütt (1895) and Jörgensen (1923) are very similar. These circumstances seem to indicate that this species is rather constant. The specimen represented by our Figure 31: 2 should be regarded as aberrant. The following characters are the most variable: the size of the body, the inclination of the longitudinal axis of the body, the relative depth of the body, and the shape and structure of the posterior portion of the left sulcal list.

Comparisons: — This species is established on the specimens figured by Schütt (1895, pl. 1, fig. 7) and Jörgensen (1923, fig. 29) under the name of *Dinophysis sphaerica* Stein, and on two specimens found in the material of the Expedition. Its most outstanding characteristics are the absence or strong reduction of the posterior main rib of the left sulcal list and the rounded to rounded-angular shape of the posteroventral portion of this list. Before Jörgensen's (1923) paper was available, we were inclined to consider these peculiarities as signs of recent binary fission (see Figure 46: 2, of *D. caudata* f. *acutiformis*). However, the fact that Jörgensen (1923) found this form to be "numerous" in the Mediterranean and always characterized by these features very strongly indicates that we are concerned with characters of specific value. The reasons given by Jörgensen (1923, p. 23) for assigning to *D. sphaerica* Stein the specimens of *D. similis* found by him hardly can be considered as valid. As the type of *D. similis* we regard the specimen represented by Jörgensen's (1923) figure 29.

The structurally closest-known relatives of *Dinophysis similis* are *D. sphaerica* and *D. ovum*. The two last species differ from the first mainly in having the posterior main rib of the left sulcal list well developed, about as long as or somewhat longer than the fission rib of this list, and in having the posteroventral portion of this list angular, instead of rounded to rounded angular. (See also *Dinophysis sphaerica* and *Phalacroma expulsum*, the sections on comparisons.)

Synonymy: — As stated above, *Dinophysis similis* has previously been treated by Schütt (1895) and Jörgensen (1923) under the name of *D. sphaerica* Stein. *D. sphaerica* Pavillard (1916) is also identical with *D. similis*, and not with *D. sphaerica* Stein, as is plainly shown by Pavillard's (1916, p. 60) statement that his specimens of this species had the body of about the same shape as the specimen represented by Schütt's (1895) Plate 1, figure 7: 1, and that their left sulcal list "répond exactement au dessin de Schütt; son bord inférieur est convex et non concave comme dans le dessin approximatif de Stein." It should be noted in this connection that *D. sphaerica* Schütt (1895, p. 64) refers to *Phalacroma rotundatum* (Claparède and Lachmann).

Occurrence: — *Dinophysis similis* is recorded at two of the 127 stations. Of these two stations, one (4691) is on the third line of the Expedition and in the Easter Island Eddy; the other (4701) is on the fourth line and in the South Equatorial Drift, just to the north of the Easter Island Eddy. Both records refer to hauls from 300–0 fathoms.

The temperature of these two stations at the surface was 72° and 73°.

The frequency is less than 1% at both stations.

Schütt (1895) does not give any information as to the localities of his material; however, it probably was taken in the tropical and subtropical regions of the Atlantic or near Naples. Pavillard (1916) found this species to be rare in the Gulf of Lyons. Jörgensen (1916) reports it as fairly common and "widely distributed in the Western Mediterranean"; he also found it in the Bay of Cadiz and in the Guinea Current. It probably is widely distributed in tropical, subtropical, and warm-temperate seas.

Dinophysis okamurai, sp. nov.

Figure 31: 5

Dinophysis vanhöffenii Okamura, 1907, *partim*, p. 131, pl. 5, fig. 41c.

Diagnosis: — Body subovate in lateral outline, with dorsal shoulder-like constriction at girdle, with ventral margin somewhat concave between R_2 of left sulcal list and epitheca, deepest in the middle, and 1.32–1.50 times longer than deep. Anterior cingular list about as wide as transverse furrow. Left sulcal list 0.44–0.50 the length of the body; distance between R_1 and R_3 0.37–0.42 the length of the body; R_2 is 0.15, R_3 is 0.12–0.29 the greatest depth of body; margin forms angle of 100°–110° at R_3; R_3 inclined posteriorly at 5°–25°. Length, 38.3–53.0 μ.

Eastern tropical Pacific, Japan.

Description: — This is a rather small or medium-sized species, the body of which is subovate in lateral outline, with a dorsal shoulder-like constriction at the girdle, with the ventral margin somewhat concave between the fission rib of the left sulcal list and the epitheca, and deepest in the middle. The ratio between the length and the depth of the body is 1.32–1.50: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about 0.37–0.38 as deep as the hypotheca, slightly convex, highest in or near the middle, and not visible above the anterior cingular list. The transverse furrow is flat or slightly concave, and about three times as wide as the greatest height of the epitheca. The posterior cingular list is about 0.10–0.11 the length of the body from the apex. The hypotheca is somewhat asymmetrical. The dorsal margin is moderately and subuniformly convex. The ventral margin is gently to moderately concave in front of the fission rib of the left sulcal list; behind this rib it is slightly convex or almost straight. The postmargin is strongly and subuniformly convex and confluent with the dorsal and ventral margins. The posterior portion of the body is decidedly deeper than the anterior.

The anterior cingular list, which is about as wide as the transverse furrow and 0.16–0.28 the greatest depth of the body, has an anterior inclination of 30°–40°. The posterior cingular list is narrower than the anterior, sometimes even very narrow as in the type specimen; it has an anterior inclination of 40°–50°. The structure of the cingular lists is unknown. The right sulcal list extends to the fission rib of the left sulcal list and is subtriangular in shape, decreasing gradually in width posteriorly. The left sulcal list is comparatively small. Its length is 0.44–0.50 the length of the body, and the distance between the anterior and posterior main ribs is 0.37–0.42 the length of the body. The anterior main rib is about 0.18, the fission rib 0.15, and the posterior main rib 0.12–0.29 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib and between the fission rib and the posterior main rib, the free margin of this list is straight or almost so; at the fission rib it forms an obtuse angle; at the posterior main rib it forms an angle of 100°–110°; behind the last rib it is almost straight. The main ribs of this list are straight or almost so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35–0.40 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 5°–25°. We do not know whether or not this list has any structural differentiation besides the main ribs. There are no accessory lists or sails. The structure of the theca is unknown; judging by Okamura's (1907, pl. 5, fig. 41c) figure, it appears to be a fine areolation.

Megacytic stages have not been recorded.

The dimensions of the type specimen and of the specimen figured by Okamura (1907, pl. 5, fig. 41c) were measured.

Dimensions: — Length of body, 38.3–53.0 μ (type, 53.0 μ). Greatest depth of body, 25.4–40.0 μ (type, 40.0 μ).

Comparisons: — *Dinophysis okamurai* is established on a single outline drawing of a specimen in lateral view found in the material of the Expedition. The shape of the body in dorsoventral view, the structure of the cingular lists and of the theca are unknown, and our knowledge of the structure of the left sulcal list is incomplete.

When compared with the type specimen, the specimen figured by Okamura (1907, pl. 5, fig. 41c) is smaller (38.3 μ as compared with 53.0 μ) and narrower (ratio between length and depth of body, 1.50: 1 as compared with 1.32: 1); its ventral margin is more concave anteriorly, and its posterior cingular list is somewhat wider relatively. The fission rib of its left sulcal list is comparatively long, which makes the ventral margin of this list more angular at this rib than in any other known species. The difference in the shape of the ventral margin of the body may be due to the fact that Okamura (1907) made his drawing from a detached valve.

The shape of the body in lateral view and the shortness of the left sulcal list in this species are suggestive of *Dinophysis ovum* and *Phalacroma expulsum*. However, these resemblances cannot be considered as sufficient proofs of a close relationship. *Dinophysis okamurai* is easily distinguished from *D. ovum* by the characteristic sinuation of the ventral margin of its body and from *Phalacroma expulsum* by the shape of its left sulcal list.

Synonymy: — Under the name of *Dinophysis vanhöffenii* Ostenfeld, Okamura (1907) figures two specimens, one of which (his Plate 5, fig. 41c) belongs to the species described above. Later (1912) he writes *D. vanhöffenii* Okamura (1907) as a synonym of *D. ovum* Schütt.

Occurrence: — *Dinophysis okamurai* is recorded at only one (4673, the type locality) of the 127 stations, on the third line of the Expedition, in the Peruvian Current, from 300–0 fathoms, at a surface temperature of 67°. The frequency is less than 1% (one specimen).

Previously the species was found in Japanese waters by Okamura (1907).

Dinophysis fortii Pavillard

Figure 31:7

Dinophysis fortii Pavillard, 1923a, p. 881.
Dinophysis laevis Bergh, Pouchet, 1883, p. 426, pl. 18, 19, fig. 6.
Dinophysis intermedia Pavillard, 1916, p. 58, pl. 3, fig. 4. Forti, 1923, p. 110, 112, 190, 209, fig. 119. Jörgensen, 1923, p. 19, 21, 22, 44, 45.
Dinophysis intermedia f. *pachyderma* Jörgensen, 1923, fig. 21.

Diagnosis: — Body narrowly subovate in lateral outline, with flattened ventral margin, and broadly and evenly rounded posteriorly; deepest somewhat behind the middle, and 1.44–1.56 times longer than deep; longitudinal axis deflected posteroventrally at 3°–15°. Markedly compressed bilaterally, with lateral contours almost parallel. Anterior cingular list 1.4–2.0 as wide as transverse furrow, without ribs. Left sulcal list 0.63–0.67 as long as body; distance between R_1 and R_3 0.50–0.53 the length of body; R_2 is 0.26–0.30, R_3 is 0.33–0.43 the greatest depth of body; margin forms angle of 65°–85° at R_3; R_3 inclined posteriorly at 10°–25°; besides main ribs this list has distinct reticulation. Theca finely and closely areolate. Length, 62.3–66.1 μ.

Probably widely distributed in subtropical, warm-temperate, and temperate seas.

Description: — This is a medium-sized species, narrowly subovate in lateral outline, with flattened ventral margin, broadly and evenly rounded posteriorly, and deepest somewhat behind the middle. The ratio between the length and the depth of the body is 1.48 (1.44–1.56) : 1. The longitudinal axis is deflected posteroventrally at 9° (3°–15°).

The epitheca is 0.38–0.48 as deep as the hypotheca, moderately convex (Figure 31:7) to almost flat (Jörgensen, 1923, fig. 21), not visible above the anterior cingular list, and highest in or somewhat dorsally to the center. The transverse furrow is flat, or slightly concave or convex, and its depth is 2.0–2.5 the greatest height of the epitheca. The posterior cingular list is 0.09–0.10 the length of the body from the apex. The hypotheca is somewhat asymmetrical to subsymmetrical, and more or less deflected posteroventrally (see above). Its dorsal margin (from the girdle to the antapex) is rather strongly and almost evenly convex. Its ventral margin (between the anterior and posterior main ribs of the left sulcal list) is almost straight, or slightly and evenly convex. Its postmargin is evenly subsemicircular and confluent with the dorsal and ventral margins; it does not form an angle just behind the posterior main rib of the left sulcal list. The posterior end of the body is strikingly deeper than the anterior. In dorsoventral view the body is markedly compressed bilaterally, and its lateral contours are subparallel (Jörgensen, 1923, p. 19).

The cingular lists may be subequal, but in most cases the anterior is somewhat wider than the posterior; the anterior is 1.5–2.0 as wide as the transverse furrow, and 0.20–0.23 the greatest depth of the body; both are funnel-shaped, with an anterior inclination of 30°–50°; sometimes the posterior is somewhat less, in other cases somewhat more inclined anteriorly than the anterior; both lack distinct structural differentiation. The right sulcal list ends at or just behind the fission rib of the left sulcal list; it is subtriangular and decreases gradually in width posteriorly; anteriorly it is about as wide as, or slightly wider or narrower than the transverse furrow; its ventral margin is slightly and evenly convex, or almost straight. The left sulcal list is fairly large. Its length is 0.66 (0.63–0.67) the length of the body; and the distance between the anterior and posterior main ribs is 0.52 (0.50–0.53) the length of the body. The anterior main rib is 0.25 (0.24–0.26), the fission rib 0.28 (0.26–0.30), and the posterior main rib 0.38 (0.33–0.43) the greatest depth of the body; behind the last rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list either is almost straight (Pavillard, 1916, pl. 3, fig. 4), or it is almost straight anteriorly and gently convex posteriorly (Jörgensen, 1923, fig. 21); at the posterior main rib it forms an angle of 75° (65°–85°); behind the last rib it either is nearly straight (Pavillard, 1916, pl. 3, fig. 4) or more or less concave (Jörgensen, 1923, fig. 21). The two anterior of the main ribs are of moderate strength, and straight or nearly so; the posterior, which sometimes (Jörgensen, 1923, fig. 21) is club-shaped, is almost straight (Pavillard, 1916, pl. 3, fig. 4), or more or less strikingly concave posteriorly (Jörgensen, 1923, fig. 21). The distance between the anterior main rib and the fission rib is 0.44 (0.40–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 18° (10°–25°). Besides the main ribs this list has a well-developed reticulation. There are no accessory lists or sails. The thecal wall is closely and rather finely areolate; the areoles are subequal in size.

Megacytic specimens have not been recorded.

The dimensions of one specimen found in the material of the Expedition and of the specimens figured by Pavillard (1916, pl. 3, fig. 4) and Jörgensen (1923, fig. 21) were measured.

Dimensions: — Our specimen: Length of body, 62.3 μ. Greatest depth of body, 40.0 μ. Type specimen (Pavillard, 1916, pl. 3, fig. 4): Length of body, 66.1 μ. Greatest depth of body, 45.7 μ. The specimen figured by Jörgensen (1923, fig. 21) was 63.8 μ long and 43.7 μ deep. According to a statement in the text, the specimens examined by Jörgensen (1923, p. 19) were about 64 μ long and 49 μ deep "reckoned vertically and parallel to girdle."

Variations: — This species appears to be rather variable. The most variable of its characters are as follows: the inclination of the longitudinal axis of the body, the curvature of the epitheca, the shape of the posterior portion of the left sulcal list, and the shape and structure of the posterior main rib of this list.

Comparisons: — The specimen found in the material of the Expedition and assigned to *Dinophysis fortii* shows a close agreement with the type specimen as figured by Pavillard (1916, pl. 3, fig. 4). It differs from the type mainly in being somewhat smaller and more slender.

The specimen figured by Jörgensen (1923, fig. 21) under the name of *Dinophysis intermedia* Pavillard, f. *pachyderma* has the longitudinal axis of the body rather strikingly inclined posteroventrally; the posterior portion of the left sulcal list is strikingly recurved; and the posterior main rib of this list is decidedly club-shaped and has a pronounced posterior concavity.

Dinophysis fortii is morphologically and probably also genetically intermediate between *D. ovum* Schütt and *D. schröderi*. Of these three species *D. ovum* is the shortest, most rounded, and presumably most primitive; *D. schröderi* is the longest, most elongate, and presumably most highly developed (see also *D. schröderi*, the section on comparisons).

Synonymy: — This species was established by Pavillard (1916), who described and figured it under the name of *Dinophysis intermedia*. Jörgensen (1923), who described it under the same name, once, on page 22, used the name *D. intermedium* (*lapsus pennae*). Without referring to it in the text, Jörgensen (1923, fig. 21) figured a specimen under the name of *D. intermedia* Pavillard, f. *pachyderma*. According to our opinion, this specimen is an old, thick-walled representative of the main species, and so its name has been included in our bibliographical list of *D. fortii*. Forti (1922) gave a reproduction of Pavillard's (1916) figure of the type specimen.

Pavillard (1923a, p. 881) rejected *intermedia* as the specific name of this form and replaced it with *fortii*, on account of the fact that *Dinophysis intermedia* Pavillard (1916) was antedated by *D. intermedia* Cleve (1902b, p. 30).

Jörgensen (1923, p. 19) suggests that *Dinophysis atlantica* Ehrenberg (1854, p. 239) may be identical with this species. This question cannot be settled as yet, since Ehrenberg's (1854a) diagnosis of *D. atlantica* is too incomplete for certainty of specific identification.

Pouchet (1883, p. 426, pl. 18–19, fig. 6) figures, under the name of *Dinophysis laevis* Bergh, a specimen which very decidedly resembles *D. fortii*. Pouchet's assignment of this specimen is wrong. According to our opinion, *D. laevis* Pouchet

(1883) may be identical with *D. fortii*, but Jörgensen (1899, p. 30) refers it to *D. acuminata* Claparède and Lachmann, and Paulsen (1908, p. 15) to *D. arctica* Mereschowsky.

Jörgensen (1923, p. 19) suggests that the specimen which Cleve (1901c, p. 239) recorded from the Florida Current under the designation of *Dinophysis acuta* Ehrenberg belonged to *D. intermedia* (= *fortii*). This suggestion has not been verified as yet.

Occurrence: — *Dinophysis fortii* is recorded at only one of the 127 stations. This station (4667) is on the second line of the Expedition and in the Peruvian Current. The depth is 300–0 fathoms, the surface temperature 68°, and the frequency less than 1% (one specimen).

The type locality of this species is the Gulf of Lyons (Pavillard, 1916). Forti (1922) obtained one specimen in the Ligurian Sea, and Jörgensen (1923) found the species to be widely distributed throughout the Mediterranean. Outside the Mediterranean the species has been found by Jörgensen (1923), who reported it from the Bay of Cadiz, and "from the Florida Current (off the northern coast of Florida, temp. 23°C., 6/5 1910) and from several places, partly in mixed water, along the northern course of the Gulf Stream, far to the south of Nova Scotia, from 39° to 43° N., and 70°–40° W. (temp. 22°–18°C., salinity abt. 36.5)." *Dinophysis atlantica* Ehrenberg (1854a), which may be identical with *D. fortii*, was taken off Newfoundland. *D. laevis* Pouchet (1883), which also may be identical with *D. fortii*, was found at Concarneau, on the west coast of France.

The species probably is eupelagic and widely distributed in subtropical, warm-temperate, and temperate seas.

Dinophysis norvegica Claparède and Lachmann?

Figure 31 : 8

?Dinophysis norvegica Broch, 1910a, p. 31, fig. 1: A, B.

The single specimen represented by Figure 31 : 8 was taken in the Panamic Area, at Station 4638 of the Expedition. The depth was 300–0 fathoms, and the surface temperature was 75°. The length of this specimen is 44.5 μ. The similarity between this specimen and the one from Spitzbergen figured by Broch (1910a, fig. 1 : A) is very striking. However, since the surface markings of the theca are not indicated in our drawing, and a certain knowledge of this character is essential for a well-founded determination of the species of the Acuta group, our assignment of this specimen should be regarded as tentative. A record of this specimen is being published mainly because of the fact that *Dinophysis* *norvegica*, which supposedly is a neritic and boreoarctic species, has not been found previously in waters of tropical and subtropical character. Our specimen might have been a vagrant from polar waters.

Dinophysis schröderi Pavillard

Figure 31:6

Dinophysis schroederi Pavillard, 1909, p. 284, fig. 5; 1916, p. 58, pl. 3, fig. 5. Schiller, 1911a, p. 52; 1911b, p. 90. Schröder, 1911, p. 22, 25, 36. Forti, 1922, p. 110, 112, 190, 209, fig. 120. Jörgensen, 1923, p. 21, 45, fig. 22.

Diagnosis: — Body elongated in lateral outline, deepest somewhat behind the middle, 1.68–1.90 times longer than deep; dorsal margin fairly strongly convex; ventral margin nearly straight in front of R_3 of left sulcal list and more or less angular at R_3; narrowly rounded to subacute posteriorly; longitudinal axis deflected posteroventrally at 1°–12°. Markedly compressed bilaterally; lateral contours parallel or even slightly concave. Anterior cingular list 1.4–2.0 as wide as transverse furrow, without ribs. Left sulcal list 0.66–0.70 as long as body; distance between R_1 and R_3 0.58–0.61 the length of body; R_2 is 0.20–0.31 and R_3 is 0.33–0.50 the greatest depth of body; margin forms angle of 40°–55° at R_3; R_3 inclined posteriorly at 10°–35°; except for main ribs this list almost lacks structure. Theca finely and closely areolate. Length, 73.0–88.0 μ.

Probably widely distributed in subtropical, warm-temperate, and temperate seas.

Description: — This is a medium-sized species, the body of which is elongate in lateral outline, with well-convex dorsal margin, almost straight ventral margin, subacute antapical end, and the greatest depth somewhat behind the middle. The ratio between the length and the depth of the body is 1.79 (1.68–1.90): 1. The longitudinal axis is deflected posteroventrally at 7° (1°–12°).

The epitheca is 0.43–0.46 as deep as the hypotheca, rather strongly convex (Figure 31:6) to almost flat (Jörgensen, 1923, fig. 22), not visible above the anterior cingular list, and highest in or somewhat dorsally to the center. The transverse furrow is flat or slightly concave or convex, and its width is 1.5–2.5 the greatest height of the epitheca. The posterior cingular list is 0.07–0.11 the length of the body from the apex. The hypotheca is asymmetrical and more or less deflected posteroventrally (see above). Its dorsal margin (from the girdle to the antapex) is rather strongly convex; sometimes (Figure 31:6) the convexity is almost even, sometimes (Pavillard, 1916, pl. 3, fig. 5) it is more pronounced near the middle than anteriorly and posteriorly. Its ventral margin (between the anterior and posterior main ribs of the left sulcal list) is almost straight or but slightly convex or concave. Just behind the posterior main rib of the left sulcal list the margin forms a more or less pronounced but rounded corner, and between this corner and the antapex the margin is almost straight or slightly convex. Posteriorly the body is narrowly rounded to subacute. However, according to Jörgensen (1923, p. 21), some specimens which "undoubtedly should be referred to *D. schroederi*" had the posterior end of the body "evenly rounded"; these specimens were from the southern part of the Atlantic. In dorsoventral view the body is markedly compressed bilaterally, with the lateral contours parallel or even slightly concave (Jörgensen, 1923, p. 21).

The cingular lists may be subequal (Pavillard, 1909, fig. 5), but in most cases the posterior is somewhat narrower than the anterior; the anterior is 1.4–2.0 as wide as the transverse furrow and 0.21 (0.17–0.25) the greatest depth of the body; both are funnel-shaped, with an anterior inclination of 20°–40°; sometimes the posterior is somewhat less inclined anteriorly than the anterior; both lack distinct structural differentiation. The right sulcal list ends at or just in front of the fission rib of the left sulcal list; it is subtriangular and decreases gradually in width posteriorly; anteriorly it is about as wide as or slightly wider than the transverse furrow; its ventral margin is almost straight, gently and evenly convex, or gently convex anteriorly and slightly concave posteriorly. The left sulcal list is fairly large; its length is 0.68 (0.66–0.70) the length of the body, and the distance between the anterior and posterior main ribs is 0.60 (0.58–0.61) the length of the body. The anterior main rib is 0.22 (0.17–0.27), the fission rib 0.25 (0.20–0.31), and the posterior main rib 0.41 (0.33–0.50) the greatest depth of the body; behind the last rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list either is almost straight, or it is almost straight anteriorly and gently convex posteriorly (Pavillard, 1916, pl. 3, fig. 5), or slightly undulating, concave anteriorly and posteriorly and convex in the middle (Pavillard, 1909, fig. 5); at the posterior main rib this margin forms an angle of 48° (40°–55°); behind the last rib it either is almost straight (Figure 31: 6) or more or less strikingly concave (Jörgensen, 1923, fig. 22). The main ribs of this list are of moderate strength; the two anterior are straight or almost so; the posterior, which may be club-shaped (Jörgensen, 1923, fig. 22), is almost straight (Figure 31: 6), or more or less strikingly concave posteriorly. The distance between the anterior main rib and the fission rib is 0.42 (0.40–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 20° (10°–35°). Except for the main ribs this list is without structure, or it has a faint reticulation near the posterior main rib. There are no accessory lists or sails. The thecal wall is closely and rather finely areolate.

Megacytic specimens have not been recorded.

The dimensions of one specimen found in the material of the Expedition and of the specimens figured by Pavillard (1909, fig. 5; 1916, pl. 3, fig. 5) and Jörgensen (1923, fig. 22) were measured.

Dimensions: — Our specimen: Length of body, 73.0 μ. Greatest depth of body, 38.5 μ. Type specimen (Pavillard, 1909, fig. 5): Length of body, 88.0 μ. Greatest depth of body, 52.2 μ. The specimen figured by Pavillard (1916, pl. 3, fig. 5) was 81.5 μ long and 46.7 μ deep; according to Pavillard (1916, p. 58) this species has a length of 80 μ or more, and a depth of 45–50 μ. The specimen figured by Jörgensen (1923, fig. 22) was 83.2 μ long and 45.4 μ deep.

Variations: — Judging by the available figures, this species appears to be relatively constant. However, the specimens examined by Jörgensen (1923) seem to have been rather variable, since this investigator points out that he at times found it difficult to distinguish with certainty between this species and *Dinophysis acuta* Ehrenberg (Jörgensen). The most variable characters are: the size of the body, the inclination of the longitudinal axis of the body, the curvature of the epitheca, the shape of the dorsal margin of the body, and the shape and structure of the posterior main rib of the left sulcal list.

Comparisons: — The specimen found in the material of the Expedition and assigned to *Dinophysis schröderi* agrees rather closely with the specimens from the Mediterranean figured by Pavillard (1909, 1916). It differs from these specimens mainly in being somewhat smaller (73.0 μ as compared with 81.6–88.0 μ) and more slender.

The specimen from the Mediterranean figured by Jörgensen (1923) also agrees closely with Pavillard's (1909, 1916) specimens. It is noteworthy because of its flat epitheca and the somewhat club-shaped posterior main rib of its left sulcal list.

Dinophysis schröderi is structurally very closely related to *D. acuta* Ehrenberg (Jörgensen). Indeed, we should have been inclined to regard these two forms as belonging to the same species, if it were not for the fact that *D. schröderi* was established by such a careful investigator as Pavillard, who, moreover, reported *D. acuta* from the same locality as *D. schröderi*. According to Pavillard's (1916) data, these two forms differ mainly in the size of the body and in the shape of the posterior portion of the body. Jörgensen (1923, p. 21) seems to be somewhat in doubt as to the status of *D. schröderi* as an independent species; he writes as follows: *D. schröderi* "seems therefore to be a true Mediterranean species (*or form*)," and it "is at times hard to distinguish with certainty" from *D. acuta*. According to Jörgensen (1923), *D. schröderi* differs from *D. acuta* in the following respects: — (*1*) it is somewhat more elongated; (*2*) its dorsal margin is somewhat more evenly convex; (*3*) the posterior portion of its body, as a rule, is slightly more rounded; (*4*) it is markedly compressed in dorsoventral view with the lateral contours of the body parallel to each other or even slightly concave, while in *D. acuta* the body in dorsoventral view "is generally narrowly elliptical, with convex lateral contours"; (*5*) its anterior cingular list is slightly higher relatively, and narrower at the base; and (*6*) its left sulcal list is almost without reticulation.

Dinophysis schröderi is also structurally close to *D. fortii*. It differs from this species mainly in the subacute posterior end of its body, in the angularity of the ventral margin of its body at the posterior main rib of the left sulcal list, and in the very slight development of the reticulation of its left sulcal list (see also *D. fortii*, the section on comparisons).

Another close relative of *Dinophysis schröderi* probably is *D. norvegica*. However, the latter species, which is easily recognized by its heavy surface markings, is too insufficiently known for a detailed comparison.

Synonymy: — This species was established by Pavillard (1909, p. 284, fig. 5), who described and figured it under the name of *Dinophysis schroederi*. Later it was described and figured by Pavillard (1916) and by Jörgensen (1923) under the same name. Forti (1922) gave a reproduction of Pavillard's (1916) figure of this species.

Occurrence: — *Dinophysis schröderi* was obtained at only one of the 127 stations. This station (4574) is on the first line of the Expedition and in the California Current. The sample was taken at the surface. The surface temperature was 69°, and the frequency less than 1% (one specimen).

The species was first recorded by Pavillard (1909, 1916) from the Gulf of Lyons, which thus is the type locality. Later it was reported from the Ligurian Sea by Forti (1922) and from the Adriatic by Schiller (1911a, 1911b) and Schröder (1911). Jörgensen (1923) found it to be widely distributed throughout the Mediterranean. Outside the Mediterranean it has been recorded only by Jörgensen (1923), who found it in the Bay of Cadiz and at "several places in the southern Atlantic, partly near and west of the southernmost part of Africa (German South-Pole Expedition, 1/7–1/8 1903), partly east of South America ('Fram' 1911)."

Of the writers who have contributed to our knowledge of the distribution of this species, Schiller and Schröder do not give any descriptions or figures by means of which their determinations may be checked.

This is a eupelagic species widely distributed but rare in subtropical, warm-temperate, and temperate seas.

2. Hastata Group. Fourteen species are assigned to this group. Of these the following have been found to occur in the Eastern Pacific: — *Dinophysis hastata*, *D. uracantha*, *D. urceolus*, *D. monacantha*, *D. trapezium*, *D. swezyi*, *D. collaris*, *D. schütti*, *D. nias*, *D. jörgenseni*, and *D. triacantha*.

Dinophysis hastata Stein

Figure 32, 34

Dinophysis hastata Stein, 1883, pl. 19, fig. 12. Hensen, 1887, p. 77, tab. 13, 15; 1895, p. 190; 1911, p. 165, tab. 15. Möbius, 1887, p. 121. Ostenfeld, 1898b, p. 42, tab. 5; 1899, tab. 5, 8; 1900, p. 56, tab. 2, 5–7; 1906, p. 18; 1909, p. 22; 1913a, p. 309; 1916b, p. 13. Murray & Whitting, 1899, p. 331, tab. 1–3, 6. Jörgensen, 1899, p. 32, lxxii; 1912, p. 11, 16; 1923 (*partim?*), p. 31–33, 44. Lemmermann, 1899a, p. 319, 372; 1901a, p. 374; 1902a, p. 263; 1905a, p. 36. Ostenfeld & Schmidt, 1901, p. 169. Cleve, 1901a, p. 15; 1901c, p. 239; 1902b, p. 29; 1903b, p. 343. Entz, 1902b, p. 94; 1905, p. 111. Ostenfeld & Paulsen, 1904, p. 164, 171. Zacharias, 1906, p. 530. Karsten, 1907, p. 234. Paulsen, 1907, p. 5; 1908, p. 12, 13, fig. 9; 1912, p. 289. Nathansohn, 1908, p. 604; 1909, p. 46; 1910, p. 61, fig. 29: 12. Gräf, 1909, p. 143, 151, 155, 159, 171, 173, 179, 182, 184, 188, 190, 192. Pavillard, 1909, p. 283, 284; 1915a, p. 2; 1916, p. 47, 53, 60; 1923a, p. 879, 880, fig. 2A. Okamura, 1912, p. 19, 33, fig. 73–75. Mangin, 1912, p. 33, tab. 2. Forti & Issel, 1923, p. 3, 4, fig.; 1924, p. 7.

Phalacroma hastatum Pavillard, 1909, p. 283, fig. 4; 1916, p. 53; 1923a, p. 879, 880. Schiller, 1911a, p. 52; 1912, p. 27. Schröder, 1911, p. 17, 25, 37. Forti, 1922, p. 104, fig. 108. Lebour, 1925, p. 83, fig. 21c.

Dinophysis hastata var. or form. *phalacromides* Jörgensen, 1923, p. 31, fig. 41 (*nomen rejectum*).

Dinophysis hastata var. or form. *uracanthides* Jörgensen, 1923, p. 31, 32, 33, fig. 40 (*nomen rejectum*).

Dinophysis uracantha var. *mediterranea* Jörgensen, 1923, p. 32, fig. 43.

Dinophysis hastata var. *parvula* Lindemann, 1923, p. 219, fig. 6.

Diagnosis: — Body subobovate, subovate, or subellipsoidal in lateral outline; rounded, subtruncate, or truncate anteriorly; subacute, or narrowly to broadly rounded posteriorly; deepest somewhat in front of to somewhat behind the middle; length: depth, 1.10–1.60: 1; longitudinal axis deflected posteroventrally at 0°–15°. In dorsal view narrowly obovate, about 2.5 times longer than wide. Cingular lists sometimes but slightly inclined anteriorly; epitheca sometimes visible above anterior cingular list; anterior cingular list 1.5–2.5 times wider than transverse furrow; posterior sometimes ribbed. Left sulcal list 0.48–0.77 the length of body; distance between R_1 and R_3 0.37–0.58 the length of body; R_2 is 0.11–0.29, R_3 is 0.25–0.74 the depth of body; margin forms angle of 20°–90° at R_3; R_3 inclined posteriorly at 15°–55°; sometimes with reticulation and accessory ribs. With triangular to spine-like posterior sail, usually somewhat ventrally to midline, and inclined ventrally at 0°–40°; its length 0.19–0.61 the depth of body and 1.0–4.0 its basal width; with or without central rib or reticulation, sometimes with marginal ribs; separated from left sulcal list. Theca usually finely and closely areolate. Length, 42.5–90.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a medium-sized to small species, the body of which is very variable in shape. It is subobovate, subovate, or subellipsoidal in lateral outline; rounded, subtruncate, or truncate anteriorly; subacute, or narrowly to broadly rounded posteriorly; and deepest somewhat in front of to somewhat behind the middle. The ratio between the length and the depth of the body is 1.10–1.60: 1; in our specimens this ratio is 1.27 (1.17–1.38): 1; in Stein's (1883, pl. 19, fig. 12) figure of the type specimen it is about 1.60: 1; in Okamura's (1912, fig. 73–75) specimens, 1.10–1.18: 1; and in Pavillard's (1909, fig. 4A), Jörgensen's (1923, fig. 40, 41), and Lindemann's (1923, fig. 6) specimens, 1.14–1.27: 1. The longitudinal axis either is perpendicular to the transverse furrow, as in the type specimen, or it is deflected posteroventrally at an angle of 1°–15°; in our specimens this deflection is 6° (0°–11°); in Pavillard's (1909) specimen, which is extreme in this respect, it is 15°.

The epitheca is very variable in depth and shape; it is 0.67 (0.54–0.86) as deep as the hypotheca, usually gently convex, but sometimes rather strongly convex (Figure 32: 14) or more or less flat (Figure 32: 9; Figure 33: 2), highest in the center or near the dorsal side (Figure 32: 9; Figure 33: 1, 3), and sometimes visible above the anterior cingular list. The transverse furrow is flat or slightly convex, and about as wide as or somewhat wider or narrower than the greatest height of the epitheca. The posterior cingular list is 0.18 (0.12–0.24) the length of the body from the apex. The hypotheca sometimes is symmetrical, *e.g.*, in the type specimen and in the specimens represented by our Figure 32: 12, 13, 16; but usually it has a more or less pronounced posteroventral inclination (see above). The dorsal margin (from the girdle to the antapex) usually is subuniformly and gently to moderately convex; sometimes it is more or less flattened anteriorly (Figure 32: 2) or posteriorly (Figure 32: 8), or both anteriorly and posteriorly (Figure 32: 10, 11). The ventral margin (from the girdle to the antapex) usually is more or less flattened posteriorly, or it is subuniformly and gently to moderately convex; sometimes (Figure 32: 9) it forms a broadly rounded corner at or near the posterior main rib of the left sulcal list. The posterior portion of the body is subacute, or narrowly to broadly rounded; in most specimens it is strikingly narrower than the anterior portion, but sometimes it is of about the same depth (Figure 32: 7) or even deeper (Figure 32: 13). In dorsoventral view (Pavillard, 1909, fig. 4B) the body is narrowly obovate, about 2.5 times longer than wide, and its side contours are evenly convex.

The cingular lists are subequal or the posterior is somewhat narrower than

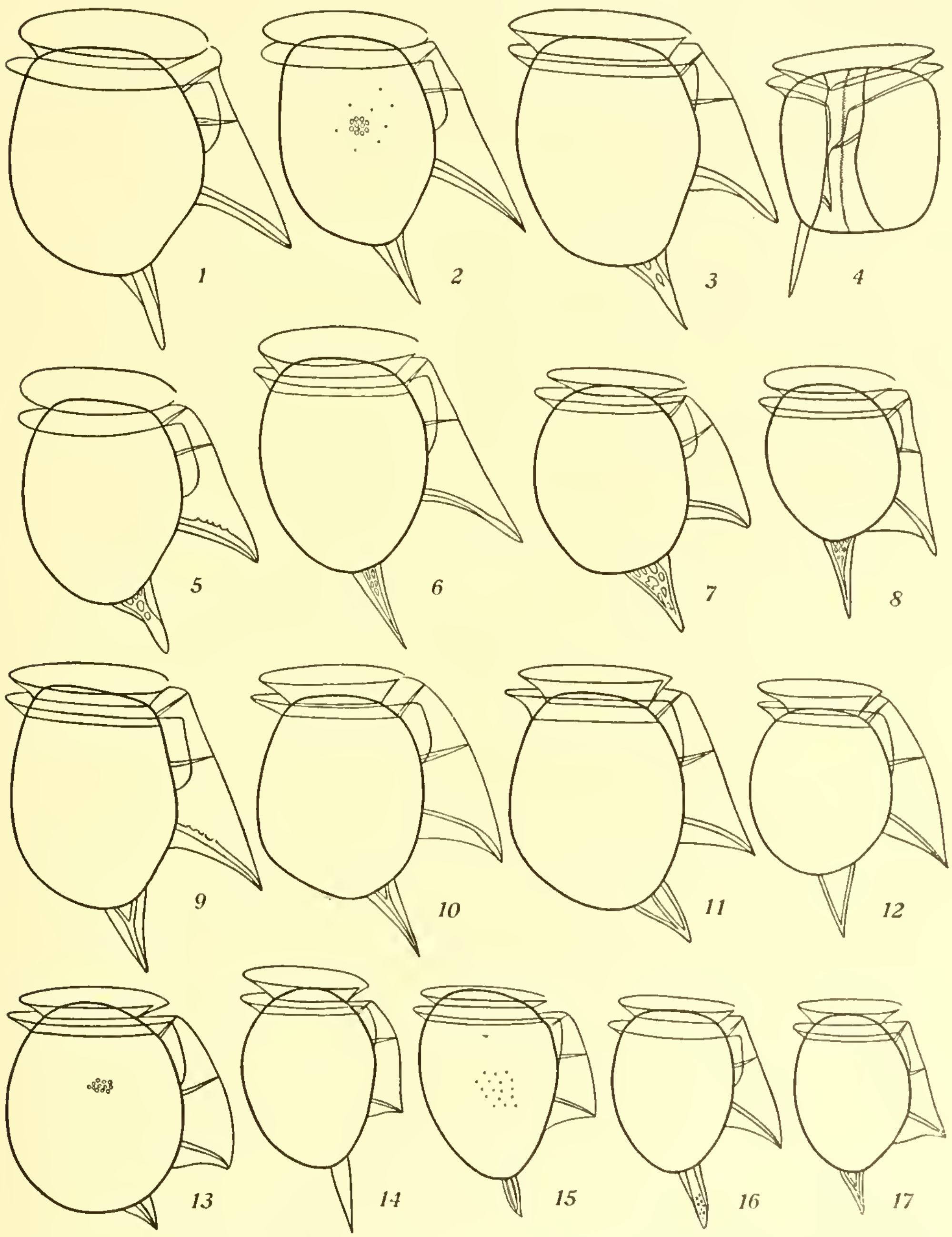

FIGURE 32.— *Dinophysis hastata* Stein, all, except 4, seen in right lateral view; 4, in ventral view; structure of thecal wall indicated in 2, 13, and 15 only; 4 and 14 from the same specimen. × 430. 1, 5, 6, 9, 10, from Station 4737 (300–0, or 100–0 fathoms); 2, from Station 4732 (300–0 fathoms); 3, from Station 4734 (300–0 fathoms); 4, 14, from Station 4724 (300–0 fathoms); 7, from Station 4722 (300–0 fathoms); 8, 13, from Station 4730 (300–0 fathoms); 11, 12, from Station 4740 (300–0 fathoms); 15, 16, 17, from Station 4711 (300–0 fathoms).

the anterior. In the type specimen (Stein, 1883, pl. 19, fig. 12) and in the specimen figured by Jörgensen (1923, fig. 43) under the name of *Dinophysis uracantha* var. *mediterranea*, the posterior list is very narrow, about 0.30–0.40 the width of the anterior (see the section on comparisons). The anterior cingular list is 1.5–2.5 times wider than the transverse furrow and 0.20 (0.13–0.27) the greatest depth of the body. In most specimens both these lists are more or less funnel-shaped, being inclined anteriorly at 20°–50°; sometimes, however, the posterior or even both of them (Jörgensen, 1923, fig. 41; Pavillard, 1909, fig. 4A) may be subhorizontal. The anterior one has, on each valve, about 15–25 usually simple, straight, and almost equidistant ribs; sometimes these ribs ramify and anastomose into an indistinct and incomplete reticulum (Jörgensen, 1923). The posterior cingular list may have the same structure as the anterior (Pavillard, 1909, fig. 4A), but usually it lacks structural differentiations. The right sulcal list sometimes ends at the fission rib of the left sulcal list, but usually it extends somewhat beyond this rib; in exceptional cases (Jörgensen, 1923, fig. 41) it extends as far as to the posterior main rib of the left sulcal list; it either is subtriangular, decreasing gradually in width posteriorly, or it is of subuniform width throughout the greater part of its length and rounded posteriorly (Figure 32: 9); anteriorly it is about as wide as the transverse furrow, sometimes somewhat narrower. The left sulcal list is of moderate size or rather large, and usually strikingly wider posteriorly than anteriorly. Its length is 0.58 (0.48–0.77) the length of the body, and the distance between the anterior and posterior ribs is 0.48 (0.37–0.58) the length of the body. The anterior main rib is 0.19 (0.13–0.25), the fission rib 0.22 (0.11–0.29), and the posterior main rib 0.52 (0.25–0.74) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight (Figure 32: 6, 11), evenly and gently to moderately convex (Figure 32: 11, 13), or slightly irregular (Pavillard, 1909, fig. 4A; Jörgensen, 1923, fig. 41). At the posterior main rib this margin forms an angle of 45° (20°–90°). Behind this rib the margin may be almost straight (Figure 32: 11), but usually it is gently to moderately concave. The main ribs of this list are of moderate strength; the anterior two are straight or almost so; the posterior, which sometimes (Figure 32: 6, 10) is club-shaped, may be straight, but in most specimens it is gently to moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.42 (0.30–0.55) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 30° (15°–55°). In some specimens the entire left sulcal list has a fairly well-developed reticulation; in other specimens it has numerous fine ribs and imperfect reticulation; sometimes there is no structural differentiation except the three main ribs. On the right valve there is an acute, triangular to spine-like posterior sail, which is situated either on or generally somewhat ventrally to the midline, and is inclined ventrally at 0°–40°; in our specimens this sail has a ventral inclination of 22° (7°–40°), in Stein's (1883) specimen it was parallel to the longitudinal axis of the body. The left sulcal list usually ends at a distance from the posterior sail equaling about 0.30 the greatest depth of the body; in extreme cases the corresponding figure may be as high as 0.45, or the left sulcal list may extend almost to the posterior sail (Figure 32: 8). The size of the posterior sail is somewhat variable, probably due to the fact that in each binary fission one of the daughter schizonts has to form this structure anew. When fully developed, its length is 0.46 (0.19–0.61) the greatest depth of the body; *i.e.*, its average length is slightly less than that of the posterior main rib of the left sulcal list. It is 2.2 (1.0–4.0) times longer than it is wide at the base. In most cases it is straight or almost so; its margins are almost straight, or gently convex, concave, or sigmoid; and the angle at its tip is 22° (10°–40°). In most of our specimens this sail is supported by a central rib, which may be quite or nearly solid (Figure 32: 1, 2), more or less broken up into an irregular reticulum (Figure 32: 3, 5, 7), or bifurcate at the base (Figure 32: 9, 10). In one of our specimens (Figure 32: 11) this sail had a marginal rib besides a central rib, in another (Figure 32: 12) only a marginal rib (see also the section on comparisons). No parasagittal lists are developed.

In most specimens (Figure 32: 2) the thecal wall is finely and closely areolate and has scattered pores; some specimens (Figure 33: 1) are characterized by rather large areoles, others (Figure 33: 2) are reticulate. In northern waters the living cell, according to Jörgensen (1923, p. 31), is "of a light rose, without chromatophores, or hyaline."

Megacytic stages were seen by Pavillard (1916, p. 47) and by ourselves (Figure 32: 4).

The dimensions of nineteen of our specimens and of the specimens figured by Stein (1883), Pavillard (1909), Okamura (1912), Jörgensen (1923), and Lindemann (1923) were measured.

Dimensions: — Our specimens: Length of body, 50.2–80.6 μ (average, 67.2 μ). Greatest depth of body, 37.7–63.8 μ (average, 53.3 μ). The size of the type specimen (Stein, 1883, pl. 19, fig. 12) is unknown. Judging by Stein's (1883) information about the magnification of his figures, given in an introductory remark to the explanation of the plates, the length of this specimen was somewhere between

71.5 μ and 110.0 μ. A specimen found by Jörgensen (1899, p. 32) on the west coast of Norway was 73 μ long and 53 μ deep. The specimens recorded by Pavillard (1909, fig. 4A) under the name of *Phalacroma hastatum* were 85–90 μ long and 35–40 μ deep. The three specimens figured by Okamura (1912, fig. 73–75) were 59.5–77.5 μ long and 50.6–70.3 μ deep. The specimens represented by Jörgensen's (1923) figures 40 and 41 were 58.7 μ long and 47.5 μ deep, and 78.0 μ long and 61.3 μ deep, respectively; the specimen figured by Jörgensen (1923, fig. 43) under the name of *Dinophysis uracantha* var. *mediterranea* was 42.5 μ long and 38.0 μ deep. Lindemann's (1923) specimen was 60 μ long.

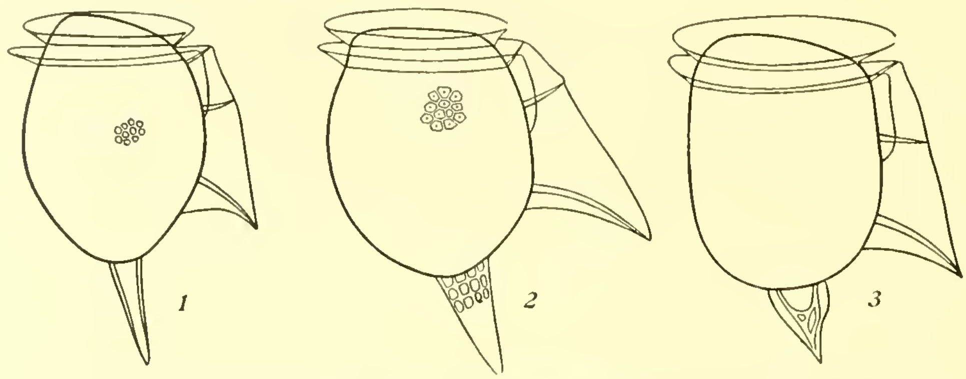

FIGURE 33.—*Dinophysis hastata* Stein, right lateral view of three aberrant specimens; structure of thecal wall indicated in 1 and 2. Specimen represented by 2 had left sulcal list and posterior sail heavily reticulated, but its posterior sail had no central rib. × 430. 1, from Station 4711 (300–0 fathoms); 2, from Station 4730 (300–0 fathoms); 3, from Station 4732 (300–0 fathoms).

Variations: — The variability of *Dinophysis hastata*, as conceived in the present paper and by Jörgensen (1923), is amazing, and, according to our opinion, there can be but little doubt that future investigators, with adequate material at their disposal, will find it necessary and feasible to divide this species into two or more systematic units. The principles which we have been forced to apply in our treatment of this species completely upset those used in almost all the other species of the genera Dinophysis and Phalacroma. Indeed, some of our specimens of this species have the habitus characteristic of Dinophysis, while others look like rather typical representatives of Phalacroma. Jörgensen (1923, p. 31) writes that this species in the Mediterranean at times varies "to an extraordinary degree."

The following characters are the most variable: — the size of the body, the inclination of the longitudinal axis of the body, the shape and the relative depth of the epitheca, the shape of the hypotheca, the inclination of the cingular lists, the width and the shape of the left sulcal list, the shape and relative size of the right sulcal list, and the size, shape, structure, and position of the posterior sail.

Comparisons: — The type specimen, as figured by Stein (1883, pl. 19, fig. 12), has an oblong, subovoidal, and symmetrical body, subtruncate anteriorly and subacute posteriorly; its anterior cingular list is wide and funnel-shaped, and its posterior cingular list is very narrow; its posterior sail is located on the very midline, directed posteriorly, and furnished with a simple, strong, central rib. Specimens of the same habitus as the type specimen appear not to have been found by later investigators. For instance, Okamura (1912) emphasizes that in his specimens the body was "shorter and more roundish" than in the type specimen, and he found the posterior sail to be without central rib or its central portion "is partly thickened like a spine." Pavillard (1916, p. 60), too, found the body to be shorter and more rounded than in Stein's (1883) figure of the type specimen; he also remarks that in his specimens the posterior sail was displaced ventrally and that the presence of a central rib in this sail "paraît très douteuse." Hensen (1895, p. 190) observed that his specimens of this species were "schief." It is, of course, not excluded that Stein (1883) made mistakes in his representation of some of the structures of the type specimen. However, the striking variability of this species makes it appear possible that this author has correctly figured a specimen of an unusual habitus. A glance at our figures will show that we have found specimens of this species (Figure 32: 16, 17) almost as elongated as in the figure of the type. As to the position and structure of the posterior sail, Jörgensen (1923, p. 31) writes as follows: "Terminal spine displaced toward the ventral side, and directed obliquely ventrally, rarely almost in the middle and pointing straight down, often with distinct median rib and more or less broad sail lists, or quite or nearly solid throughout, with narrow sail lists or none." With regard to the width of the posterior cingular list of the type, it should be mentioned that this list is very narrow in *Dinophysis uracantha* var. *mediterranea* Jörgensen (1923, p. 43), a form which probably is referable to *D. hastata* (see below, the section on synonymy).

As previously indicated, none of the specimens found in the material of the Expedition and assigned to *Dinophysis hastata* agrees exactly with the type specimen of this species, as figured by Stein (1883, pl. 19, fig. 12). Moreover, only a few of our specimens (Figure 32: 16) show a comparatively close resemblance to the type.

The specimens represented by Figure 32: 1, 2, 3, 5, 6, 9, 10, may be considered as typical of *Dinophysis hastata*, as found by us in the tropical and subtropical regions of the eastern Pacific. This form may be characterized briefly in the following way. The body is somewhat asymmetrical, with posteroventrally inclined longitudinal axis, subovoidal, subtruncate anteriorly, and subacute to narrowly rounded posteriorly. The posterior sail is located somewhat ventrally to the midline, directed posteroventrally, and furnished with a central rib, which either is quite or nearly solid throughout or more or less broken up into an irregular reticulum.

On the other hand, the specimens represented by Figure 32: 4, 7, 8, 11–17, and by Figure 33 should be regarded as unusual. A detailed discussion of each of these figures would lead too far; the mentioning of a few outstanding facts must suffice. Figure 32: 16, as previously mentioned, approaches the type specimen as figured by Stein (1883). Figure 32: 12 resembles Jörgensen's (1923, fig. 40) figure of *Dinophysis hastata* f. *uracanthides*, and approaches *D. uracantha* in having the posterior sail bordered with marginal ribs; this specimen would have been assigned to *D. uracantha*, if its posterior sail had not been displaced ventrally. Figure 33: 2 approaches Jörgensen's (1923, fig. 41) figure of *D. hastata* f. *phalacromides*. We would have separated the three specimens represented by Figure 33, from *D. hastata*, were it not for the following statement by Jörgensen (1923, p. 31): "I have not been able with certainty to distinguish *Phalacroma hastatum* Pavill. from *Dinophysis hastata*, not even as a separate variety, though it is often rather characteristic." Since our material is not sufficient for a well-founded solution of this problem, we have considered it advisable to accept temporarily Jörgensen's (1923) decision (see Pavillard, 1923a, p. 879, 880).

Jörgensen (1923, p. 31) states that the specimens of this species, found on the west coast of Norway and in the Black Sea, are relatively small, with narrow left sulcal list without posterior main rib, and with small posterior sail. In none of the fully developed specimens of this species, found by us in the material of the Expedition and in a collection from Alaska, did the left sulcal list lack the posterior main rib.

Dinophysis hastata is structurally closely related to *D. uracantha*. The ranges of variation of these two species, as conceived in the present paper, even may overlap (see, for instance, Figure 32: 12). When typical, according to our conception of the species, *D. hastata* differs from the typical *D. uracantha* in being somewhat larger, in having the body more elongated and somewhat deflected posteroventrally, and in having the posterior sail situated somewhat ventrally to the midline.

Dinophysis monacantha, *D. pusilla*, and *D. alata* are presumably also rather close relatives of *D. hastata*. These relationships are indicated by the presence of a posterior sail and by the relatively simple structure of the left sulcal list. The typical *D. hastata* differs from *D. monacantha* mainly in lacking a parasagittal list, in having the longitudinal axis of the body deflected posteroventrally instead of posterodorsally, and in having the posterior sail with a central and not with a marginal rib. From *D. pusilla* it differs strikingly in its larger size and in its more elongated body. *D. alata* is characterized by the wide parasagittal list along the dorsal margin of the body. See also *D. monacantha*, the section on comparisons.

Synonymy: — The species was established by Stein (1883, pl. 19, fig. 12), who figured it under the name of *Dinophysis hastata*. Later it was described by Paulsen (1908, p. 13) and figured by Okamura (1912, fig. 73–75) and Forti and Issel (1923) under the same name. Paulsen (1908), who bases his description on Stein's (1883) figure of the type specimen, gives a reproduction of this figure. Other reproductions of Stein's (1883) figure are to be found in Nathansohn (1910, fig. 29: 12) and Lebour (1925, fig. 21e).

For reasons mentioned in the section on comparisons, the name of *Phalacroma hastatum* Pavillard (1909) has been included in our bibliographical list of *Dinophysis hastata*. However, we wish to emphasize that this should be regarded as a tentative measure, and that we consider it possible that *Phalacroma hastatum* is specifically distinct. It should be pointed out in this connection that Schiller (1911a, 1912) and Schröder (1911), who recorded *Phalacroma hastatum* from the Adriatic Sea, as well as Forti (1922), who found it in the Ligurian Sea, did not mention *Dinophysis hastata* as occurring in their collections. Forti (1922) gives a reproduction of Pavillard's (1909) figure of *Phalacroma hastatum* (see also Pavillard, 1923a, p. 879). It should be noted that if this form is specifically distinct, then its name must be changed, since *P. hastatum* is preoccupied. This name was first used as a *nomen nudum* by Hensen (1895, p. 190; see also Hensen, 1911, p. 166, 167).

Jörgensen (1923, p. 31) writes that he had tried to distinguish between two varieties of *Dinophysis hastata*, viz., var. *uracanthides* and var. *phalacromides*, the latter "answering to *Phalacroma hastatum* Pavill.," "but this again cannot, as far as my experience goes, be maintained with certainty." *Dinophysis uracantha* Stein var. *mediterranea* Jörgensen (1923) should be assigned to *D. hastata* in spite of its small size, since the longitudinal axis of its body is deflected posteroventrally, and since its posterior sail is situated ventrally to the antapex and is furnished with a central rib and not with marginal ribs.

Lindemann's (1923, fig. 6) figure of *Dinophysis hastata* var. *parvula* from the Bosporus corroborates Jörgensen's (1923, p. 31) statement that the specimens of this species found by him in the Black Sea were relatively small, with small left sulcal list and small posterior sail.

Occurrence: — *Dinophysis hastata* is recorded at forty-eight of the 127 stations. There are 10, 9, 9, 7, 9, and 4 stations on the six lines of the Expedition. Of these forty-eight stations, three (4571, 4580, 4583) are in the California Current; six (4587, 4588, 4590, 4594, 4596, 4605) are in the Mexican Current; four (4613, 4634, 4637, 4638) are in the Panamic Area; eight (4650, 4651, 4659, 4664, 4665, 4666, 4675, 4676) are in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; twenty (4679, 4680, 4681, 4683, 4687, 4701, 4705, 4707, 4711, 4717, 4721, 4722, 4724, 4730, 4732, 4734, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current; and one (4542) is in the Equatorial Counter Current. There are eight records from the surface (Stations 4583, 4588, 4596, 4666, 4676, 4680, 4741, 4542); at two of these stations (4583, 4676) the species was taken in hauls from 300–0 fathoms as well as at the surface; at one station (4666) it was taken in a haul from 800–0 fathoms as well as at the surface; at the remaining five stations it is recorded from surface catches only. At one station (4737) the species is recorded from 100–0 fathoms and 300–0 fathoms, and at one station (4681) from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The species is also recorded from surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these forty-eight stations at the surface was 66°–85°; the average was 75.3°. At the eight stations in the surface catches of which this species was found, the surface temperature ranged from 67° to 84°; the average was 76.7°.

At two of the surface stations (4542, 4666) a frequency of 1% was found; in the remaining cases frequencies of less than 1% are recorded. For the catches from 100, 300, or 800 fathoms to the surface the records of frequency are as follows: 2% at one station (4689), 1% at ten stations (4571, 4580, 4587, 4634, 4681, 4724, 4734, 4737, 4740, 4742), and less than 1% at the remaining stations.

In addition it may be mentioned that we have found this species also in plankton from Yes Bay, Alaska.

Stein (1883) recorded this species "aus dem Atlantischen Meer und der Südsee." It was mentioned as occurring in the Cattegat by Ostenfeld (1906, 1916b) and Paulsen (1912); and in the Skager Rak by Paulsen (1907), Jörgensen (1912), and Ostenfeld (1913a). (It has not been found in the Baltic. Lemmermann's, 1902a, p. 263, statement that Möbius, 1887, recorded it from the western part of the Baltic is erroneous.) It was found on the west coast of Norway by Jörgensen (1899, 1912); in the North Sea, by Ostenfeld (1906, 1909) and by Paulsen (1912). Ostenfeld (1898b, 1899, 1900) reported it from twelve localities in the northern part of the Atlantic, between lat. 59° 36′ N.–63° 57′ N. and long. 2° 28′ W.–28° 45′ W. Hensen (1887) and Möbius (1887) found it west of Scot-

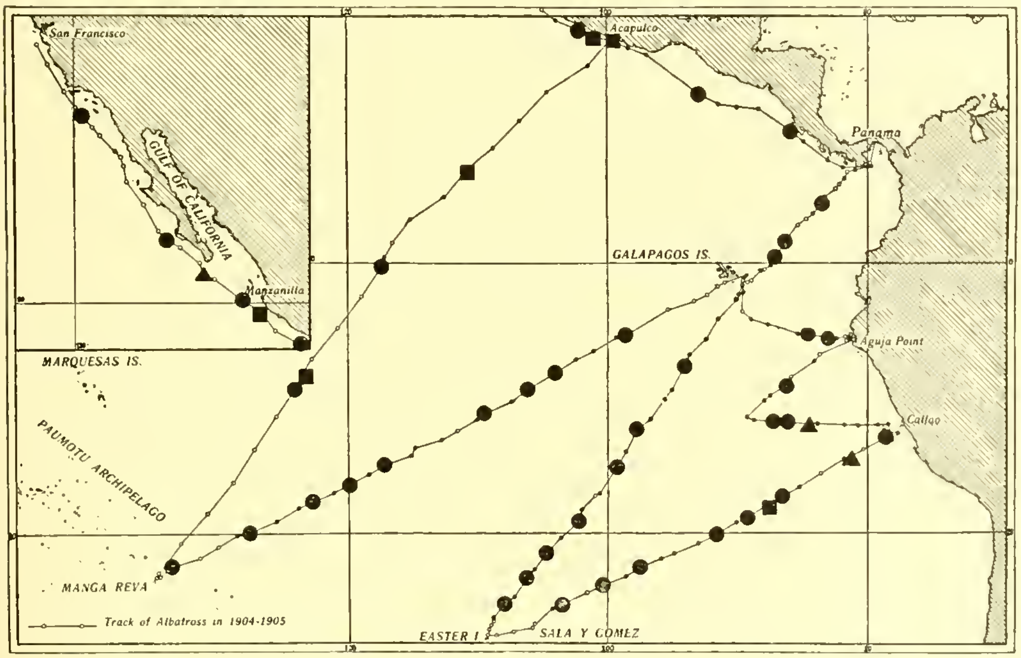

Figure 34.—Occurrence of *Dinophysis hastata* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

land, at about lat. 57° N. and long. 10°–11° W., and Ostenfeld and Paulsen (1904) at lat. 59° 41′ N., long. 22° 27′ W. Other papers in which this species is mentioned as occurring in the northern part of the Atlantic are Ostenfeld (1906) and Paulsen (1912). Mangin (1912) found it in the English Channel; Jörgensen (1923), on the southwest coast of Portugal and in the Bay of Cadiz; Murray and Whitting (1899), at six stations in the Atlantic, between lat. 45° 38′ N.–18° 20′ N. and long. 13° 53′ W.–52° 40′ W.; Cleve (1901c), at twelve localities in the Atlantic, between lat. 62° N.–19° S., and long. 1° W.–66° W.; Cleve (1903b), at lat. 37° N., long. 8° W.; Cleve (1902b), at lat. 24° S., long. 4° E.; Gräf (1909), at lat. 4° 37′ N., long. 9° 52′ W., lat. 17° 22′ S., long. 0° 13′ E., and lat. 31° 12′ S., long. 16° 1′ E.;

Hensen (1911), in the Gulf Stream, Florida Current, Sargasso Sea, Canary Current, North Equatorial Current, Guinea Current, South Equatorial Current, and on the coast of Brazil. In the Mediterranean this species has been found by several investigators, viz.: in the Gulf of Lyons, by Pavillard (1909, 1916); off Monaco, by Nathansohn (1908, 1909); in the Ligurian Sea, by Forti (1922); near Naples, by Zacharias (1906); in the Adriatic Sea, by Entz (1902b, 1905), Schröder (1911), Schiller (1911a, 1912), and Forti and Issel (1923); and at a rather great number of localities in various parts of the Mediterranean, by Jörgensen (1923). Lindemann (1923) reported it from the Bosporus; and Jörgensen (1923) from the Marmora Sea, Bosporus, and the Black Sea. In the Red Sea it was found by Cleve (1903b); in the Gulf of Aden, by Ostenfeld and Schmidt (1901), and by Cleve (1903b); in the Arabian Sea, at lat. 9° N., long. 59° E., by Cleve (1901a); in the Indian Ocean, at lat. 2° S., long. 91° E., by Cleve (1901a), at lat. 34° 13′ S., long. 80° 30′ E., by Karsten (1907), and at the Suvadiva Atoll, at Rodriguez Island, and on the west coast of Madagascar by Gräf (1909); in the Antarctic Ocean, south of Africa, at lat. 42° 55′ S., long. 22° 53′ E., by Gräf (1909); in the East Indies, near Sumatra, Celebes, Amboina, and on the north coast of New Guinea, by Gräf (1909); in Japanese waters, by Okamura (1912); and in the Peruvian Current by Lemmermann (1899a).

Karsten (1907) reported the species as taken with a closing net between 80 and 60 meters. Most of the remaining records refer to surface hauls.

According to the investigators who have contributed to our knowledge of the distribution of this species, it occurs in waters of the following temperatures and salinities. Ostenfeld (1898b): — temperature, 51.8°; salinity, 35.25. Ostenfeld (1899): — temperature: range, 44.6°–52.7°; mean of four observations, 48.8°. Salinity: range, 35.37–35.50; mean of four observations, 35.41. Ostenfeld (1900): — temperature: range, 45.0°–55.4°; mean of seven observations, 52.4°. Salinity: range, 35.00–35.34; mean of seven observations, 35.18. Murray and Whitting (1899): — temperature: range, 61°–79°; mean of six observations, 71.9°. Cleve (1901a): — temperature, 82.3°; salinity, 32.13. Cleve (1901c): — temperature: range, 44.6°–77.2°; mean of eighteen observations, 63.7°. Salinity: range, 33.93–37.36; mean of eighteen observations, 35.71. Cleve (1902b): — temperature, 71.6°; salinity, 35.95. Cleve (1903b): — temperature, 60.3°–84.7°; salinity, 36.44–40.70 (four samples). Ostenfeld and Paulsen (1904): — temperature, 52.2°. Gräf (1909): — temperature, 82.8°–84.1° (two samples). Salinity: range 33.78–36.22; mean of eleven observations, 34.79.

Of the authors who have contributed to our knowledge of the distribution of this species, only Stein (1883), Pavillard (1916), Okamura (1912), Forti (1922), Jörgensen (1923), Forti and Issel (1923), and Lindemann (1923) give descriptions or drawings by means of which their determinations of this species may be checked (see the section on synonymy).

Dinophysis hastata is eupelagic and occurs in tropical, subtropical, and warm-temperate regions of all seas. It has been found in the northern part of the Atlantic, in the North Sea, Norwegian Sea, Skager Rak, and Cattegat, but it is probably a warm-water form and not endogenetic in these waters. The specimens recorded probably were stragglers of southern origin, carried to the north by the Gulf Stream (see Paulsen, 1912, p. 289). It is thermophilous but eurythermal and, as far as known, stenohaline. According to our records, it is almost uniformly distributed throughout the area investigated by the Expedition and has its optimum habitat in deeper waters, within the levels of photosynthesis.

Dinophysis uracantha Stein

Figure 35, 36

Dinophysis uracantha Stein, 1883, pl. 20, fig. 22, 23. Hensen, 1895, p. 190; 1911, p. 165, tab. 15. *non* Schütt, 1895, p. 16, 17, pl. 2, fig. 9. Lemmermann, 1899a, p. 373; 1901a, p. 375; 1905a, p. 36. Murray & Whitting, 1899, p. 331, tab. 1–6, 8, 9. Schröder, 1900a, p. 35; 1906a, p. 326, 329. Ostenfeld & Schmidt, 1901, p. 171. Cleve, 1903b, p. 344. Zacharias, 1906, p. 557. Kofoid, 1907a, p. 196; 1910a, p. 184. Karsten, 1907, p. 234, 237, 247. Pavillard, 1916, p. 60; 1923a, p. 879, 880, fig. 2B. Jörgensen, 1923, p. 31, 33, 34, fig. 42. Forti & Issel, 1924, p. 6, 7. Lebour, 1925, p. 83, fig. 20g.
non *Dinophysis uracantha* var. *mediterranea* Jörgensen, 1923, p. 32, fig. 43.

Diagnosis: — Body subcircular to subovate in lateral outline, seldom truncate anteriorly; deepest somewhat in front of to somewhat behind the middle; length: depth, 0.98–1.14 : 1; longitudinal axis deflected posterodorsally at 0°–13°. Anterior cingular list 1.5–2.5 times wider than transverse furrow; epitheca seldom visible above this list. Left sulcal list 0.60–0.75 the length of body; distance between R_1 and R_3 0.50–0.57 the length of body; R_2 is 0.13–0.30, R_3 is 0.50–0.88 the greatest depth of body; margin forms angle of 20°–40° at R_3; R_3 inclined posteriorly at 20°–55°; sometimes with secondary ribs and reticulation. With triangular or claw-like posterior sail located somewhat dorsally to midline; its length is 0.45–0.88 the greatest depth of body and 1.5–3.0 its basal width; with marginal ribs but without central rib; separated from left sulcal list. Theca finely and closely areolate. Length, 37.5–63.5 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a small or medium-sized species of rather variable shape. The body is subcircular to subovate in lateral outline, seldom truncate anteriorly, and deepest somewhat in front of, to somewhat behind, the middle. The ratio between the length and the depth of the body is 1.07 (0.98–1.14): 1. The longitudinal axis either is perpendicular to the transverse furrow, as in the specimen represented by Stein's (1883) Plate 20, figure 23, or it is deflected posterodorsally at 8° (1°–13°).

The epitheca is variable in depth and shape; it is 0.59 (0.40–0.69) as deep as the hypotheca, usually gently convex, but sometimes rather strongly convex (Figure 35: 2) or flat (Figure 35: 3), highest in or near the center, and seldom visible above the anterior cingular list. The transverse furrow is flat to slightly convex, and about as wide as or more or less decidedly wider than the greatest height of the epitheca. The posterior cingular list is 0.17 (0.09–0.20) the length of the body from the apex. The hypotheca sometimes is symmetrical, *e.g.*, in the specimens represented by Figure 35: 3 and by Stein's (1883) Plate 20, figure 23, but usually it has a more or less pronounced posterodorsal inclination. The dorsal margin (from the girdle to the antapex) sometimes is subuniformly and moderately to gently convex, sometimes (Figure 35: 4) flattened anteriorly, and sometimes (Figure 35: 1) somewhat more strongly convex anteriorly than posteriorly. The ventral margin (from the girdle to the antapex) sometimes, as in the type specimen and in Figure 35: 3, is subuniformly and moderately convex, but usually it is more or less flattened posteriorly. The posterior portion of the body is broadly rounded, but seldom (Figure 35: 2) strikingly deeper than the anterior.

The cingular lists are subequal or the posterior is slightly narrower than the anterior. In the two specimens figured by Stein (1883, pl. 20, fig. 22, 23) the posterior list is very narrow and only about 0.30–0.50 as wide as the anterior; this is probably due to an imperfect observation, since Stein (1883) made this list very narrow in almost all his figures of species of Dinophysis. The anterior of these lists is 1.5–2.5 times wider than the transverse furrow and 0.27 (0.20–0.40) the greatest depth of the body. In most specimens both these lists are funnel-shaped, being inclined anteriorly at 20°–50°; however, the posterior, which sometimes is somewhat less inclined than the anterior, may be subhorizontal (Jörgensen, 1923, fig. 42). The anterior has, on each valve, 10–20 simple, straight, and almost equidistant ribs, some of which may be incomplete; the posterior appears always to lack structure. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly, or (Figure 35: 7) of subuniform width throughout the greater part of its length and rounded posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is comparatively large and usually strikingly wider posteriorly than anteriorly. Its length is 0.68 (0.60–0.75) the length of the body, and the distance between the anterior and posterior main ribs is 0.53 (0.50–0.57) the length of the body. The anterior main rib is 0.21 (0.15–0.24), the fission rib 0.22 (0.13–0.30), and the posterior main rib 0.67 (0.50–0.88) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is nearly straight, as in the type specimen and in our Figure 35: 5, or it is gently sigmoid or somewhat irregular; when sigmoid, it may be convex anteriorly and concave posteriorly (Figure 35: 6), or *vice versa* (Figure 35: 2, 3); when irregular, it may be straight anteriorly and concave posteriorly (Figure 35: 4), or *vice versa* (Figure 35: 7). At the posterior main rib this margin forms an angle of 28° (20°–40°). Behind this rib the margin usually is gently or moderately concave, but sometimes it is gently or moderately sigmoid. The main ribs of this list are of moderate strength; the two anterior are straight or almost so; the posterior, which in exceptional cases is club-shaped, may be straight, but in most specimens it is gently or moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.38 (0.33–0.45) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 37° (20°–55°). Besides the three main ribs this list has either a more or less developed reticulum of anastomosing, almost parallel transverse ribs, or a varying number of almost parallel, or more or less irregular transverse ribs, not connected by anastomoses. On the right valve there is an acute, triangular or claw-like posterior sail, which is situated on or generally somewhat dorsally to the midline and directed posteriorly or slightly ventrally. The left sulcal list ends at a distance from the posterior sail equaling 0.38 (0.29–0.50) the greatest depth of the body. When the posterior sail is fully developed, its length is 0.60 (0.45–0.88) the greatest depth of the body, *i.e.*, its average length is slightly less than that of the posterior main rib of the left sulcal list; and it is 2.1 (1.5–3.0) times longer than it is wide at the base. Sometimes both its margins are almost straight; but generally its dorsal margin is convex and its ventral concave, or both of them are gently sigmoid (Figure 35: 6); the angle at its tip is 18° (10°–25°). It is supported by marginal ribs and lacks a central rib. No parasagittal lists are developed.

The thecal wall is finely and closely areolate; the size of the areoles is somewhat variable. The structure varies with age; in old, thick-walled specimens it is very distinct (Jörgensen, 1923, p. 32).

Megacytic stages have not been recorded.

The dimensions of nine of our specimens and of the specimens figured by Stein (1883) and Jörgensen (1923) were measured.

Dimensions: — Our specimens: Length of body, 37.5–63.5 μ (average, 50.8 μ). Greatest depth of body, 33.1–55.4 μ (average, 47.7 μ). The size of the type specimen is unknown. Judging by Stein's (1883) information about the magnification of his figures, given in an introductory note to the explanations of the plates, the length of this specimen was somewhere between 40.0 μ and 61.3 μ. The specimen figured by Jörgensen (1923, fig. 42) was 56.3 μ long and 50.0 μ deep.

Variations: — *Dinophysis uracantha,* as conceived in the present paper, is rather strikingly variable, and future investigations probably will prove it neces-

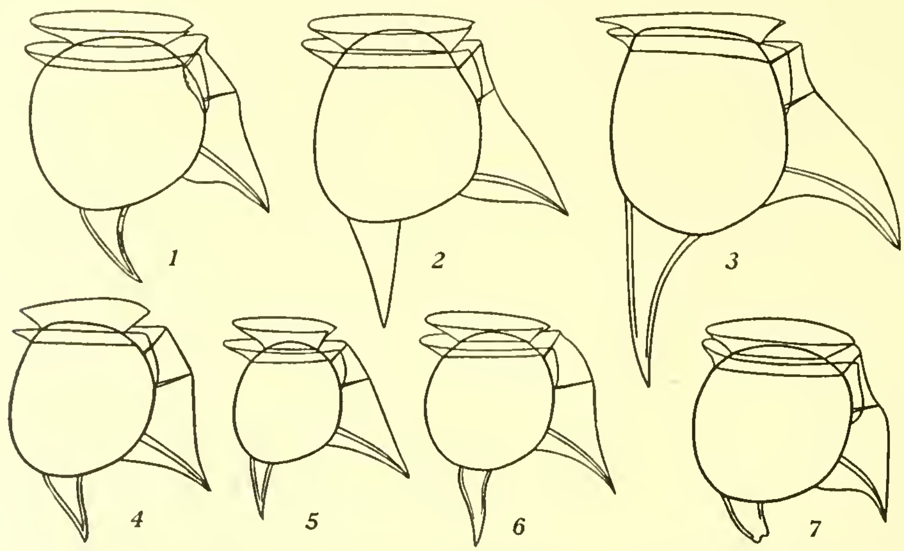

FIGURE 35.— *Dinophysis uracantha* Stein, right lateral view. 1, 4–7, typical; 2, 3, atypical. In 2 the marginal ribs of the posterior sail may have been overlooked. × 430. 1, from Station 4724 (300–0 fathoms); 2, 3, from Station 4732 (300–0 fathoms); 4, 5, 7, from Station 4722 (300–0 fathoms); 6, from Station 4711 (300–0 fathoms).

sary and possible to split this species into two or more systematic units. Our material is unfortunately insufficient for a well-founded solution of this question.

The following characters are the most variable: — the size of the body, the shape and the relative depth of the epitheca, the shape of the hypotheca, the shape and the relative width of the left sulcal list, and the shape and size of the posterior sail.

Comparisons: — Stein (1883, pl. 20, fig. 22, 23) figures two specimens of fairly different habitus under the name of *Dinophysis uracantha.* Of these specimens the one represented by his Plate 20, figure 22, should be regarded as the type (Jörgensen, 1923, p. 32) and may be characterized briefly in the following manner: the body is subcircular in lateral view, and its longitudinal axis is slightly deflected posterodorsally; the anterior cingular list is very wide, with narrow base, funnel-shaped, and ribbed; the posterior cingular list is very narrow, inclined anteriorly, and without ribs; the posterior main rib of the left sulcal list has a pronounced posterior concavity, and the posteroventral portion of this list is strikingly recurved; the posterior sail is placed somewhat dorsally to the antapex and is supported by marginal ribs and not by a central rib; the theca has very fine areolation. The specimen represented by Stein's (1883) Plate 20, figure 23, differs from the type mainly in the following respects: the body is more elongated and decidedly deeper posteriorly than anteriorly, and its longitudinal axis is perpendicular to the girdle; the base of the anterior cingular list is wider; the posterior main rib of the left sulcal list has but a slight posterior concavity, and the posteroventral portion of this list is not strikingly recurved; the posterior sail is situated at the very antapex; the areolation of the thecal wall is somewhat coarser. Both these specimens belong to *D. uracantha* as conceived in the present paper.

Most of the specimens found in the material of the Expedition and assigned to *Dinophysis uracantha* (Figure 35: 1, 4–7) show a striking resemblance to the type; they differ mainly in the following respects: the posterior cingular list is about as wide as the anterior, the posterior main rib of the left sulcal list has but a slight posterior concavity, and the posteroventral portion of this list is not strikingly recurved. In the two last characters our specimens resemble the specimen represented by Stein's (1883) Plate 20, figure 23. The specimens represented by Figure 35: 2, 3, one of which is subovate with strongly rounded epitheca, the other subovate and strikingly truncate anteriorly, should be regarded as unusual in our material and may belong to two hitherto undescribed species, closely related to *D. uracantha*. In the specimen represented by Figure 35: 2 the marginal ribs of the posterior sail may have been overlooked.

The specimen figured by Jörgensen (1923, fig. 42) under the name of *Dinophysis uracantha* undoubtedly is correctly determined. It differs from the type mainly in the following respects: the body is less regularly subcircular, its dorsal margin being decidedly flatter than the ventral; the base of the anterior cingular list, or in other words the epitheca, is somewhat deeper; the posterior cingular list is wider. The difference in the width of the posterior cingular list may be apparent, since in Stein's (1883) iconography almost all drawings of species of Dinophysis are characterized by the extreme narrowness of this list.

The structurally closest-known relative of *Dinophysis uracantha* is *D. urceolus,* from which it is easily recognized by its more regularly shaped body (see the latter species, the section on comparisons). Next to *D. urceolus, D. hastata* appears to be most closely related to *D. uracantha* (see *D. hastata,* the section on comparisons). According to Jörgensen (1923, p. 33), *D. pusilla* may be a degenerate form of *D. uracantha.* The former species resembles the latter in its small size and in the subcircular shape of its body; on the other hand, the posteroventral position of its posterior sail is suggestive of a closer relationship to *D. hastata* (see also *D. monacantha,* the section on comparisons).

Synonymy: — This species was established by Stein (1883, pl. 20, fig. 22, 23), who figured it under the name of *Dinophysis uracantha.* Later it was described and figured under the same name by Jörgensen (1923, p. 32, fig. 42) and Pavillard (1923a, fig. 2B). Lebour (1923, fig. 20g) published a reproduction of Jörgensen's (1923) figure.

The specimens referred to *Dinophysis uracantha* by Schütt (1895, pl. 2, fig. 9: 1–5) were assigned to a new species, *D. schütti,* by Murray and Whitting (1899, p. 331). The specimen represented by Jörgensen's (1923) figure 42 is, in our opinion, a fairly typical *D. uracantha. D. uracantha* var. *mediterranea* Jörgensen (1923, fig. 43), on the other hand, probably represents *D. hastata,* since its body is fairly elongated and somewhat deflected posteroventrally, and since its posterior sail is located ventrally to the antapex and is supported by a central rib and not by marginal ribs. The specimen figured by Jörgensen (1923, fig. 40) under the name of *D. hastata* f. *uracanthides* and the one represented by our Figure 32: 12 occupy an intermediate position between *D. hastata* and *D. uracantha,* and their allocation to the former species should be regarded as tentative. The elongation of the body of these specimens and the posteroventral position of the posterior sail are suggestive of *D. hastata,* while the fact that the posterior sail is supported by marginal ribs and not by a central rib indicates a close relationship to *D. uracantha.* Furthermore, the longitudinal axis of the body is about perpendicular to the girdle, while in typical *D. hastata* and *D. uracantha* it is inclined posteroventrally and posterodorsally, respectively.

Jörgensen (1923, p. 33) writes: "The species *Dinophysis uracantha* was first recorded from the Mediterranean by Schröder, 1900 (from Naples, he does not mention the far more frequent form *D. hastata,* so that his note perhaps applies to the larger and similar *D. hastata* var. *uracanthides* . . .)." This suggestion, of course, is without foundation, since Schröder (1900a) recorded neither *D. uracantha* nor *D. hastata* from Naples. *D. uracantha* is mentioned only once by

Schröder (1900a, p. 35), and then as an example of a warm-water species of Dinophysis.

Occurrence: — *Dinophysis uracantha* is recorded at twenty-nine of the 127 stations. There are 4, 6, 3, 5, 10, and 1 stations on the six lines of the Expedition. Of these twenty-nine stations, four (4588, 4590, 4592, 4605) are in the Mexican Current; two (4637, 4638) are in the Panamic Area; five (4647, 4648, 4659, 4671, 4676) are in the Peruvian Current; three (4691, 4697, 4699) are in the Easter Island Eddy; and fifteen (4679, 4701, 4705, 4711, 4717, 4719, 4721, 4722, 4724,

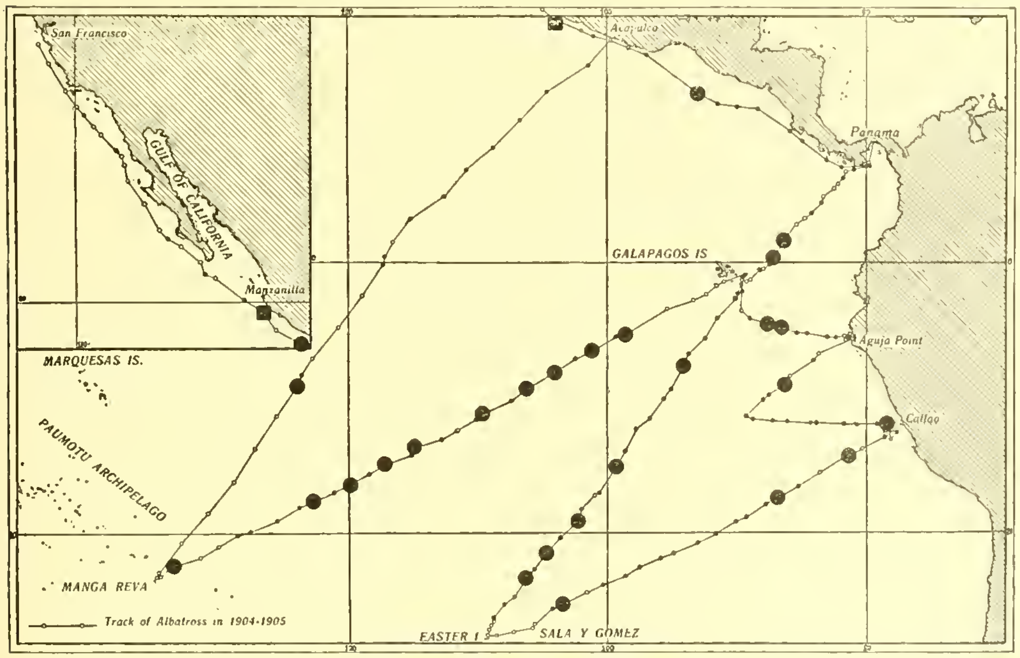

FIGURE 36.— Occurrence of *Dinophysis uracantha* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4728, 4730, 4732, 4734, 4739, 4740) are in the South Equatorial Drift. There are two records from the surface (Stations 4588 [Salpa], 4592); at both these stations the species was taken in surface catches only. At one station (4647) the species was found only in a catch from 800–0 fathoms; and at one station (4724) in a catch from 300–0 fathoms as well as in one from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these twenty-nine stations at the surface was 66°–85°; the average was 75.7°. At the two surface stations the surface temperature was 82° and 84°, respectively.

At eight stations (4590, 4592, 4638, 4648, 4671, 4679, 4722, 4740) the frequency is 1%; at the remaining ones it is less.

The specimens figured by Stein (1883) were "aus der Südsee." Murray and Whitting (1899) recorded this species from a great number of localities in the Atlantic, between lat. 18° N. and lat. 43° N., and in the Caribbean Sea; their northernmost localities are situated in the Gulf Stream. Zacharias (1906) found it in the Atlantic, at lat. 12° N., long. 28° W. Hensen (1911) recorded it at several stations in different regions of the Atlantic, viz., in the Irminger Sea, Gulf Stream, Florida Current, Sargasso Sea, Canary Current, North Equatorial Current, Guinea Current, South Equatorial Current, and off the coast of Brazil. Jörgensen (1923) reported it from the west coast of Norway (at Bergen), the Bay of Biscay, the west coast of Portugal, the Bay of Cadiz, the Gulf of Guinea, and the southern Atlantic. In the Mediterranean this species has been found by the following investigators, viz.: at lat. 36° N., long. 5° W., by Cleve (1903b); in the Gulf of Lyons, by Pavillard (1916); and at several stations in different regions of this sea, by Jörgensen (1923). In the Arabian Sea it has been recorded by Ostenfeld and Schmidt (1901) and by Schröder (1906a); in the Indian Ocean by Schröder (1906a) and by Karsten (1907); Karsten found it at three localities between lat. 10° S. and lat. 34° S.

Karsten (1907) reported this species as taken with a closing net between 80 and 60 meters. Most of the remaining records refer to surface hauls.

According to the investigators who have contributed to our knowledge of the distribution of this species, it occurs in waters of the following temperatures and salinities. Murray and Whitting (1899): — temperature, 54°–84°. Cleve (1903b): — temperature, 66°; salinity, 36.45.

Of the authors mentioned in this section only Stein (1883) and Jörgensen (1923) give descriptions or figures by means of which their determinations of this species may be checked. With regard to Jörgensen's (1923) determinations, see the section on synonymy.

This is a eupelagic species, widely distributed in tropical, subtropical, and warm-temperate seas. It has been found as far to the north as in the Irminger Sea and on the west coast of Norway (at Bergen), but is probably a warm-water species, and the specimens found in these relatively cold regions were presumably of southern origin, carried to the north by the Gulf Stream. This supposition is borne out by the fact that this species has never been recorded by the International Council for the Investigation of the Sea. According to our records, it is almost uniformly distributed throughout the area investigated by the Expedition and has its optimum habitat in deeper waters, within the levels of photosynthesis. Its absence from the California Current may be worth emphasis.

Dinophysis urceolus, sp. nov.

Figure 37:1

Diagnosis: — Body rounded subtrapeziform to pitcher-shaped in lateral outline, deepest in or just behind the middle, and 1.13 times longer than deep; longitudinal axis deflected posterodorsally at 10°. Cingular lists inclined anteriorly at only 10°–20°, subequal, about twice as wide as transverse furrow. Left sulcal list 0.73 the length of body; distance between R_1 and R_3 0.58 the length of body; R_2 is 0.21, R_3 is 0.51, the greatest depth of body; margin forms angle of 25°–30° at R_3; posteroventral portion of list recurved; R_3 inclined posteriorly at 50°–55°. With triangular posterior sail somewhat dorsally to midline; its length 0.44 the greatest depth of body and 1.6 the basal width; with marginal ribs but without central rib. Distance between posterior sail and left sulcal list 0.50 the greatest depth of body. Length, 48.5 μ.

Eastern tropical Pacific.

Description: — This is a small species, the body of which is rounded subtrapeziform to pitcher-shaped in lateral outline, and deepest in or just behind the middle. The ratio between the length and the depth of the body is 1.13: 1. The longitudinal axis is deflected posterodorsally at about 10°.

The epitheca is about 0.53 as deep as the hypotheca, gently concave, highest dorsally, and not visible above the anterior cingular list. The transverse furrow is gently concave and somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.14 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin (from the girdle to the posterior sail) is subuniformly and moderately convex. The ventral margin (from the girdle to the posterior end of the left sulcal list) is subuniformly and gently convex. The postmargin is but slightly convex, inclined dorsoposteriorly at an angle of 15°–20° to a plane parallel to the girdle.

The cingular lists are subequal, about twice as wide as the transverse furrow and 0.25 the greatest depth of the body, and have an anterior inclination of only 10°–20°; their structure is unknown. The right sulcal list extends slightly beyond the fission rib of the left sulcal list, is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is about 0.73 the length of the body; and the distance between the anterior and posterior main ribs is about 0.58 the length of body. The anterior main rib is about 0.21, the fission rib 0.21, and the posterior main rib 0.51 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently undulating, slightly convex anteriorly and posteriorly and slightly concave in the middle. At the posterior main rib this margin forms an angle of about 25°–30°; behind this rib it is moderately concave. The posteroventral portion of this list is recurved. The main ribs are of moderate strength and not club-shaped or otherwise modified; the anterior two are straight, and the posterior has a moderate posterior concavity. The distance between the anterior main rib and the fission rib is about 0.33 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 50°–55°. We do not know whether or not this list has any structural differentiation besides the main ribs. On the right valve there is an acute, triangular posterior sail, which is situated somewhat dorsally to the midline and directed posteriorly and slightly

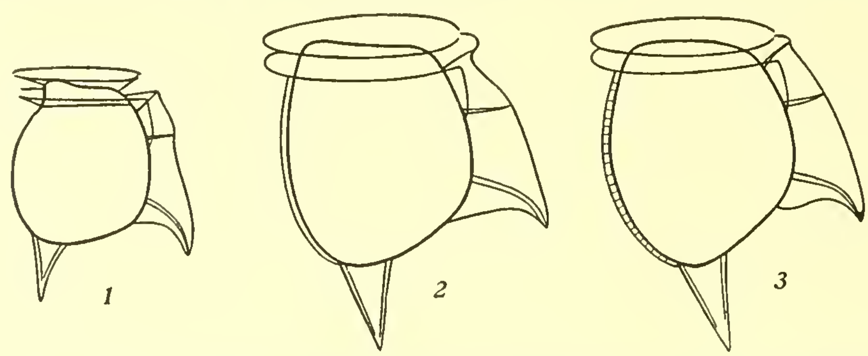

FIGURE 37.— 1, *Dinophysis urceolus*, sp. nov., right lateral view of type specimen. × 430. Station 4681 (300–0 fathoms). 2, 3, *Dinophysis monacantha*, sp. nov., right lateral view. 2, from type specimen. × 430. 2, from Station 4730 (300–0 fathoms); 3, from Station 4691 (300–0 fathoms).

dorsally. The left sulcal list ends at a distance about 0.50 the greatest depth of the body from this sail. When the posterior sail is fully developed, its length is about 0.44 the greatest depth of the body; *i.e.*, it is somewhat shorter than the posterior main rib of the left sulcal list; and it is about 1.6 times longer than it is wide at the base. Its margins are almost straight, and the angle at the tip is about 25°–30°. It is supported by marginal ribs and lacks a central rib. No parasagittal lists are developed.

Megacytic stages have not been recorded.

The dimensions of the type specimen only were measured.

Dimensions: — Length of body, 48.5 μ. Greatest depth of body, 43.0 μ.

Comparisons: — *Dinophysis urceolus* is established on a single outline drawing of a specimen in lateral view found in the material of the Expedition. The shape of the body in dorsoventral view, the structure of the cingular lists and of the theca are unknown, and our knowledge of the structure of the left sulcal list is incomplete.

The species forms structurally a connecting link between *Dinophysis uracantha* and *D. collaris*. It resembles the former species in the small size of the body, in the posterodorsal inclination of the longitudinal axis of the body, in the shape of the left sulcal list, and in the size, structure, and position of the posterior sail. Furthermore, it approaches this species in the anterior inclination of the cingular lists. It recalls *D. collaris* very strikingly in the pitcher-like shape of the body in lateral view. It is easily distinguished from *D. uracantha* by the peculiar pitcher-like shape of the body in lateral view and from *D. collaris* in having only one posterior sail.

Dinophysis monacantha resembles *D. urceolus* in the development of the sulcal lists and of the posterior sail, and in the shape of the ventral and posterior margins of the hypotheca. The latter species is readily distinguished from the former by the smaller size of the body, by the sigmoid shape of the dorsal margin of the body, by the absence of parasagittal lists, and by the fact that the posterior sail is situated somewhat nearer to the dorsal side of the body and is inclined posterodorsally instead of posteroventrally.

Occurrence: — *Dinophysis urceolus* is recorded at only one (4681, the type locality) of the 127 stations, on the third line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, at a surface temperature of 68°. The frequency is less than 1% (one specimen).

Dinophysis monacantha, sp. nov.

Figure 37: 2, 3

Diagnosis: — Body rounded subtrapeziform in lateral outline, deepest in or just behind the middle, and 1.19–1.22 times longer than deep; longitudinal axis perpendicular to girdle or deflected posterodorsally at 1°–3°. Cingular lists subhorizontal, subequal, 2.0–2.5 times wider than transverse furrow. Left sulcal list 0.64–0.69 the length of body; distance between R_1 and R_3 0.50–0.51 the length of body; R_2 is 0.24–0.29, R_3 is 0.45–0.50 the greatest depth of body; margin forms angle of 30° at R_3; posteroventral portion of list recurved; R_3 inclined posteriorly at 30°–40°. With triangular posterior sail located on midline or but slightly displaced dorsally or ventrally; its length is 0.45–0.52 the greatest depth of body and 1.6–2.0 its basal width; with marginal ribs but without central rib. Distance between posterior sail and left sulcal list 0.35–0.37 the greatest depth of body. Along dorsal margin a narrow parasagittal list of subuniform width, extending from posterior cingular list to posterior sail; its average width about half the width of transverse furrow. Length, 68.2–69.7 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, the body of which is subtrapeziform in lateral outline, deepest in or just behind the middle. The ratio between the length and the depth of the body is 1.19–1.22: 1. The longitudinal axis is either perpendicular to the girdle or deflected posterodorsally at about 1°–3°.

The epitheca is 0.64–0.72 as deep as the hypotheca, gently convex, flat or even slightly concave, highest in the middle or dorsally, and visible above the anterior cingular list. The transverse furrow is flat or gently convex, and somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.13–0.16 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin (from the girdle to the posterior sail) is subuniformly and gently to moderately convex. The ventral margin (from the girdle to the posterior end of the left sulcal list) is subuniformly and moderately convex. The postmargin is gently convex or flattened, inclined dorsoposteriorly, forming an angle of 25°–30° to a plane parallel to the girdle, confluent with the ventral margin, and, in some specimens, forms with the dorsal margin a distinct but well-rounded corner.

The cingular lists are subhorizontal and subequal, and 2.0–2.5 times wider than the transverse furrow; their structure is unknown. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is 0.64–0.69 the length of the body, and the distance between the anterior and posterior main ribs is about 0.50–0.51 the length of body. The anterior main rib is 0.20–0.21, the fission rib 0.26 (0.24–0.29), and the posterior main rib 0.47 (0.45–0.50) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently and evenly convex, or it is somewhat concave anteriorly; at the posterior main rib it forms an angle of about 30°, and behind this rib it is gently concave or sigmoid. The posteroventral portion of this list is somewhat recurved. The main ribs are of moderate strength, and not club-shaped or otherwise modified; the two anterior are straight or almost so, and the posterior one has a moderate posterior concavity. The distance between the anterior main rib and the fission rib is 0.38–0.40 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 30°–40°. We do not know whether or not this list has any structural differentiation besides the main ribs. On the right valve there is an acute, triangular posterior sail, which is located on the midline or but slightly displaced dorsally or ventrally and directed somewhat posteroventrally. The left sulcal list ends at a distance from this sail equaling about 0.35–0.37 the greatest depth of the body. When the posterior sail is fully developed, its length is 0.45–0.52 the greatest depth of the body; *i.e.*, it has about the same length as the posterior main rib of the left sulcal list; and it is 1.6–2.0 times longer than its width at the base. Its margins are almost straight, and the angle at the tip is 25°–30°. It is supported by marginal ribs and lacks a central rib. Along the dorsal margin of the body there is a narrow parasagittal list of subuniform width, extending from the posterior cingular list to the posterior sail; its average width is about half the width of the transverse furrow, and at least in some specimens (Figure 37:3) it has a fairly great number of cross-ribs.

Megacytic stages have not been recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 68.2–69.7 μ (type, 68.2 μ). Greatest depth of body, 57.0–57.2 μ (type, 57.2 μ).

Variations: — Judging by the two specimens examined, this species is relatively constant.

Comparisons: — *Dinophysis monacantha* is established on outline drawings of two specimens in lateral view, found in the material of the Expedition. The shape of the body in dorsoventral view, the structure of the cingular lists and of the theca are unknown, and the structure of the left sulcal list needs further examination.

The species combines characteristics of *Dinophysis hastata* and *D. uracantha*. In the elongation and relatively large size of the body, and in the posteroventral inclination of the posterior sail, it approaches *D. hastata;* and in the tendency to develop a posterodorsal rather than a posteroventral inclination of the longitudinal axis of the body and in the structure of the posterior sail, it recalls *D. uracantha*. In the position of the posterior sail, it is intermediate between these two species. It differs from both these species in having a parasagittal list along the dorsal margin of the hypotheca.

It resembles *Dinophysis alata* in having a posterior sail and in having a parasagittal list along the dorsal margin of the hypotheca. It is easily distinguished from this species by the more irregular shape of the body, by the subhorizontal position of the cingular lists, by the narrowness of the parasagittal list, and by the structure of the posterior sail. With regard to the relationships between *D. monacantha*, and *D. urceolus* and *D. trapezium*, see the last two species, the sections on comparisons.

Occurrence: — *Dinophysis monacantha* is recorded at two of the 127 stations. Of these two stations, one (4691) is on the third line of the Expedition and in the Easter Island Eddy; the other (4730), the type locality, is on the fifth line and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 73°–79°, and the frequency less than 1% (one specimen at each station).

Dinophysis trapezium, sp. nov.

Figure 38: 2, 3

Diagnosis: — Body subtrapeziform in lateral outline, protracted posterodorsally, deepest in or just behind the middle, and 1.23–1.31 times longer than deep; longitudinal axis deflected posterodorsally at about 15°. Cingular lists subhorizontal, subequal, and 1.5–2.5 times wider than transverse furrow. Epitheca visible above anterior cingular list. Left sulcal list: distance between R_1 and R_3 about 0.50 the length of body; R_2 is 0.17–0.21, R_3 is 0.56–0.70 the greatest depth of body; margin forms angle of 35°–55° at R_3; R_3 inclined posteriorly at 15°–25°; reticulated; behind R_3 this list has an acute, wedge-shaped accessory lobe, which has a height 0.28–0.32 the greatest depth of body and an angle at the tip of 30°–40°. With triangular posterior sail somewhat dorsally to midline; length is 0.43–0.50 the greatest depth of body; angle at tip 25°–35°; with marginal ribs; sometimes connected with left sulcal list by very narrow list, sometimes unconnected. Length, 65.2–67.5 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, the body of which is subtrapeziform in lateral outline, protracted posterodorsally, and deepest in or just behind the middle. The ratio between the length and the depth of the body is 1.27 (1.23–1.31) : 1. The longitudinal axis is deflected posterodorsally at about 15°.

The epitheca is deep, 0.70–0.72 as deep as hypotheca, flat to slightly convex, highest in the middle or ventrally, and visible above the anterior cingular list. The transverse furrow is flat or gently convex, and about as wide as or somewhat narrower than the greatest height of the epitheca. The posterior cingular list is 0.19–0.22 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin (from the girdle to the posterodorsal sail) is almost straight or subuniformly and gently convex. The ventral margin (from the girdle to a point somewhat behind the posterior main rib of the left sulcal list) is gently to moderately convex. The postmargin is gently to moderately convex, inclined dorsoposteriorly at an angle of 25°–30° to a plane parallel to the girdle, confluent with the ventral margin, and forms with the dorsal margin a distinct but well-rounded corner.

The cingular lists are subhorizontal and subequal, and 1.5–2.5 times wider than the transverse furrow; their structure is unknown. The right sulcal list extends to a point somewhat beyond the fission rib of the left sulcal list; it is either subtriangular, decreasing gradually in width posteriorly, or of subuniform width throughout its anterior half and gently rounded posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is relatively long and strikingly wider posteriorly than anteriorly. The distance between the anterior and posterior main ribs is about 0.50 the length of the body. The anterior main

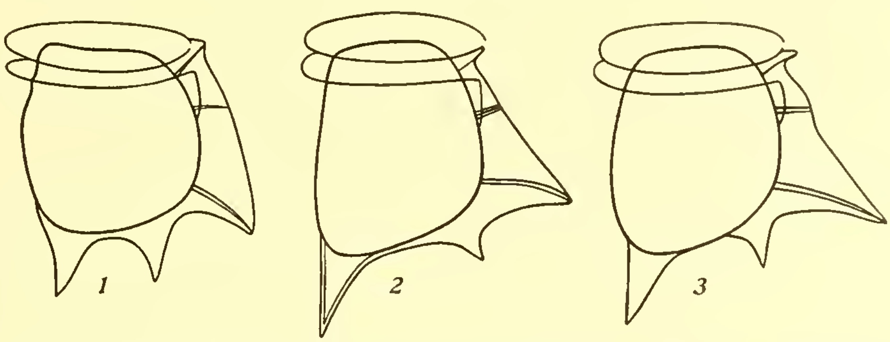

FIGURE 38.— 1, *Dinophysis collaris* Kofoid and Michener, right lateral view. × 430. Station 4711 (300–0 fathoms). 2, 3, *Dinophysis trapezium*, sp. nov., right lateral view. 2, from type specimen. × 430. Station 4709 (300–0 fathoms).

rib is 0.22 (0.20–0.25), the fission rib 0.19 (0.17–0.21), and the posterior main rib 0.63 (0.56–0.70) the greatest depth of the body. Behind the posterior main rib the list decreases suddenly in width. The free margin of this list is almost straight (Figure 38: 2) or slightly irregular (Figure 38: 3) between the anterior and posterior main ribs; at the posterior main rib it forms an angle of 35°–55°; and behind this rib it first is gently concave and then forms an acute, wedge-shaped accessory lobe. This lobe has a height 0.28–0.32 the greatest depth of the body; and the angle at its tip is 30°–40°. The main ribs of this list are of moderate strength and not club-shaped; or the posterior may be slightly club-shaped (Figure 38: 2); the anterior two are straight or almost so, the posterior is slightly to moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.43 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 15°–25°. Besides the main ribs this list has many cross-ribs anastomosing into an irregular reticulum. On the right valve there is an acute, triangular posterior sail, which is located somewhat dorsally to the midline and has a dorsal inclination of 15°–20° to the midline. When this sail is fully developed, its length is 0.43–0.50 the greatest depth of the body; its margins are almost straight, and the angle at its tip is 25°–35°; it is supported by marginal ribs; sometimes it is connected with the left sulcal list by a very narrow list (Figure 38: 2), and sometimes it is unconnected. As far as we know, there are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca. The structure of the theca is unknown.

Megacytic specimens have not been recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 65.2–67.5 μ (average, 66.4 μ; type, 67.5 μ). Greatest depth of body, 51.5–52.8 μ (type, 51.5 μ).

Variations: — The two specimens examined are rather similar. They differ mainly in the shape of the hypotheca viewed laterally, in the relative length of the posterior main rib of the left sulcal list, and in regard to the connection between the posterior sail and the left sulcal list.

Comparisons: — *Dinophysis trapezium* is established on two drawings representing the lateral outlines of two specimens from the material of the Expedition. The shape of the body in dorsoventral view, as well as the structure of the cingular lists and of the thecal wall are unknown. The structure of the left sulcal list and of the posterior sail needs to be further examined.

The species is on the border line between the genera Phalacroma and Dinophysis, and its present generic allocation should be regarded as tentative. Its structurally closest-known relative is *Dinophysis collaris* (see this species, the section on comparisons). Next to *D. collaris, D. monacantha* appears to be its nearest relative. It shows a striking resemblance to the last species in the shape of the body in lateral view, in the position of the cingular lists, and in the size, shape, structure, and position of the posterior sail. *D. trapezium* is easily distinguished from *D. monacantha* in having a parasagittal list along the dorsal margin of the hypotheca and in lacking the accessory lobe behind the posterior main rib of the left sulcal list.

Another species which probably is rather closely related to *Dinophysis trapezium* is *D. swezyi.* This relationship is indicated by the similar shape of the body in lateral view (compare Figure 38: 2, 3, and Figure 39: 2, 3) and by the fact that in both these species the left sulcal list has an accessory lobe behind the posterior main rib. *D. swezyi,* which is a typical representative of its genus, is easily recognized by the anterior inclination of its cingular list, by the shape of its left sulcal list, and by the fact that its posterior sail is supported by a central rib and not by marginal ribs.

Occurrence: — *Dinophysis trapezium* is recorded at only one (4709, the type locality) of the 127 stations, on the fourth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, at a surface temperature of 72°. The frequency is less than 1% (two specimens).

Dinophysis swezyi, sp. nov.

Plate 5, fig. 9. Figure 39

Diagnosis: — Body broadly ovate to rounded subtrapeziform in lateral outline, deepest somewhat behind the middle, 1.12–1.31 times longer than deep; longitudinal axis perpendicular to girdle or deflected posterodorsally at 1°–10°. Cingular lists ribbed, the anterior 2.0–4.0 times wider than transverse furrow. Left sulcal list 0.74–0.83 the length of body; distance between R_1 and R_3 0.55–0.64 the length of body; R_2 is 0.41–0.71, R_3 is 0.73–1.07 the greatest depth of body; margin often strikingly concave just behind R_2 and forms angle of 25°–35° at R_3; R_3 inclined posteriorly at 25°–45° and sometimes club-shaped; behind R_3 this list forms a rounded to subacute accessory lobe, the height of which is 0.25–0.41 the greatest depth of body; between R_2 and R_3 there are a few short basal ribs, and the accessory lobe supported by similar ribs, one of which extends to tip of lobe. With triangular posterior sail, located dorsally to midline, and supported by central rib; its length is 0.69–0.83 the greatest depth of body and 1.9–2.7 its basal width; separated from left sulcal list. Theca reticulate; 11–12 polygons border girdle posteriorly. Length, 47.2–56.4 μ.

Eastern tropical, subtropical, and warm-temperate Pacific.

Description: — This is a medium-sized species, the body of which is broadly ovate to rounded subtrapeziform in lateral outline, and deepest somewhat behind the middle. The ratio between the length and the depth of the body is 1.23 (1.12–1.31): 1. The longitudinal axis is either perpendicular to the girdle or deflected posterodorsally at 8° (1°–10°).

The epitheca is 0.55 (0.50–0.61) as deep as the hypotheca, of moderate to gentle convexity, highest in or somewhat dorsally to the center, and not visible above the anterior cingular list. The transverse furrow is flat or gently convex, and about as wide as or somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.15 (0.11–0.17) the length of the body from the apex. The hypotheca is very variable in shape. Sometimes (Figure 39: 1) it is symmetrical and broadly ovate; its dorsal and ventral margins are of moderate and subuniform convexity or either of them is somewhat flattened anteriorly; its postmargin is broadly and subuniformly convex and confluent with the dorsal and ventral margins. In most specimens, however, it is more or less strikingly asymmetrical; its dorsal margin (from the girdle to the posterior sail) is subuniformly and slightly to gently convex, or (Figure 39: 2) it is more or less bulging posteriorly; its ventral margin (from the girdle to the posterior main rib of the left sulcal list) is gently convex; its postmargin is gently to moderately convex, inclined dorsoposteriorly, forming an angle of 25°–35° to a plane parallel to the girdle, confluent with the ventral margin, and forms with the dorsal margin a fairly distinct but well-rounded corner.

The anterior cingular list is 2.8 (2.0–4.0) times wider than the transverse furrow and 0.30–0.33 the greatest depth of the body; it is inclined anteriorly at 20°–30° and has, on each valve, about 13–14 simple, straight, and almost equidistant ribs. The posterior cingular list resembles the anterior but in some specimens it is somewhat narrower or somewhat less inclined anteriorly. The right sulcal list is rather variable; it extends to or somewhat beyond the fission rib of the left sulcal list; sometimes (Figure 39: 3) it is subtriangular, decreasing gradually in width posteriorly; sometimes it is of subuniform width throughout the greater portion of its length and rounded to angular (Plate 5, fig. 9) posteriorly; anteriorly it is about as wide as or somewhat wider than the transverse furrow. The left sulcal list is large. Its length is 0.79 (0.74–0.83) the length of the body, and the distance between the anterior and posterior main ribs is 0.59 (0.55–0.64) the length of the body. The anterior main rib is 0.25 (0.21–0.29), the fission rib 0.59 (0.41–0.71), and the posterior main rib 0.89 (0.73–1.07) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib the free margin of this list is almost straight or slightly concave, convex, or sigmoid; between the fission rib and the posterior main rib it is concave, and the concavity usually is very striking just behind the fission rib. At the posterior main rib this margin forms an angle of 28° (25°–35°), and behind this rib it first is gently concave and then forms a more or less narrowly rounded to subacute accessory lobe, the height of which is 0.32 (0.25–0.41) the greatest depth of the body. The main ribs are of moderate strength, and the fission rib and the posterior main rib sometimes are club-shaped. The anterior main rib is straight or nearly so; the fission rib and the posterior main rib usually are gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.48 (0.45–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 36°

(25°–45°). Between the fission rib and the posterior main rib there are a few (about three) short ribs, and the posterior accessory lobe is supported by similar ribs, one of which extends to the tip of the lobe (Plate 5, fig. 9). On the right valve there is an acute posterior sail, situated somewhat dorsally to the midline, and supported by a central rib, which is gently concave ventrally and which may be club-shaped (Figure 39: 2) or split lengthwise (Plate 5, fig. 9). When this sail is fully developed, its length is 0.75 (0.69–0.83) the greatest depth of the body and 2.3 (1.9–2.7) its basal width; except for the central rib it lacks structural differentiation, and it is separated from the left sulcal list by a distance equaling 0.34 (0.27–0.42) the greatest depth of the body. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca. The thecal wall is reticulate and porulate. About 11–12 polygons border the girdle posteriorly. In the girdle there are two rows of meshes.

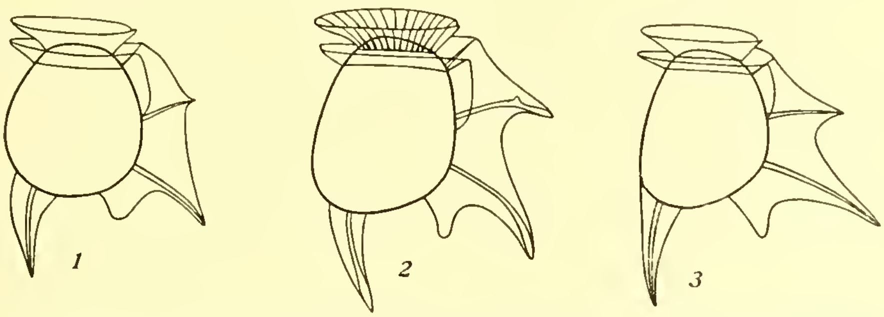

FIGURE 39.— *Dinophysis swezyi*, sp. nov., right lateral view. × 430. 1, from Station 4679 (300–0 fathoms); 2, from Station 4638 (300–0 fathoms); 3, from Station 4732 (300–0 fathoms).

Megacytic stages have not been reported.

The dimensions of three specimens from the material of the Expedition and of the type specimen were measured.

This species is named for Dr. Olive Swezy, the collaborator with the senior author in the preparation of "The Free-living Unarmored Dinoflagellata," who during her investigations on the dinoflagellates of the San Diego region made our drawing of the type specimen (Plate 5, fig. 9) as well as sketches of several other specimens of this species.

Dimensions: — Length of body, 47.2–56.4 μ (average, 52.1 μ; type, 55.0 μ). Greatest depth of body, 39.2–44.8 μ (average, 42.3 μ; type, 44.8 μ).

Variations: — This species is rather constant except in the shape of the body in lateral view and in the shape of the free margin of the left sulcal list between the fission rib and the posterior main rib, in which respects it is strikingly variable. The body usually is more or less asymmetrical, rounded subtrapeziform, and protracted posterodorsally, but sometimes (Figure 39: 1) it is symmetrical and broadly ovate. The margin of the left sulcal list between the fission rib and the posterior main rib usually is deeply concave just behind the fission rib, but sometimes (Figure 39: 1) it is gently and subuniformly concave. Other characters exhibiting variations are: the shape and size of the right sulcal list, the shape and relative length of the fission rib and of the posterior main rib of the left sulcal list and of the central rib of the posterior sail; and the shape of the accessory lobe of the left sulcal list. The specimen represented by Figure 39: 1, may be specifically different from the other specimens assigned to this species.

Comparisons: — This species is rather closely related to *Dinophysis trapezium* and *D. schütti.* Its relationship to *D. trapezium* is indicated by the shape of the body in lateral view (compare Figure 39: 2, 3, and Figure 38 : 2, 3) and by the fact that in both these species the left sulcal list has an accessory lobe behind the posterior main rib. Its relationship to *D. schütti* is suggested by the shape of the body in lateral view (compare Figure 39: 2, 3, and Figure 40: 3, 5), by the shape of the ventral margin of the left sulcal list, and by the shape, structure, and relative size of the posterior sail. *D. swezyi* is easily distinguished from *D. trapezium* by the shape of the ventral margin of its left sulcal list, by the anterior inclination of its cingular lists, and by its posterior sail being supported by a central rib and not by marginal ribs. It differs from *D. schütti* especially in having the left sulcal list with an accessory lobe behind the posterior main rib.

Occurrence: — *Dinophysis swezyi* is recorded at four of the 127 stations. There are 0, 1, 1, 0, 2, and 0 stations on the six lines of the Expedition. Of these four stations, one (4638) is in the Panamic Area; and three (4679, 4732, 4737) are in the South Equatorial Drift. At one of these stations (4737) the species was taken in a haul from 100–0 fathoms. All the other records refer to hauls from 300–0 fathoms.

The temperature range of these four stations at the surface was 69.0°–81.5°; the average was 76.1°.

The frequency is in every case less than 1%.

The type specimen (Plate 5, fig. 9) was taken at San Diego, California, where this species has been found on several occasions.

Dinophysis collaris Kofoid and Michener

Plate 5, fig. 2, 8. Figure 38: 1

Dinophysis collaris Kofoid & Michener, 1911, p. 292.

Diagnosis: — Body rounded trapeziform in lateral outline, deepest in the middle, 1.05–1.07 times longer than deep; longitudinal axis deflected posterodorsally at 10°–15°. In dorsal view about three times longer than wide, widest at girdle, with almost straight side contours and rounded apices. Cingular lists subhorizontal, subequal, 1.5–2.5 times wider than transverse furrow, and ribbed. Epitheca visible above anterior cingular list. Left sulcal list: distance between R_1 and R_3, 0.55–0.59 the length of body; R_2 is 0.21–0.22, R_3 is 0.39–0.43 the greatest depth of body; margin forms angle of 35°–65° at R_3; R_3 inclined posteriorly at 30°–40°; reticulated. Two parasagittal lists encircle hypotheca. The left is of subuniform width throughout, 0.5 as wide as transverse furrow. The right continues left sulcal list and forms two subequal, acute, wedge-shaped posterior sails, one on each side of midline, both with irregularly anastomosing ribs; length of sails somewhat less than R_3; angles at their tips 30°–50°; width of list between sails and between ventral sail and R_3 subequal to width of transverse furrow or less. Theca reticulate; 25–30 polygons border girdle posteriorly. Length, 58.0–67.0 μ.

Eastern tropical and subtropical Pacific.

Description: — This is a medium-sized species, the body of which is rounded trapeziform in lateral outline, and deepest near the middle. The ratio between the length and the depth of the body is 1.05–1.07 : 1. The longitudinal axis is deflected posterodorsally at 10°–15°.

The epitheca is very deep, 0.73–0.74 as deep as the hypotheca, flat or even gently concave, highest dorsally, and visible above the anterior cingular list. The transverse furrow is flat or gently concave, and about as wide as or slightly wider than the greatest height of the epitheca. The posterior cingular list is 0.17–0.21 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin is sigmoid, being slightly to moderately concave anteriorly, gently to moderately convex in the middle, and more or less flattened posteriorly. The ventral margin (from the girdle to the posterior end of the left sulcal list) is subuniformly, and gently to moderately convex. The postmargin is gently to moderately convex and is inclined dorsoposteriorly, forming an angle of about 10°–25° to a plane parallel to the girdle. In dorsoventral view the body is bilaterally compressed, widest at the girdle, about three times longer than wide, with almost straight side contours, and with rounded apices.

The anterior cingular list is 1.5–2.5 times wider than the transverse furrow and 0.17–0.22 the greatest depth of the body; usually it is subhorizontal, but sometimes it has an anterior inclination of about 10°–20°; on each valve it has 15–20 simple, straight, and almost equidistant ribs. The posterior cingular list may be somewhat narrower than but usually it is about as wide as the anterior; it is subhorizontal and has about the same ribbing as the anterior. The sulcus is about 0.40–0.45 as long as the hypotheca. The flagellar pore is located at a distance from the girdle subequal to the width of the transverse furrow. The right sulcal list extends to a point somewhat beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is of moderate width and rather long. The distance between the anterior and posterior main ribs is 0.55–0.59 the length of the body. The anterior main rib is 0.19–0.24, the fission rib 0.21–0.22, and the posterior main rib 0.39–0.43 the greatest depth of the body. Behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight, or gently to moderately convex; the convexity is either subuniform or somewhat irregular (Plate 5, fig. 2). At the posterior main rib this margin forms an angle of 35°–65°; behind this rib it is gently concave. The main ribs of this list are of moderate strength and not club-shaped; the anterior two are straight or almost so, the posterior, which sometimes is branched (Plate 5, fig. 2), is slightly to moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.33 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 30°–40°. Besides the main ribs this list has many cross-ribs anastomosing into a very irregular reticulum. The epitheca has no accessory lists. The hypotheca, on the other hand, has two parasagittal lists, which sometimes are limited to the postmargin (Figure 38: 1), but usually continue to the posterior cingular list. The left one of these lists is of subuniform width throughout, and its average width is about half the width of the transverse furrow; sometimes it has no distinct structural differentiation, sometimes it has a few cross-ribs. The right, which forms a direct continuation of the left sulcal list, resembles the left but is characterized by two subequal, acute, wedge-shaped posterior sails, one on either side of the midline, and both furnished with irregularly anastomosing ribs. The length of the dorsal sail is 0.31 (0.25–0.37), that of the ventral sail 0.31 (0.27–0.35) the greatest depth of the body; in other words, these sails are somewhat shorter than the posterior main rib of the left sulcal list. The angles at their tips are about 30°–50°. The width of the right parasagittal list, between the left sulcal list and the ventral sail and between the two sails, is subequal to the width of the transverse furrow or less.

The surface of the theca is uniformly covered with small, irregular polygons of heavy mesh. On each valve about 25–30 polygons border the girdle posteriorly. In the transverse furrow there are two rows of polygons, each row with 15–25 polygons on each valve.

Megacytic specimens have not been recorded.

The dimensions of two of our specimens were measured.

Dimensions: — Length of body, 58.0–67.0 μ (average, 62.5 μ; type, 67.0 μ, not 58 μ, as stated in the original description). Greatest depth of body, 55.4–62.5 μ (average, 58.9 μ; type, 62.5 μ, not 55 μ, as stated in the original description).

Variations: — Judging by the few specimens examined, this species appears to be rather constant. The most variable character is the extension of the parasagittal lists. Sometimes these lists are limited to the postmargin of the body, sometimes they continue along the whole dorsal margin of the hypotheca to the posterior cingular list. These variations presumably are related to skeletal reorganization consequent upon binary fission.

Comparisons: — Our description and figures of *Dinophysis collaris* are based on the type material.

The generic assignment of this species is uncertain, and its present allocation should be regarded as tentative. The great relative depth of the epitheca, the subhorizontal position of the cingular lists, the ribbing of the posterior cingular list, the presence of parasagittal lists on the dorsal side of the hypotheca, and the reticulation of the thecal wall affiliate it with Phalacroma. On the other hand, the posterodorsal inclination of the longitudinal axis of the body, the shortness of the epitheca, the shape of the hypotheca in lateral view, and the great width of the cingular lists suggest relationship to Dinophysis. Two posterior sails are to be found in Dinophysis as well as in Phalacroma. The species shows that the separation of these two genera is almost arbitrary.

The structurally closest-known relative of *Dinophysis collaris* is *D. trapezium*. The former species differs from the latter mainly in the less-pronounced trapeziform shape of its body, in having its body less protracted posterodorsally, in the shorter posterior main rib of its left sulcal list, in the subequal size of its two posterior sails, and in having these sails supported by irregularly anastomosing ribs (see also *D. trapezium*, the section on comparisons).

Another close relative of *Dinophysis collaris* is *D. urceolus*. This relationship is indicated by the almost complete agreement in the lateral shape of body in these two species. The latter species, which is a rather typical representative of Dinophysis, is easily distinguished from the former by having only one posterior sail, viz., the one situated dorsally to the midline of the body.

Among the species of Phalacroma, *P. bipartitum* resembles *Dinophysis collaris* in the structural differentiation of the parasagittal list of the right valve. *Dinophysis collaris* is easily distinguished from *Phalacroma bipartitum* by the rather irregular shape of its body, by its much lower epitheca, and by its larger and more differentiated cingular and sulcal lists.

Occurrence: — This species is recorded at six of the 127 stations. There are 0, 1, 2, 2, 1, and 0 stations on the six lines of the Expedition. Of these six stations one (4671) is in the Peruvian Current; one (4713) is in the Galapagos Eddy; and four (4679, 4681, 4711, 4730) are in the South Equatorial Drift. All the records refer to catches from 300–0 fathoms.

The temperature range of these six stations at the surface was 66°–79°; the average was 71.7°.

The frequency in every case is less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) at Station 4671 of the Expedition, which thus is the type locality.

The prevalence of this species in the Peruvian Current and in the regions directly influenced by this current, as well as its absence from the California Current, the Mexican Current, and the Panamic Area may be noteworthy.

Dinophysis schütti Murray and Whitting

Figure 40, 41

Dinophysis schuettii Murray & Whitting, 1899, p. 331, tab. 8, pl. 31, fig. 10. Lemmermann, 1899a, p. 373; 1901a, p. 375. Ostenfeld, 1900, p. 56, tab. 2. Cleve, 1901a, p. 15. Kofoid, 1907a, p. 196. Karsten, 1907, p. 421, 473. Paulsen, 1908, p. 12, 18, fig. 19. Nathansohn, 1908, p. 604; 1909, p. 46. Meunier, 1910, p. 58. Pavillard, 1916, p. 60. Jörgensen, 1923, p. 34, 44, fig. 46.
Dinophysis uracantha Schütt (*non* Stein), 1895, p. 16, 17, pl. 2, fig. 9.
Dinophysis schuettii var. *uracanthoides* Forti & Issel, 1924, p. 6, fig. 2.

Diagnosis: — Body subovate to subellipsoidal in lateral outline, deepest near the middle; length: depth, 1.09–1.23: 1; longitudinal axis deflected posterodorsally at 0°–6°. In dorsal view rather narrowly ellipsoidal, 1.45 times longer than wide. Anterior cingular list 2.0–3.0 times wider than transverse furrow. Left sulcal list 0.68–0.84 the length of the body; distance between R_1 and R_3 0.58–0.68 the length of body; R_2 is 0.85–1.25, R_3 is 0.89–1.33 the greatest depth of body; margin strongly concave between R_2 and R_3 and forms angle of 5°–15° at R_3; R_3 inclined posteriorly at angle of 30°–55°; R_2 and R_3 often club-shaped; sometimes slightly reticulated. With triangular posterior sail located somewhat dorsally to midline; its length is 0.81–1.35 the greatest depth of body and 1.7–4.0 its basal width; supported by central rib, which often is club-shaped distally and sometimes bifurcate or trifurcate proximally; separated from left sulcal list. Theca finely and closely areolate. Length, 29.6–62.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a small to medium-sized species, the body of which is subovate to subellipsoidal in lateral outline and deepest near the middle. The ratio between the length and the depth of the body is 1.09–1.23: 1; in our specimens this ratio is 1.21 (1.19–1.23): 1; in the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923) it varies between 1.09: 1 and 1.11: 1. The longitudinal axis either is perpendicular to the transverse furrow, as in our Figure 40: 1, 6, or it is deflected posterodorsally at an angle of 2° (1°–6°).

The epitheca is 0.30–0.50 as deep as the hypotheca, moderately to rather strongly convex, highest in or just dorsally to the center, and not visible above the anterior cingular list. The transverse furrow is flat or gently convex, and in most specimens about 2.0–3.0 times wider than the greatest height of the epitheca. The posterior cingular list is 0.15 (0.13–0.17) the length of the body from the apex. The hypotheca sometimes is symmetrical, as in Figure 40: 1, 6, but usually it has a slight posterodorsal inclination (see above). The dorsal margin (from the girdle to the antapex) sometimes is subuniformly and moderately to gently convex, and sometimes (Figure 40: 5) it is flattened anteriorly and boldly convex posteriorly. The ventral margin (from the girdle to the antapex) is subuniformly and moderately to rather strongly convex, or it is somewhat flattened posteriorly (Figure 40: 5); its curvature either is about the same as that of the dorsal margin, or it is more pronounced, in which case the body appears to be flattened dorsally (Figure 40: 3). The apices sometimes are of about the same depth, but usually the body is distinctly deeper posteriorly than anteriorly. In dorsoventral view the body is rather narrowly ellipsoidal, widest in the middle, about 1.45 times longer than wide, and with the apices well rounded and of about the same width.

The anterior cingular list is 2.0–3.0 times wider than the transverse furrow and 0.30–0.50 the greatest depth of the body; it has a well-developed funnel-shape, being inclined anteriorly at 20°–40°, and, on each valve, is furnished with about ten to twenty simple, straight, and almost equidistant ribs, some of which may be incomplete. The posterior cingular list may be about as wide as the anterior, but usually it is somewhat narrower; its inclination usually is about the same as that of the anterior, and it appears always to lack structural differentiation. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly, or of subuniform width throughout the greater part of its length and rounded posteriorly; anteriorly it is about as wide as or somewhat wider than the transverse furrow. The left sulcal list is unusually large, with very long fission rib and posterior main rib. Its length is 0.74 (0.68–0.84) the length of the body, and the distance between the anterior and posterior main ribs is 0.63 (0.58–0.68) the length of the body. The anterior main rib is 0.34 (0.27–0.42), the fission rib 1.04 (0.85–1.25), and the posterior main rib 1.07 (0.89–1.33) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. The ventral margin of this list sometimes (Figure 40: 2, 4) extends to the tips of the fission rib and the posterior main rib, but usually it terminates at some distance from the tips, and the distal portions of these two ribs are free; the length of the free portions may even slightly exceed half the length of these ribs. Between the anterior main rib and the fission rib the margin is almost straight or gently concave; between the fission rib and the posterior main rib it is strongly concave; at the posterior main rib it forms an angle of 9° (5°–15°), and behind this rib it is gently to moderately concave or almost straight. The main ribs of this list sometimes are straight, sometimes the fission rib and the posterior main rib are concave posteriorly; the two last ribs frequently are club-shaped distally. The distance between the anterior main rib and the fission rib is 0.43 (0.33–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 47° (30°–55°). Besides the three main ribs this list sometimes has a slight indication of reticulation (Schütt, 1895, pl. 2, fig. 9: 3). On the right valve there is an acute, triangular posterior sail, which is situated somewhat dorsally to the midline and usually directed posterodorsally at an angle of about 10°. The left sulcal list ends at a distance from the posterior sail equaling 0.51 (0.42–0.61) the greatest depth of the body. When the posterior sail is fully developed, its length is 1.00 (0.81–1.35) the greatest depth of the body; *i.e.*, its average length is subequal to that of the posterior main rib of the left sulcal list; and it is 2.9 (1.7–4.0) times longer than it is wide at the base. Sometimes both its margins are almost straight or slightly concave, but usually its dorsal margin is gently convex and its ventral margin gently concave; the angle at its tip is about the same as that at the tip of the posterior main rib of the left sulcal list. The posterior sail is supported by a central rib. This rib, which frequently is club-shaped distally, sometimes is straight and sometimes gently concave ventrally; in some specimens its base is bifurcate or trifurcate; sometimes the sail extends to the tip of this rib, sometimes it terminates at some distance from the tip, and the distal portion of the rib is free; the length of the free portion, which is variable, may exceed half the length of the rib. No parasagittal lists are developed. The thecal wall is finely and closely areolate and has scattered pores

(Schütt, 1895, pl. 2, fig. 9: 3). According to Schütt (1895, p. 64), this species lacks chromatophores.

Megacytic stages have not been recorded.

The dimensions of eight of our specimens and of the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923) were measured.

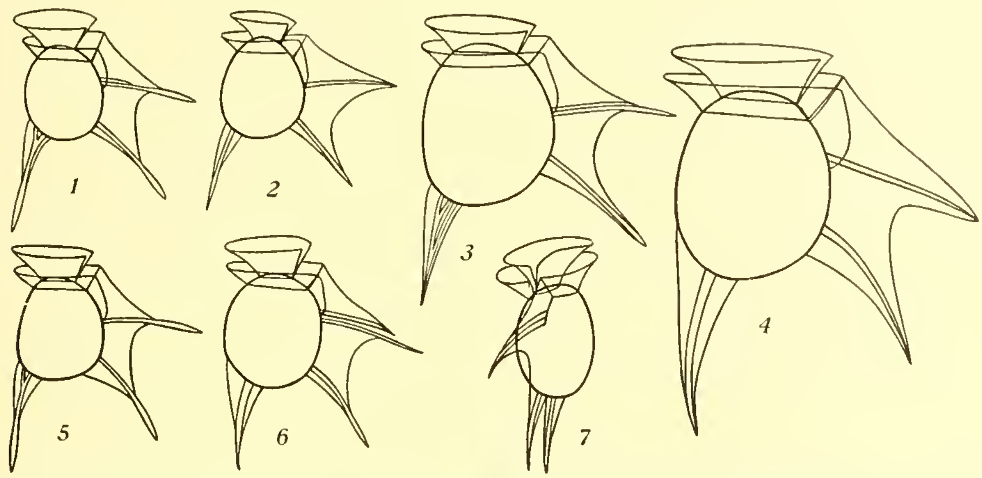

FIGURE 40.— *Dinophysis schütti* Murray and Whitting, all, except 7, in right-lateral view; 7, in ventral view; 6 and 7, from the same specimen. × 430. 1, from Station 4730 (300–0 fathoms); 2, from Station 4732 (300–0 fathoms); 3, from Station 4697 (300–0 fathoms); 4, 6, 7, from Station 4679 (300–0 fathoms); 5, from Station 4701 (300–0 fathoms).

Dimensions: — Four of our large specimens: Length of body, 49.8–57.7 μ (average, 52.6 μ). Greatest depth of body, 40.5–47.8 μ (average, 43.2 μ). Four of our small specimens: Length of body, 29.6–35.5 μ (average, 32.2 μ). Greatest depth of body, 24.7–29.1 μ (average, 27.7 μ). The specimen represented by Schütt's (1895) Plate 2, figure 9: 1, was 45.3 μ long and 41.4 μ deep. The type specimen, as figured by Murray and Whitting (1899, pl. 31, fig. 10), was 37.5 μ long and 34.1 μ deep. The specimens measured by Jörgensen (1923) formed two size classes, the larger specimens being 54–62 μ long and 45–47 μ deep, the smaller 40–43 μ long and 32–36 μ deep.

Variations: — *Dinophysis schütti,* as conceived in this paper, is rather strikingly variable, and a future subdivision of this species is not excluded. The following characters are the most variable: — the size of the body, the shape of the hypotheca, the width of the cingular lists, the shape of the left sulcal list and the shape and relative lengths of its ribs, and the structure of the midrib of the posterior sail.

Comparisons: — Jörgensen (1923, p. 34) writes about this species as follows: "It occurs in two forms, a larger, 54–62 μ long by 45–47 μ broad, often with downward curving ventral spines, and a smaller, 40–43 μ by 32–36 μ, generally with straight ventral spines." Our specimens of this species also form two distinct size classes: the specimens of the larger class are 52.6 (49.8–57.7) μ long and 43.2 (40.5–47.8) μ deep; the smaller class comprises specimens 32.2 (29.6–35.5) μ long and 27.7 (24.7–29.1) μ deep. The type specimen, figured by Murray and Whitting (1899, pl. 31, fig. 10), is 37.5 μ long and 34.1 μ deep and thus belongs to the small size class. The specimen figured by Schütt (1895, pl. 2, fig. 9: 1) is 45.3 μ long and 41.4 μ deep and should be referred to the larger size class.

Do these size classes represent two different systematic units, or only developmental or cyclic stages of one and the same species? The very marked discontinuity in the size-frequency distribution of Jörgensen's (1923) specimens as well as of those examined by us undoubtedly seems to indicate that these classes are systematically distinct. On the other hand, no correlation has been found between any morphological character and the size of the body. In the following the main results of an attempt to establish a correlation of this kind will be given.

In our large specimens the ratio between the length and the greatest depth of the body is 1.22 (1.21–1.23): 1; in our small specimens, 1.20 (1.19–1.22): 1. In the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923) this ratio varies between 1.09: 1 and 1.11: 1. In other words, in our large specimens this ratio is about the same as in our small specimens, and the difference established has no systematic importance as is shown by a comparison with the corresponding ratio in the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923).

The ratios between the lengths of the three main ribs of the left sulcal list and the greatest depth of the body are to be found in the following table.

	R_1	R_2	R_3
Our large specimens:	0.33 (0.27–0.40)	0.96 (0.85–1.07)	1.06 (1.00–1.10)
Our small specimens:	0.35 (0.31–0.42)	1.17 (1.07–1.25)	1.15 (1.00–1.33)
Schütt (1895, fig. 9: 1):	0.33	0.89	0.89
Murray and Whitting (1899, pl. 31, fig. 10):	0.29	0.87	0.98
Jörgensen (1923, fig. 46):	0.31	0.93	1.08

Our large specimens thus have, on the average, relatively shorter ribs in the left sulcal list than have our small specimens. However, that the difference established has no systematic value is again indicated by a comparison with the corresponding ratios in the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923). For instance, in spite of its small size, the specimen figured by Murray and Whitting (1899) has these ribs comparatively shorter than in our large specimens.

The ratio between the width of the anterior cingular list and the greatest depth of the body, the curvature of the ribs of the left sulcal list (mentioned by Jörgensen, 1923), the shape of the left sulcal list, and other characters exhibiting variations in this species have also been tested in order to establish a morphological difference between the two size classes. In these cases, too, the results were negative. Under these circumstances we have judged it most advisable to accept Jörgensen's (1923) decision; and so we have treated these two size classes as systematically identical.

Dinophysis schütti is structurally closely related to *D. swezyi*, from which it is distinguished mainly by the fact that its left sulcal list lacks an accessory lobe just behind the posterior main rib. Other close relatives of *D. schütti* probably are *D. hastata*, *D. uracantha*, *D. triacantha*, *D. jörgenseni*, and *D. nias*. *D. schütti* is easily distinguished from *D. hastata* and *D. uracantha* by the great length of the fission rib of its left sulcal list and the shape of the ventral margin of this list. From *D. triacantha*, *D. jörgenseni*, and *D. nias*, it is easily distinguished by having only one posterior sail.

Synonymy: — This species was established by Murray and Whitting (1899), who described and figured it under the name of *Dinophysis schüttii*. However, it had been figured previously by Schütt (1895) under the name of *D. uracantha* Stein. Jörgensen (1923) described and figured this species, Paulsen (1908) described it; both used the name *D. schütti*. Paulsen (1908) gave a reproduction of Murray and Whitting's (1899) figure of the type specimen. Murray and Whitting (1899), Paulsen (1908), and Jörgensen (1923) wrote *D. uracantha* Schütt (1895) as a synonym of *D. schütti*. The form described and figured by Forti and Issel (1924) under the name of *D. schuettii* var. *uracanthoides*, is, according to our opinion, not systematically different from the main species but should be regarded as one of the several modifications occurring in this.

According to Jörgensen (1923, p. 34), Ostenfeld's (1900) record of *Dinophysis schütti* from the northern Atlantic "is perhaps due to confusion with some other form (*Dinophysis uracantha*?)." There are no facts available supporting this assumption. Ostenfeld (1900) does not give any figure, but he refers his readers to Murray and Whitting's (1899) Plate 31, figure 10, of *D. schütti*. Under these circumstances we accept Ostenfeld's (1900) assignment and consider the specimen recorded by him as a straggler of southern origin carried to the north by the Gulf Stream.

Occurrence: — *Dinophysis schütti* is recorded at twenty-two of the 127 stations. There are 1, 1, 7, 8, 4, and 1 stations on the six lines of the Expedition. Of these twenty-two stations, one (4587) is in the Mexican Current; two (4652, 4676) are in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; two (4713, 4715) are in the Galapagos Eddy; and twelve (4679, 4681, 4683, 4687, 4701, 4705, 4711, 4722, 4730, 4732, 4736, 4740) are in the South Equatorial Drift. At one of these stations (4676) the species was taken in a surface haul as well as in a haul from 300–0 fathoms; at one station (4652) in a haul from 100–0 fathoms; at one station (4689) in a haul from 800–0 fathoms; at one

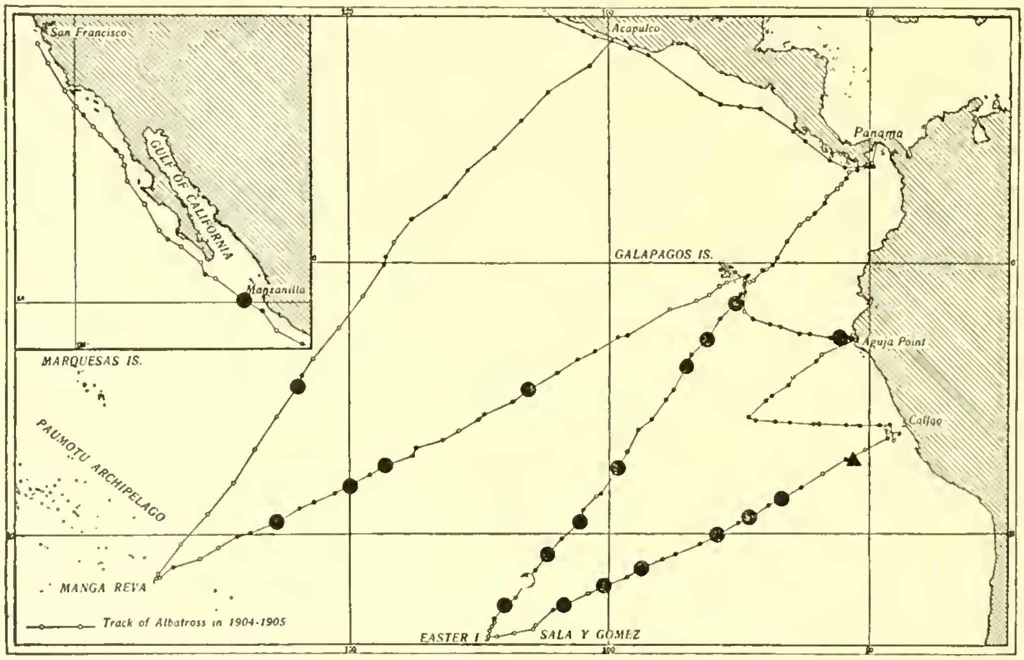

FIGURE 41.— Occurrence of *Dinophysis schütti* Murray and Whitting. Large, solid circles indicate records from vertical hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

station (4681) in hauls from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these twenty-two stations at the surface was 66°–82°; the average was 74.0°. At Station 4676, where the species was taken in a surface haul, the surface temperature was 69°.

The frequency is 2% at one station (4695), 1% at four stations (4681, 4689, 4699, 4701), and less than 1% at the remaining stations.

Schütt (1895), who was the first to treat this species, did not give any information as to the localities of his specimens; however, his material probably was taken either in the tropical or subtropical Atlantic or at Naples. Murray and Whitting (1899) recorded the species from the Sargasso Sea, lat. 29° 20′ N.–31° 20′ N., long. 44° 50′ W.–42° 30′ W. Ostenfeld (1900) found it at lat. 59° 47′ N., long. 25° 53′ W., *i.e.*, about midway between the northern point of Scotland and the southern point of Greenland; Jörgensen (1923), in the Bay of Cadiz. According to Jörgensen (1923, p. 34), the species "occurs in the tropical and subtropical Atlantic, especially south of the equator"; however, there is no information as to what material this statement is founded upon. In the Mediterranean it has been found by the following authors: — in the Gulf of Lyons, by Pavillard (1916); off Monaco, by Nathansohn (1908, 1909); in the Adriatic Sea, by Forti and Issel (1924); and at several stations in different regions of this sea, by Jörgensen (1923). From the Marmora Sea it is reported by Jörgensen (1923), and from the Indian Ocean, at lat. 7°–3° N., long. 73°–86° E., by Cleve (1901a).

Murray and Whitting (1899) recorded a temperature of 67° for this species; Ostenfeld (1900), a temperature of 45.3° and a salinity of 35.21.

Of the authors mentioned in connection with the distribution of this species, only Schütt (1895), Murray and Whitting (1899), Jörgensen (1923), and Forti and Issel (1924) give descriptions or figures by means of which their determinations of this form may be checked.

This is a eupelagic species, widely distributed in tropical, subtropical, and warm-temperate seas. On one occasion it was recorded as far to the north as in the Irminger Sea, but the specimen found in this relatively cold region was presumably a straggler of southern origin, carried to the north by the Gulf Stream. Its distribution in the Eastern Pacific, according to our data, is peculiar in so far as it has never been found in the California Current and in the Panamic Area and only once in the Mexican Current; its relatively frequent occurrence in the Easter Island Eddy is also noteworthy. Its optimum habitat presumably is in deeper waters, within the levels of photosynthesis.

Dinophysis nias Karsten

Figure 42: 1

Dinophysis nias Karsten, 1907, p. 262, 421, 473, 540, pl. 47, fig. 7.
Dinophysis triacantha Karsten, 1907, p. 421, 540, pl. 47, fig. 7.

Diagnosis: — Body subovate in lateral outline, deepest somewhat behind the middle; length: depth, 1.18–1.23: 1; longitudinal axis deflected posteroventrally at 10°–15°. Both cingular lists ribbed; the anterior 3.0 times wider than transverse furrow. Left sulcal list 0.62–0.67 the length of body; distance between R_1 and R_3

0.50–0.53 the length of body; R_2 is 0.25–0.31, R_3 is 0.84–0.92 the greatest depth of body; margin forms angle of 10°–15° at R_3; R_3 inclined posteriorly at 30°. With two acute posterior sails, one on each side of midline, each supported by central rib which may be bifurcate basally. Ventroposterior sail 0.82–0.83 the greatest depth of body in length, 3.0–3.3 times longer than its basal width, and separated from left sulcal list and dorsal posterior sail by distance equaling or somewhat exceeding its basal width. Dorsoposterior sail 0.63–0.78 the greatest depth of body in length and 2.2–3.0 times longer than its basal width. Except for central ribs posterior sails appear to lack structure. Theca finely and closely areolate. Length, 52.2–56.0 μ.

Probably widely distributed in tropical seas.

Description: — This is a medium-sized species, subovate in lateral outline, subtruncate anteriorly, and deepest somewhat behind the middle. The ratio between the length and the depth of the body is 1.18–1.23: 1. The longitudinal axis is deflected posteroventrally at about 10°–15°.

The epitheca is about 0.54 as deep as the hypotheca, gently convex, highest in the center, and not visible above the anterior cingular list. The transverse furrow is flat or gently convex and about twice as wide as the greatest height of the epitheca. The posterior cingular list is about 0.13 the length of the body from the apex. The hypotheca has a rather pronounced posteroventral inclination (see above). The dorsal margin (from the girdle to the antapex) has a subuniform and moderate convexity. The ventral margin (from the girdle to the antapex) is rather strongly convex posteriorly and more or less flattened anteriorly. The posterior end of the body is distinctly deeper than the anterior.

The anterior cingular list is about 3.0 times wider than the transverse furrow and 0.33–0.40 the greatest depth of the body; it is inclined anteriorly at about 40°–50° and has, on each valve, about 11–12 simple, straight, and almost equidistant ribs (Karsten, 1907, pl. 47, fig. 7). The posterior cingular list is about as wide as or somewhat narrower than the anterior, inclined anteriorly at about 40°, and has, on each valve, about 13–14 simple, straight, and nearly equidistant ribs (Karsten, 1907, pl. 47, fig. 7). Judging by Karsten's (1907) figure, the right sulcal list extends to the fission rib of the left sulcal list and is subtriangular, decreasing in width posteriorly. The left sulcal list is strikingly wider posteriorly than anteriorly. Its length is 0.62–0.67 the length of the body, and the distance between the anterior and posterior main ribs is 0.50–0.53 the length of the body. The anterior main rib is 0.22–0.28, the fission rib 0.25–0.31, and the posterior main rib 0.84–0.92 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight or slightly undulating (Karsten, 1907, pl. 47, fig. 7). At the posterior main rib the list is acuminate, and the margin forms an angle of 10°–15°. Behind this rib the margin is moderately convex or sigmoid. The main ribs are of moderate strength and not club-shaped or otherwise modified; the two anterior are straight or almost so, the posterior is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.45–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 30°. Except for the main ribs, this list appears to lack ribs. On the right valve there are two acute posterior sails, one on each side of the midline, each supported by a central rib which is gently concave ventrally and which may be bifurcate basally. The ventroposterior sail is 0.82–0.83 the greatest depth of the body in length, 3.0–3.3 times longer than its basal width, and directed posteroventrally; its ventral margin is gently concave, its dorsal margin gently convex, and the angle at its tip about 10°–15°; it is separated from the left sulcal list and from the dorsal posterior sail by distances equaling or somewhat exceeding its basal width. The dorsoposterior sail is 0.63–0.78 the greatest depth of the body in length, 2.2–3.0 times longer than its basal width, and directed posterodorsally; its ventral margin is gently concave, its dorsal margin gently convex, and the angle at its tip about 15°. With the exception of the central ribs, the posterior sails appear to lack structural differentiation. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca. The thecal wall is finely and closely areolate and has scattered pores. The areoles are of about the same size as the pores.

Megacytic stages have not been recorded.

The dimensions of one specimen from the material of the Expedition and of the type specimen, as figured by Karsten (1907, pl. 47, fig. 7), were measured.

Dimensions: — Our specimen: Length of body, 56.0 μ. Greatest depth of body, 47.2 μ. The type specimen, as figured by Karsten (1907, pl. 47, fig. 7), was about 52.2 μ long and 42.6 μ deep.

Variations: — Judging by the two specimens hitherto figured, one of which was taken off the coast of Sumatra, the other in the eastern tropical Pacific, this species appears to be rather constant.

Comparisons: — The specimen found in the material of the Expedition resembles closely the type specimen, as figured by Karsten (1907). It differs mainly in having the two posterior sails subequal and (possibly) in its somewhat narrower anterior cingular list.

The structurally closest-known relatives of *Dinophysis nias* are *D. triacantha* and *D. jörgenseni* (see the last two species, the sections on comparisons). *D. nias* is easily recognizable by the straight or nearly straight ventral margin of its left sulcal list, and by having its two posterior sails free, *i.e.*, connected neither with each other nor with the left sulcal list.

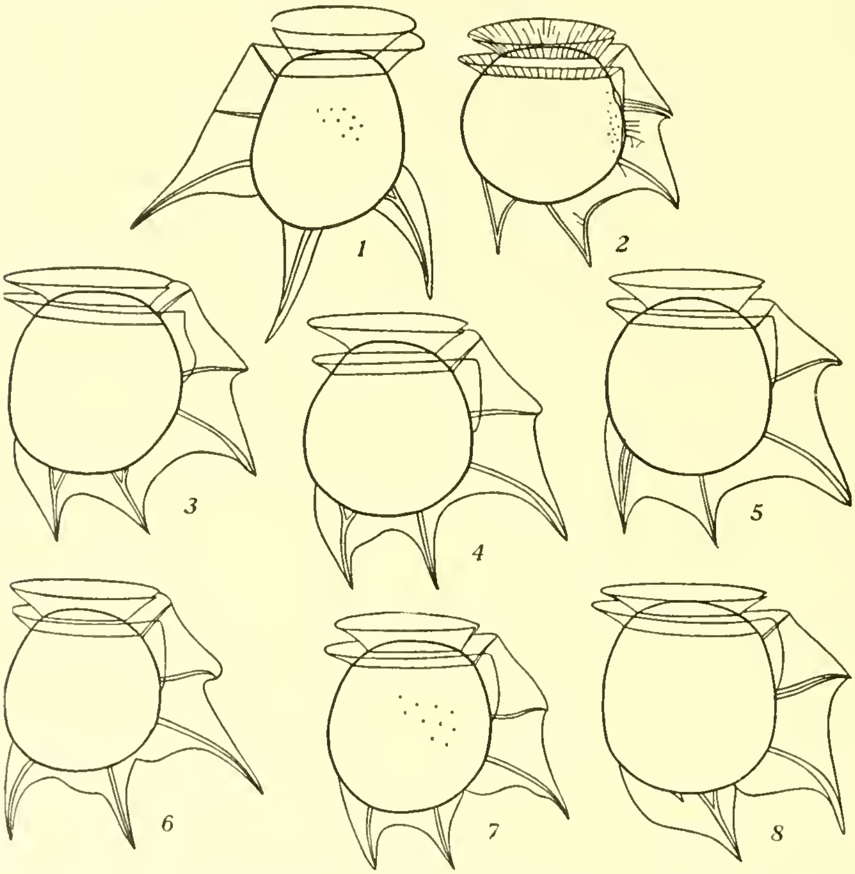

FIGURE 42.— 1, *Dinophysis nias* Karsten, left lateral view; porulation indicated on small portion of thecal wall. × 430. Station 4691 (300–0 fathoms). 2, *Dinophysis triacantha* Kofoid, right lateral view of type specimen. × 430. Station 4722 (300–0 fathoms). 3–8, *Dinophysis jörgenseni*, sp. nov., right lateral view; porulation indicated on small portion of thecal wall in 7. × 430. 3, from Station 4713 (300–0 fathoms); 4, from Station 4609 (300–0 fathoms); 5, from Station 4732 (300–0 fathoms); 6, from Station 4637 (300–0 fathoms); 7, from Station 4709 (300–0 fathoms); 8, from Station 4730 (300–0 fathoms).

Synonymy: — This species was established by Karsten (1907), who described and figured it under the name of *Dinophysis nias.* While his paper was in press, Karsten received Kofoid's (1907a) preliminary report on the dinoflagellates of the Expedition to the Eastern Tropical Pacific. Identifying Kofoid's *D. triacantha* with *D. nias,* Karsten (1907), on page 421 and in the explanation to

Plate 47, wrote the latter name within parenthesis as a synonym of the former. We do not accept this identification but consider these two forms as specifically distinct.

Occurrence: — *Dinophysis nias* is recorded at only one (4691) of the 127 stations, on the third line of the Expedition, in the Easter Island Eddy, from 300–0 fathoms, and at a surface temperature of 73°. The frequency was less than 1% (one specimen).

It was first recorded by Karsten (1907) from the west coast of Sumatra, and probably is widely distributed, but rare, in tropical seas.

Dinophysis jörgenseni, sp. nov.

Plate 5, fig. 3, 7. Figure 42: 3–8, 43

Dinophysis triacantha Jörgensen, 1923, *partim*, p. 34, 43, fig. 47.

Diagnosis: — Body subellipsoidal or subovate in lateral outline, deepest near the middle; length: depth, 0.99–1.08: 1; longitudinal axis perpendicular to girdle or somewhat deflected posterodorsally or posteroventrally. In dorsal view ovate. Anterior cingular list 1.5–2.5 times wider than transverse furrow. Left sulcal list: distance between R_1 and R_3 0.52–0.58 the length of body; R_2 is 0.35–0.43, R_3 is 0.58–0.82 the greatest depth of body; margin often rather strikingly concave just behind R_2 and forms angle of 10°–35° at R_3; R_3 inclined posteriorly at 30°–45° and often club-shaped; usually without accessory structure. With two subequal, acute posterior sails, one on each side of midline, each supported by central rib, which is 0.36–0.55 the greatest depth of body in length and sometimes bifurcate or trifurcate basally; the dorsal usually connected with ventral by list, the minimum width of which is 0.5–1.3 the width of transverse furrow; the ventral usually connected with left sulcal list by similar sail; except for central ribs, posterior sails appear to lack structure. Theca areolate or reticulate. Length, 51.1–58.8 μ.

Widely distributed, but rare, in tropical, subtropical, and warm-temperate seas.

Description: — This is a medium-sized species, the body of which is subellipsoidal to broadly subovate in lateral outline, and deepest in or near the middle. The ratio between the length and the depth of the body is 1.05 (0.99–1.08): 1. The longitudinal axis is sometimes perpendicular to the girdle and sometimes deflected posterodorsally at 3° (1°–15°); seldom it has a slight (1°–3°) posteroventral inclination. The posterodorsal deflection of this axis is unusually pronounced in the type specimen, viz., 15°; in the other specimens examined it does not exceed 5°.

The epitheca is 0.57 (0.53–0.61) as deep as the hypotheca, highest in or near the center, usually evenly and moderately convex, seldom flat (Plate 5, fig. 7), and not visible above the anterior cingular list. The transverse furrow is flat or slightly convex, and about as wide as or more or less decidedly wider than the greatest height of the epitheca. The posterior cingular list is 0.17 (0.11–0.20) the length of the body from the apex. The hypotheca is sometimes subsymmetrical (Figure 42:5), sometimes more or less asymmetrical (Plate 5, fig. 7). The dorsal and ventral margins are moderately to rather strongly convex; sometimes they have about the same shape, but either of them may be somewhat more or less convex than the other; in some specimens their convexity is subuniform, in others (Figure 42:4, 6) they are more or less flattened anteriorly. The postmargin is broadly rounded, sometimes (Plate 5, fig. 7) flattened ventrally, and confluent with the dorsal and ventral margins. The posterior end of the body is either about as deep as the anterior or more or less strikingly deeper. In dorsoventral view the body is ovate, widest somewhat behind the middle, with evenly convex side contours, and with the posterior end somewhat more broadly rounded than the anterior.

The anterior cingular list is 2.1 (1.5–2.5) times wider than the transverse furrow and 0.27 (0.23–0.29) the greatest depth of the body. It has on each valve 14–20 ribs, which usually are simple, straight, and almost equidistant; sometimes some of these ribs are branched (Plate 5, fig. 7) or incomplete (Jörgensen, 1923, fig. 47). The posterior cingular list is either about as wide as or somewhat narrower than the anterior and lacks structural differentiation. Both these lists are funnel-shaped and have an anterior inclination of 30°–40°. The right sulcal list extends to or somewhat beyond the fission rib of the left sulcal list; it is either subtriangular, decreasing gradually in width posteriorly, or of subuniform width throughout the greater portion of its length and more or less well rounded posteriorly; its ventral margin is either straight, gently convex, or sigmoid, concave anteriorly and convex posteriorly. The left sulcal list is large. The distance between the anterior and posterior main ribs is 0.55 (0.52–0.58) the length of the body. The anterior main rib is 0.24 (0.20–0.28), the fission rib 0.40 (0.35–0.43), and the posterior main rib 0.67 (0.58–0.82) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib the free margin of this list is straight or slightly convex, concave, or sigmoid; between the fission rib and the posterior main rib it is concave, and the concavity often is rather striking just behind the fission rib. At the posterior main rib this margin forms an angle of 20° (10°–35°); behind this rib it usually is gently to moderately concave, but sometimes it is sigmoid (Figure 42: 6, 8) or somewhat irregular (Figure 42: 7). The main ribs are of moderate strength, and the posterior is often somewhat club-shaped. The anterior main rib is straight or almost so; the fission rib is straight, gently concave posteriorly, or sigmoid (Plate 5, fig. 7); the posterior main rib is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.51 (0.48–0.60) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 37° (30°–45°). Except for the three main ribs, this list usually lacks structural differentiation, but in some specimens traces of an irregular reticulation may be found; furthermore, in the type specimen (Plate 5, fig. 7) there is an accessory longitudinal rib between the anterior main rib and the fission rib. On the right valve there are two subequal, acute posterior sails, one on each side of the midline, and each supported by a central rib, which may be bifurcate or trifurcate basally and which usually has a gentle ventral concavity. The rib of the ventral of these sails is 0.45 (0.40–0.52), that of the dorsal 0.46 (0.36–0.55) the greatest depth of the body; in other words, these ribs are somewhat shorter than the posterior main rib of the left sulcal list. The angle at the tip of the ventral of these sails is 23° (10°–35°); that at the tip of the dorsal, 25° (10°–40°). In the specimens examined by us the dorsal of these sails is always connected with the ventral by a list, the minimum width of which is 0.5–1.3 the width of the transverse furrow; in the specimen figured by Jörgensen (1923, fig. 47) this connection is broken. The ventroposterior sail usually is connected with the left sulcal list by a list similar to the one between the dorsal and the ventral posterior sails, but this connection too may be broken (Figure 42: 7, 8; Jörgensen, 1923, fig. 47). Except for the central ribs, the posterior sails appear always to lack structural differentiation. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca.

The thecal wall is areolate or reticulate and has scattered pores. The areoles, which are closely set, sometimes are about as small as the pores, and sometimes (Plate 5, fig. 7) they widen into polygonate meshes. The areoles and the polygonate meshes grow fainter toward the margins of the valves, and at least sometimes they are lacking on the epitheca, in the transverse furrow, and along the dorsal, posterior, and ventral margins of the hypotheca (Plate 5, fig. 7). In the transverse furrow two rows of pores are present.

Megacytic stages have not been recorded.

The dimensions of eight of our specimens and of the specimen figured by Jörgensen (1923, fig. 47) were measured.

Dimensions: — Our specimens: Length of body, 51.1–58.8 μ (average, 55.0 μ; type, 54.8 μ). Greatest depth of body, 48.6–56.2 μ (average, 52.7 μ; type, 53.5 μ). The specimen figured by Jörgensen (1923, fig. 47) was about 52.9 μ long and 50.0 μ deep.

Variations: — As conceived in the present paper, this species is rather variable. The most variable characters are as follows: — the shape and structure of the body, the shape of the ventral margin of the left sulcal list, the structure of the central ribs of the two posterior sails, and the development of the lists between the posterior sails and between the ventral posterior sail and the left sulcal list.

Comparisons: — Although fairly variable in several respects, *Dinophysis jörgenseni* is so uniform in size and structure that its systematic unity hardly can be doubted. The allocation of only one of our specimens is questionable. In this specimen (Figure 42: 8) the dorsoposterior sail is indicated only by the bulging of the dorsal margin of the ventroposterior sail and by a rudimentary central rib. Furthermore, the posterior main rib of the left sulcal list of this specimen is more club-shaped and has a more pronounced posterior concavity than in any of the other specimens examined. This specimen is included in the species, since the slight development of the dorsoposterior sail may be due to recent binary fission.

The specimen of this species figured by Jörgensen (1923, fig. 47) differs from our specimens mainly in having no connecting lists between the two posterior sails and between the ventral posterior sail and the left sulcal list. As to the systematic value of this difference, it should be mentioned that in the specimens examined by Jörgensen (1923, p. 34) the posterior sails were either "free, or joined by the sail lists, or the ventral alone connected with the lower part of the large (left) longitudinal list."

The closest-known relatives of *Dinophysis jörgenseni* probably are *D. triacantha* and *D. nias*. This relationship is suggested especially by the presence of two posterior sails. *D. triacantha* is closer to *D. jörgenseni* than is *D. nias* in the shape of its left sulcal list and in having the ventroposterior sail connected with the left sulcal list. It differs most strikingly from *D. jörgenseni* in having the posterior sails supported by marginal instead of by central ribs. *D. nias* approaches *D. jörgenseni* more than does *D. triacantha* in having the posterior sails supported by central ribs, which may be bifurcated basally. It differs from this species especially in having the posterior sails well separated from each other and from the left sulcal list and in the almost straight ventral margin of its left sulcal list (see also *D. triacantha*, the section on comparisons).

Synonymy: — This species was first described and figured by Jörgensen (1923) under the name of *Dinophysis triacantha* Kofoid. Under this name Jörgensen (1923, p. 35) also included *D. nias* Karsten.

Occurrence: — *Dinophysis jörgenseni* is recorded at twenty-three of the 127 stations. There are 3, 8, 2, 5, 4, and 1 stations on the six lines of the Expedition. Of these stations one (4598) is in the Mexican Current; three (4609, 4613, 4637) are in the Panamic Area; seven (4650, 4651, 4652, 4655, 4659, 4663, 4665) are in the Peruvian Current; two (4713, 4715) are in the Galapagos Eddy; ten (4679,

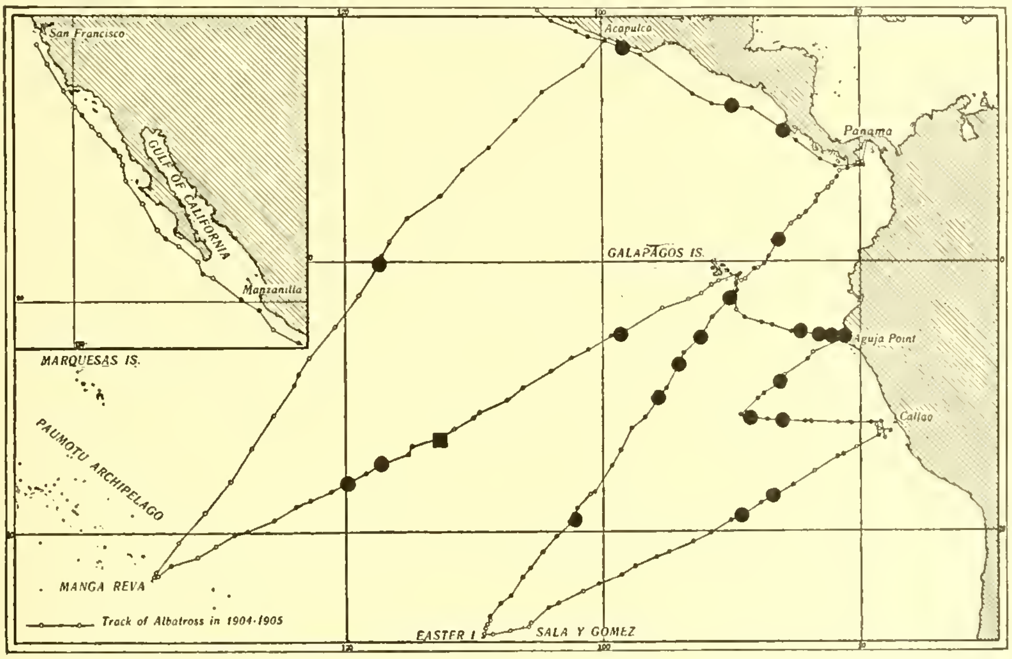

FIGURE 43.— Occurrence of *Dinophysis jörgenseni*, sp. nov. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4681, 4701, 4709, 4711, 4717, 4727 [type locality], 4730, 4732, 4742) are in the South Equatorial Drift. There is only one record from surface hauls (Station 4727). At one station (4652) the species was taken in a haul from 100–0 fathoms; at one station (4655) in a haul from 400–0 fathoms; and at two stations (4651, 4715) in hauls from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these twenty-three stations at the surface was 65°–84°; the average was 73.3°. At Station 4727, where this species was taken in a surface haul, the surface temperature was 77°.

At three stations (4613, 4663, 4715) the frequency is 1%; at the remaining stations it is less.

This species was first recorded by Jörgensen (1923), who found it at five stations in different regions of the Mediterranean, at one station on the coast of Portugal, and at lat. 3° S., long. 16° W., Gulf of Guinea. In the Mediterranean it seems to occur only below 200 meters (Jörgensen, 1923, p. 35).

This is a eupelagic species, widely distributed, but rare, in tropical, subtropical, and warm-temperate regions. The most outstanding peculiarities about its distribution in the Eastern Pacific, according to our data, are its rare occurrence in surface waters, its absence from the California Current and the northern portion of the Mexican Current, and its relatively frequent occurrence in the Peruvian Current and in the regions under the direct influence of this current. Its optimum habitat probably is in deeper waters, within the levels of photosynthesis.

Dinophysis triacantha Kofoid

Figure 42: 2

Dinophysis triacantha Kofoid, 1907a, p. 196, pl. 12, fig. 74. *non* Karsten, 1907, p. 421, 540, pl. 47, fig. 7. Kofoid & Michener, 1911, p. 292. *non* Jörgensen, 1923, p. 34, 43, fig. 47.

Diagnosis: — Body subcircular in lateral outline; length: depth, 0.97: 1. Both cingular lists ribbed; the anterior 1.5 times wider than transverse furrow. Left sulcal list: distance between R_1 and R_3 0.59 the length of body; R_2 is 0.32, R_3 is 0.48 the greatest depth of body; margin rather strikingly concave just behind R_2 and forms angle of 30° at R_3; R_3 inclined posteriorly at 35°; besides main ribs this list has a few short ribs. With two subequal, acute posterior sails, one on each side of midline, each supported by marginal ribs and lacking central rib; height of these sails, 0.37–0.44 the greatest depth of body; angles at their tips, 20°; no connecting list between posterior sails; ventroposterior sail connected with left sulcal list by list, the minimum width of which is 0.7 the width of transverse furrow; except for marginal ribs, posterior sails lack structure; theca with fine, irregular reticulation. Length, 49.4 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, subcircular in lateral outline, and deepest in the middle. The ratio between the length and the depth of the body is 0.97: 1. The longitudinal axis is perpendicular to the girdle.

The epitheca is about 0.58 as deep as the hypotheca, of moderate convexity, highest in the center, and not visible above the anterior cingular list. The transverse furrow is flat or gently concave, and about twice as wide as the greatest height of the epitheca. The posterior cingular list is about 0.21 the length of the body from the apex. The hypotheca has a subcircular outline with almost uniform convexity.

The anterior cingular list is about 1.5 times wider than the transverse furrow and 0.25 the greatest depth of the body; it is inclined anteriorly at 25°–30° and has, on each valve, about 18–20 complete or incomplete ribs, most of which are straight and unbranched. The posterior cingular list is slightly narrower than the anterior, inclined anteriorly at about 25°, and has, on each valve, about 19–20 simple, straight, and almost equidistant ribs. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, is subtriangular in shape, decreases gradually in width posteriorly, and is anteriorly about half as wide as the transverse furrow. The left sulcal list is rather large. The distance between the anterior and posterior main ribs is about 0.59 the length of the body. The anterior main rib is about 0.21, the fission rib 0.32, and the posterior main rib 0.48 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib the free margin of this list is straight or almost so; just behind the fission rib it is rather strikingly concave; at the posterior main rib it forms an angle of about 30°; and just behind the last rib it is gently concave. The main ribs are of moderate strength and not club-shaped or otherwise modified. The anterior main rib is straight or almost so; the fission rib and the posterior main rib are gently concave posteriorly. The distance between the anterior main rib and the fission rib is about 0.37 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 35°. Besides the main ribs this list has a few short ribs, some of which may be branched, or a feeble reticulation; at the base of the posterior main rib there is a short posterior branch. On the right valve there are two subequal, acute posterior sails, one on each side of the midline, each supported by marginal ribs and lacking a central rib. The ventral of these sails has a length 0.44 the greatest depth of the body and an angle at the tip of about 20°; the dorsal has a length 0.37 the greatest depth of the body and an angle at the tip of about 20°. There is no connecting list between the posterior sails, but the ventroposterior sail is connected with the left sulcal list by a list, the minimum width of which is about 0.7 the width of the transverse furrow. Except for the marginal ribs, which may have a few short branches, the posterior sails lack ribs. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca.

Megacytic stages have not been recorded.

The dimensions of one specimen only, the type, were measured.

Dimensions: — Length of body, 49.4 μ. Greatest depth of body, 50.7 μ.

Comparisons: — Our description and figure of this species are based on the type specimen.

Dinophysis triacantha appears to be structurally most closely related to *D. nias* and *D. jörgenseni* (see the last two species, the sections on comparisons). It is easily distinguished from these two species by having its two posterior sails supported by marginal ribs instead of by central ribs. The structure of its posterior sails is suggestive of a fairly close affiliation to *D. uracantha, D. urceolus, D. monacantha,* and *D. trapezium,* but this must be regarded as uncertain.

Synonymy: — The species was established by Kofoid (1907a), who described and figured it under the name of *Dinophysis triacantha. D. triacantha* Karsten (1907) is identical with *D. nias* Karsten and not with *D. triacantha* Kofoid. *D. triacantha* Jörgensen (1923) refers both to *D. nias* Karsten and to *D. jörgenseni* nobis.

Occurrence: — *Dinophysis triacantha* is recorded at only one (4722, type locality) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 75°. The frequency is less than 1% (one specimen).

3. Caudata Group.— *Dinophysis caudata, D. tripos,* and *D. miles* belong to this group. Of these only the first was found in the material of the Expedition.

Dinophysis caudata Saville-Kent

Figure 44, 45

Dinophysis caudata Saville-Kent, 1881, p. 455, 460. Jörgensen, 1923, p. 22, 24–30, 43–45. Pavillard, 1923a, p. 881.

Dinophysis acuta var. *geminata* Pouchet, 1883, p. 27, pl. 18, 19, fig. 5.

Dinophysis homunculus Stein, 1883, *partim*, p. 3, 24, pl. 21, fig. 1, 2, 5–7. Bergh, 1884, p. 385. Bütschli, 1885, p. 995, 996, pl. 55. fig. 36. Imhof, 1886, p. 102. Hensen, 1887, p. 77, tab. 13–16; 1911, p. 164, 165. Möbius, 1887, p. 121. Daday, 1888, p. 99. Whitelegge, 1891, *partim*, p. 184, pl. 28, fig. 14. Walther, 1893, p. 129. Schütt, 1895, p. 65, 112, pl. 2, fig. 8. Cleve, 1897a, p. 26, tab. 1; 1899a, p. 17; 1899c, p. 4; 1900b, p. 1031; 1900c, p. 21, 35, 39; 1900f, p. 925, 936; 1901a, p. 15; 1901c, p. 239; 1902a, p. 10, 25; 1902b, p. 29; 1903a, p. 38; 1903b, p. 344. Ostenfeld, 1898a, p. 428; 1898b, tab. 3–5; 1899, tab. 2–5; 1902, p. 20; 1906, p. 18; 1915, p. 6; 1916b, p. 13. Lemmermann, 1899a, p. 319, 373; 1901a, p. 371; 1902a, p. 263; 1905a, p. 36. Minkiewitsch, 1899, p. 357, 361. Murray & Whitting, 1899, p. 331, tab. 1, 3–6, 8, 9. Schröder, 1900a, *partim*, p. 19, 21, 35; 1900b, p. 3; 1906a, p. 321, 325, 326, 374; 1906b. p. 262; 1909, p. 211; 1911, p. 12, 17, 18, 25, 36, 37, fig. 7b. Schmidt, 1901, p. 138. Ostenfeld & Schmidt, 1901, p. 169. Cleve, Ekman & Pettersson, 1901, p. 36. Gran, 1902, p. 184. Lohmann, 1902, p. 53; 1908a, p. 168, 169. Entz, 1902a, fig. 1; 1902b, p. 94; 1905, p. 111; 1907, p. 19; 1909, p. 255. Paulsen, 1904, p. 29; 1908, p. 12, 19, fig. 20; 1912, p. 290. Pavillard, 1905, p. 59, 100, 102; 1909, p. 284; 1916, p. 56, fig. 15A. Karsten, 1905, p. 8, 34, 35; 1906, p. 180, 183, 193, 195, 196, 198, 205–207, 210–213, 215, 217, 218; 1907, p. 225, 240, 269, 278, 332, 333, 335, 359, 424, 445, 449, 451, 471, 472. Apstein, 1905a, tab. 2, 10. Clark, 1905, p. 179, 182, 188. Jörgensen, 1905, p. 50, 108; 1923, p. 24, 29. Zacharias, 1906, p. 509, 530, 531, 533, 534, 536, 538, 540, 544, 545, 549, 551, 552, 554. Linko, 1907, p. 109, 111. Nathansohn, 1908, p. 604, 612; 1909, p. 46, 59; 1910a, p. 14, 15, 20. Czapek, 1909, p. 8, fig. 5. Stüwe, 1909, p. 243, 254, 288. Gräf, 1909, p. 139, 157, 159, 161, 163, 171, 173, 184, 192. Reinhard, 1910, p. 8, 12, 14, 15, 16, 23, 26. Schiller, 1911a, p. 52; 1911b, p. 90; 1912, p. 27. Carazzi & Grandori, 1912, p. 48, tab. F. Mangin, 1912, p. 5–7, 10, 12–18, 20, 21, 58, 60, tab. 2. Faria & Cunha, 1917, p. 74. Cunha & Fonseca, 1917, p. 141. Forti, 1922, p. 107, 109, 190, 208, fig. 114.

Dinophysis allieri Gourret, 1883, p. 75, 76, 78–80, pl. 3, fig. 54, 54a.
Dinophysis inacqualis Gourret, 1883, p. 77, 78, 80, pl. 1, fig. 21.
Dinophysis homunculus and *caudata* Grenfell, 1887, p. 559.
Dinophysis semicarinata Grenfell, 1887, p. 560, pl. 11, fig. 12.
Dinophysis homunculus f. *pedunculata* Schmidt, 1901, p. 138, fig. 8. Okamura, 1907, p. 131, fig. 40; 1912, p. 19. van Oye, 1921, p. 215.
Dinophysis homunculus var. *carinata* Zacharias, 1906, p. 540.
Dinophysis homunculus var. *pedunculata* Schröder, 1906a, p. 335. Jörgensen, 1923, p. 25, 29.
Dinophysis homunculus var. *gracilis* Schröder, 1911, p. 5, 7, 22–24, 36, fig. 7a.
Dinophysis geminata Kofoid & Rigden, 1912a, p. 337.
Dinophysis pedunculata Ostenfeld, 1915, p. 6, 7.
Dinophysis caudata var. *allieri* Jörgensen, 1923, p. 25.
Dinophysis caudata allieri f. *speciosa* Jörgensen, 1923, p. 25, fig. 30.
Dinophysis caudata var. *abbreviata* Jörgensen, 1923, p. 25, 27, 28, fig. 31.
Dinophysis caudata f. *marmarae* Jörgensen, 1923, p. 26, 45, fig. 33.
Dinophysis caudata f. *pontica* Jörgensen, 1923, p. 26, 45, fig. 34.
Dinophysis homunculus var. *latus* Lindemann, 1923, p. 220, fig. 11, 12; 1925, p. 101.

Diagnosis: — Body very variable in shape, elongated; deepest somewhat in front of to somewhat behind the middle, and 1.65–3.23 times longer than deep; anterior portion irregularly obovate in lateral outline, subtruncate anteriorly; posterior portion more or less slender, pedunculate, of varying length; transition between anterior and posterior portions gradual or more or less sudden; longitudinal axis inclined posteroventrally at 7°–30°. In dorsal view strongly flattened, 7–8 times longer than wide. Anterior cingular list 1.5–2.5 as wide as transverse furrow. Left sulcal list extends to base of peduncle; distance between R_1 and R_3 0.28–0.38 the length of body; R_2 is 0.23–0.59, R_3 is 0.31–0.77 the greatest depth of body; margin forms angle of 70°–110° at R_3, or this portion of list is recurved; R_3 about parallel to girdle; with more or less developed reticulation. Theca finely and closely areolate. Length, 71.8–107.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a medium-sized to rather large species, very variable in shape, elongated, and deepest somewhat in front of to somewhat behind the middle. The anterior portion of the body is irregularly obovate in lateral outline, subtruncate anteriorly; the posterior portion is more or less slender, pedunculate, of varying length. The ratio between the length and the depth of the body is 1.65–3.23: 1; in our specimens this ratio is 2.06 (1.65–2.46): 1; in the specimens figured by Stein (1883, pl. 21, fig. 1, 2, 5) which are unusually slender, it is 2.82–3.23: 1. The longitudinal axis is inclined posteroventrally at 7°–30°; in our specimen this angle measured 20° (14°–30°). Seldom almost symmetrical specimens are found (see Stein, 1883, pl. 21, fig. 1, and Jörgensen, 1923, p. 25).

The epitheca is gently convex to very slightly concave, highest in the middle or near the dorsal side, not visible above the anterior cingular list, and 0.43–0.58 as deep as the hypotheca; in our specimens this ratio is 0.51 (0.45–0.58): 1; in Stein's (1883) it is 0.43–0.46: 1. The transverse furrow is flat or gently concave, and generally somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.04–0.08 the length of the body from the apex. The hypotheca is very variable in shape; its anterior portion is irregularly obovate, and its posterior portion is more or less slender, pedunculate. The transition between the anterior portion and the posterior (the peduncle) sometimes is gradual, sometimes more or less sudden; in forma *pedunculata* it is very sudden. The ratio between the length of the body and that of the peduncle is variable, due to the great variability of the length of the peduncle. In our specimens this ratio is 2.73 (2.35–4.21): 1; in the specimens figured by Stein (1883) it is 2.21–2.50: 1; in the other specimens of this species figured by previous authors it falls within this range of variation. The dorsal margin of the anterior portion of the hypotheca either is gently concave (Stein, 1883, pl. 21, fig. 2, 5), straight (Stein, 1883, pl. 21, fig. 1), almost uniformly and gently to moderately convex (Figure 44: 2), or its anterior and posterior parts are gently convex or almost straight and together form a broadly rounded but distinct corner (Figure 44: 4); this corner has a varying relative position (Figure 44: 5, 6), but usually it is located behind the middle of this margin. The ventral margin of the anterior portion of the hypotheca usually is straight or almost so, or it is gently undulating, being convex anteriorly and posteriorly and concave in the middle. Proximally the peduncle is 0.30–0.55 the greatest depth of the body and about 1.9–3.0 times wider than distally. In most specimens its dorsal and ventral margins are gently convex, but sometimes they are almost straight (Figure 44: 6) or somewhat irregular (Figure 44: 7). Posteriorly the peduncle is truncate, rounded, or pointed; when truncate or rounded, the antapex frequently has one to four tubercles of varying size. In dorsoventral view the body is very narrow, about seven to eight times longer than wide (Stein, 1883, pl. 21, fig. 6, 7), and with subparallel sides.

The cingular lists may be subequal, but in most specimens the posterior is somewhat narrower than the anterior; the anterior is 1.5–2.5 times wider than the transverse furrow and 0.26 (0.18–0.35) the greatest depth of the body; both are funnel-shaped, with an anterior inclination of 20°–50°; sometimes the posterior is somewhat less inclined than the anterior. In most cases the anterior has, on each valve, about ten to fifteen simple, straight, almost equidistant, and sometimes partly incomplete ribs; sometimes the posterior may have about the same structure as the anterior, but in most specimens it lacks structural differentiation. The right sulcal list ends from just in front of to somewhat behind the fission rib of the left sulcal list; it either is subtriangular, decreasing gradually in width posteriorly, or it is of subuniform width throughout its anterior half; anteriorly it is about as wide as, or usually somewhat wider than, the transverse furrow. The left sulcal list extends to the base of the peduncle; the distance between the anterior and posterior main ribs is 0.33–0.42 the length of the body. In our specimens the anterior main rib is 0.29 (0.21–0.40), the fission rib 0.32 (0.23–0.40), and the posterior main rib 0.40 (0.31–0.50) the greatest depth of the body. In the specimens figured by Stein (1883, pl. 21, fig. 1, 2, 5) this list is unusually wide and the corresponding values are 0.40 (0.34–0.50), 0.48 (0.44–0.59), and 0.66 (0.59–0.77). Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently concave (Figure 44: 6), almost straight throughout (Figure 44: 3), almost straight anteriorly and posteriorly and convex in the middle (Jörgensen, 1923, fig. 34), gently to moderately convex (Figure 44: 2), or gently sigmoid, straight to gently concave anteriorly and convex posteriorly (Figure 44: 7). At the posterior main rib this margin forms an angle of 70°–110°; or this portion of the list is more or less strikingly recurved (Stein, 1883, pl. 21, fig. 1; Jörgensen, 1923, fig. 31). Behind the posterior main rib this margin either is almost straight, somewhat convex or irregular (Figure 44: 1), or it is more or less concave (Jörgensen, 1923, fig. 31). The main ribs of this list are of moderate strength; the two anterior are straight or almost so; the posterior, which in exceptional cases (Stein, 1883, pl. 21, fig. 5) is club-shaped, is sometimes straight but generally more or less concave posteriorly. The distance between the anterior main rib and the fission rib is 0.40–0.55 the distance between the anterior and posterior main ribs. The posterior main rib is about parallel to the girdle. In some specimens the whole list has a well-developed reticulation, in others the reticulation is more or less reduced or even totally absent. There are no accessory lists or sails.

The thecal wall is areolate. The areoles are usually numerous and rather small (Figure 44: 4), but their size and number are somewhat variable (Stein, 1883, pl. 21, fig. 1, 2, 5).

Megacytic stages have not been recorded.

The species is characterized by the fact that after binary fission the two schizonts remain for some time attached to each other by a ridge along the posterior portion of the dorsal margin of the anterior part of the hypotheca. This ridge sometimes is rather narrow (Figure 44: 6), sometimes it is rather wide (Figure 44: 2); in some specimens it is without structural differentiation; in others it is areolate.

The dimensions of ten of our specimens and of the specimens figured by previous investigators were measured.

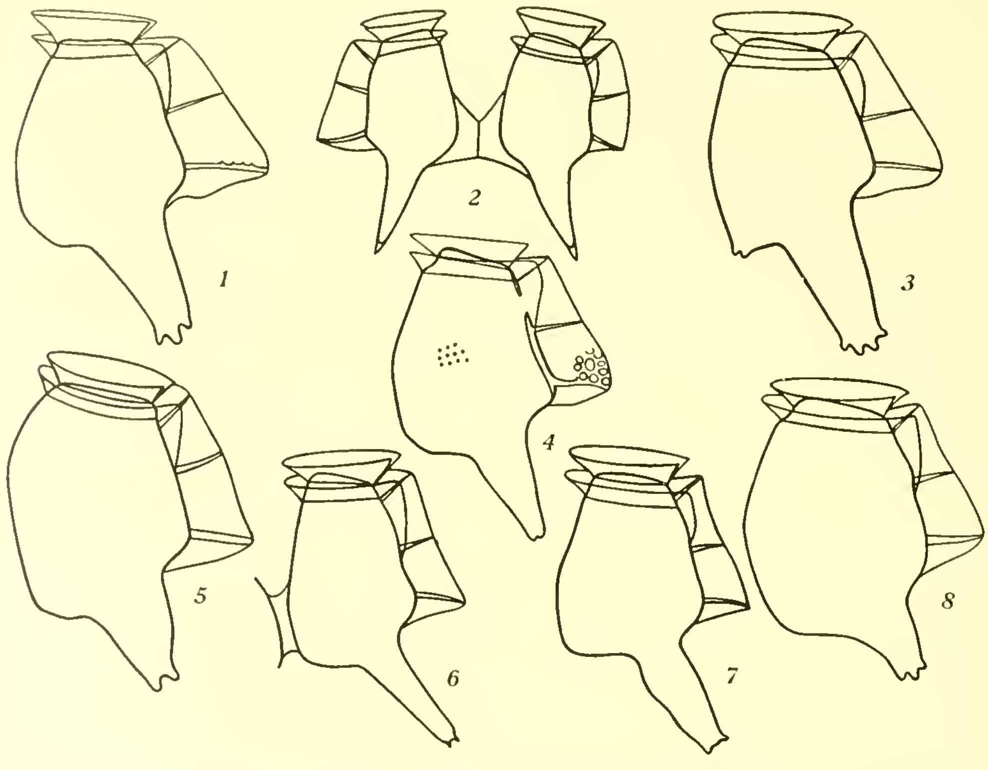

FIGURE 44. — *Dinophysis caudata* Saville-Kent, right lateral view, structure of thecal wall and of left sulcal list indicated only in 4. 2, two schizonts, not yet detached from each other. 6, two schizonts, one of which is indicated only by a portion of its dorsal margin. × 430. 1, 3, from Station 4637 (300–0 fathoms); 2, from Station 4594 (300–0 fathoms); 4, from Station 4571, surface; 5, 8, from Station 4652 (300–0 fathoms); 6, 7, from Panama Harbor, surface.

Dimensions: — Our specimens: Length of body, 71.8–107.0 μ (average, 94.3 μ). Greatest depth of body, 29.2–56.5 μ (average, 46.5 μ). The specimens figured at known magnifications by previous investigators fall within the range of variation given above for our specimens. The figures of this species given by Stein (1883, pl. 21, fig. 1, 2, 5) are of unknown magnifications. Judging by Stein's (1883) information about the magnifications of his figures, given in an introductory remark to the explanations of the plates, the length of the largest of his specimens (pl. 21, fig. 1) was somewhere between 132 μ and 201 μ.

Variations: — As conceived in the present paper, this species is almost protean. Previous authors have subdivided it into a number of forms, varieties, or even species, but this subdivision is based on rather limited material and inadequate knowledge of the species, and not on extensive biological and statistical investigations. The systematic value of these "forms," "varieties," and "species" is therefore not known as yet. Future investigators with adequate material at their disposal may be able to show that at least some of these units are the expressions of genetic processes. On the other hand, it is probable that many if not all of them are modifications, due to changes in the surrounding medium, to regulatory processes consequent upon binary fission, or to metabolic phenomena, *e.g.*, the ratio between the rate of growth of the protoplasm and the rapidity of fission.

It should be noted that in the inner region of the Aegean Sea, in the Marmora Sea, and in the Black Sea, where the salinity is low in comparison with that of the open Mediterranean, as well as in the brackish Porkljan Lake on the Dalmatian coast, this species is represented by more or less aberrant forms (Jörgensen, 1923, p. 26; Schröder, 1911, p. 36).

With regard to the possible connection between some differences in the shape and size of the body and binary fission, a "degenerate" specimen of this species figured by Jörgensen (1923, fig. 37) may be significant. This specimen evidently was taken shortly after the separation of the two schizonts in binary fission. Its right (old) valve shows a striking resemblance to Pavillard's (1916, fig. 15B) *Dinophysis homunculus* var. *ventricosa* (= *caudata* var. *acutiformis*). Its left (new) valve, on the other hand, is decidedly smaller than the right and has a shape which is very similar to that of *D. caudata* var. *subdiegensis* Jörgensen (1923, fig. 35). If in this specimen the next fission had taken place before the new valve had reached the size of the old (supposing that such a postfission increase in size does take place, which is not known), one of the daughter individuals probably would have been referable to *D. caudata* var. *acutiformis*, the other to *D. caudata* var. *subdiegensis*. The smallness of the left (new) valve of this specimen probably was due to a disproportion between the rate of growth of the protoplasm and the rapidity of fission. This supposed disproportion might have been brought about either by an increased rate of fission not accompanied by a correspondingly increased growth of the protoplasm, or by a decrease in the growth of the protoplasm without a proportionally low rate of fission. In the latter case we would be dealing with a case of degeneration, possibly called forth by adverse hydrographical conditions. It should be remembered in this connection that specimens of *D. caudata* var. *acutiformis* and var. *subdiegensis* never have been recorded except from near the coast line, where the hydrographical conditions are more or less changeable and different from those of the open sea. We should also remember "the exceedingly great sensitiveness of pelagic organisms to even slight changes in their environment" (Kofoid, 1909, p. 245).

On the other hand, the specimen mentioned above may be comparable to the heteromorphic chains found in the genus Ceratium by Lohmann (1908) and Kofoid (1909), an assumption that has already been voiced by Jörgensen (1923, p. 29). About the systematic significance and possible causes of such chains, see Kofoid (1909) and Jörgensen (1911).

A third possibility is that fission was completed before the regulatory formation of the new half of the theca was accomplished, and that this would have later ensued, restoring the organism to the ancestral form.

The value of this specimen as evidence in the problem of the variability of this species is therefore rather uncertain. Compare also the lengths of the peduncles in the two schizonts from Karrachee represented by Czapek (1909, fig. 5).

Under these circumstances it has been considered advisable in the present paper to treat most of the above-mentioned "forms," "variations," and "species" under the name of *Dinophysis caudata*, and, with one exception, not to assign the specimens found in the material of the Expedition and considered to belong to this species, to any one of these smaller units.

The following characters are more or less strikingly variable in this species, as conceived in the present paper: — the size of the body, the inclination of the longitudinal axis of the body, the depth and the shape of the anterior portion of the body, the width, shape, and size of the peduncle, *i.e.*, the posterior portion of the body, the tuberculation of the antapical end of the body, and the width, shape, and structure of the left sulcal list.

According to the conception of *Dinophysis caudata* adopted in the present paper and by Jörgensen (1923, p. 25), the specimen represented by Jörgensen's (1923) figure 30 under the name of *D. caudata* Kent *a allieri* (Gourret) f. *speciosa* Jörgensen may be considered as typical of this species. Kent's (1881, p. 460) original description of *D. caudata* is very fragmentary and is not accompanied by any illustrations. It does not suffice for a perfectly certain determination of species, but it conforms fairly well with the mentioned figure of Jörgensen (1923).

This form may be characterized briefly in the following way: — the body is slender, and its longitudinal axis is somewhat inclined posteroventrally; the transition between the anterior portion of the body and the peduncle is rather gradual than sudden; the peduncle is rather long, and attains about the length of the left sulcal list; the left sulcal list is broad, and decidedly broader posteriorly than anteriorly. None of the specimens of this species found in the material of the Expedition agrees completely with this form, and, as far as our records go, only one of them (Figure 44: 2) approaches it rather closely.

The great majority of our specimens (Figure 44: 4) resemble very closely the specimen from Japanese waters figured by Okamura (1907, fig. 40a) under the name of *Dinophysis homunculus* f. *pedunculata*. In other words, they have a habitus which in several respects is intermediate between Grenfell's (1887) *D. semicarinata* and Schmidt's (1901) *D. caudata* f. *pedunculata*. This form may be given the following short characterization: — the body is somewhat less slender than in the typical form of this species, and its longitudinal axis is somewhat inclined posteroventrally; the transition between the anterior portion of the body and the peduncle is rather sudden than gradual, but not quite so sudden as in Schmidt's (1901) *D. caudata* f. *pedunculata*; the peduncle is of moderate length, being somewhat shorter than the left sulcal list; the left sulcal list is rather broad, and somewhat broader posteriorly than anteriorly.

Some of our specimens (Figure 44: 7) show a still more pronounced resemblance to *Dinophysis caudata* f. *pedunculata* Schmidt than those mentioned in the last paragraph. Indeed, the agreement sometimes was almost complete.

As far as our records go, the form represented by Figure 44: 3 was found but once in the material of the Expedition. It is easily distinguished from the typical form of this species by the rather sudden transition between the anterior portion of the body and the peduncle, by the rather broad, tuberculate peduncle, and by the two tubercles on the dorsal protuberance of the body just in front of the peduncle. In the last character this form approaches *Dinophysis tripos*, a form which in the present paper is considered as specifically distinct from *D. caudata*, and which never was found in the material of the Expedition.

Some of our specimens of this species (Figure 44: 5, 8) differed rather strikingly from the forms discussed above, and in several respects approached the forms figured by Jörgensen (1923, fig. 33, 34) under the names of *Dinophysis caudata* f. *marmarae* and *D. caudata* f. *pontica*. These specimens may be briefly characterized as follows: — the longitudinal axis of the body is somewhat inclined posteroventrally; the anterior portion of the body is deep and bulky, and its transition to the peduncle is sometimes rather sudden, sometimes more or less gradual; the peduncle is more or less reduced in size, in some cases being only about half as long as the left sulcal list; the left sulcal list is rather broad.

In the material of the Expedition we also have found specimens which to varying extents are intermediate between the form (Figure 44:4) to which belongs the majority of our specimens of this species on the one hand, and (Figure 44:3) the form approaching *Dinophysis tripos* and the forms treated in the last paragraph. (See also *D. caudata* f. *acutiformis*, the section on comparisons, and Jörgensen, 1923, p. 24–27.)

Comparisons: — *Dinophysis tripos* is the structurally closest-known relative of *D. caudata*. Indeed, transitional specimens between these two forms have been found (Figure 44:3), and even their specific separation has been questioned; see the section on synonymy. *D. tripos* is a connecting link, presumably genetically as well as morphologically, between *D. caudata* and *D. miles*. The last species occurs in at least two rather different varieties (whether or not specifically distinct is unknown), viz., *D. miles miles* (Cleve, 1900b, fig. 1a) and *D. miles* f. *schröteri* (Forti) Ostenfeld. (A third variety, established by Schröder, 1906a, under the name *D. miles* f. *maris jonii*, has not been figured or sufficiently described and thus cannot be considered in this connection.) Of these two varieties the former is less excessively differentiated and therefore presumably more closely related to *D. caudata* than the latter. *D. caudata* differs from *D. tripos* and *D. miles* in not having a well-developed dorsal process just in front of the peduncle.

The three species mentioned in the last paragraph occupy a rather isolated position, and we do not know which of the remaining species of Dinophysis are their closest relatives. See also the section on variations and *D. caudata* f. *acutiformis*, the section on comparisons.

Synonymy: — This species, as conceived in the present paper, has appeared under several different names, which will be discussed briefly in the following paragraphs.

It was first described by Saville-Kent (1881), and later described and figured by Jörgensen (1923) under the name of *Dinophysis caudata*. These investigators, besides Grenfell (1887, p. 559, 560), are the only ones who have used this name.

The first author, after Saville-Kent (1881), to treat this species is Pouchet (1883, p. 27, pl. 18–19, fig. 5; 1885a, p. 22), who, under the name of *Dinophysis acuta* var. *geminata*, figured two schizonts not yet detached from each other. The similarity between these two specimens and *D. caudata* α *allieri* f. *speciosa* Jörgensen (1923, fig. 30), *i.e.*, the typical form of *D. caudata*, is very striking. *D. acuta* var. *geminata* is regarded as identical with *D. caudata* by Bergh (1884, p. 385), Bütschli (1885, p. 995), Paulsen (1908, p. 19), and Jörgensen (1923, p. 24). Lemmermann (1899a, p. 373) identified it with *D. allieri* Gourret (see below). Kofoid and Rigden (1912a, p. 337) use the name *D. geminata* without discussing the systematic position of this form.

Shortly after the publication of Pouchet's (1883) work, referred to in the last paragraph, *Dinophysis caudata* was excellently figured in Stein's (1883, pl. 21, fig. 1, 2, 5, 6, 7) big iconography under the name of *D. homunculus*. The name last-mentioned was accepted for this species by almost everybody, and the two older names were forgotten or disregarded. Under the name of *D. homunculus* this species was later figured or described by the following authors: — Whitelegge (1891, p. 184, pl. 28, fig. 14), Schütt (1895, p. 65, 112, pl. 2, fig. 8), Entz (1902a, fig. 1), Czapek (1909, fig. 5), Schröder (1911, p. 36, fig. 7b), and Pavillard (1916, p. 56, fig. 15a). Bütschli (1885, p. 995, 996, pl. 55, fig. 36) reproduces Stein's (1883) Plate 21, figure 1; Paulsen (1908, p. 19, fig. 20) reproduces Stein's (1883) Plate 21, figure 2; and Forti (1922, fig. 114) reproduces Pavillard's (1916) figure 15a.

Almost simultaneously with the publication of Stein's (1883) iconography, Gourret (1883) issued a paper in which were established three species belonging to the genus Dinophysis, viz., *D. allieri*, *D. inaequalis*, and *D. tripos*.

There seems to be but little doubt that *Dinophysis allieri* and *D. inaequalis* should be referred to *D. caudata*. Indeed, *D. allieri* probably represents the typical form of this species; see Jörgensen (1923, p. 25). *D. allieri* Gourret (1883, p. 75, 76, 78, 79, 80, pl. 3, fig. 54, 54a) is considered as identical with *D. caudata* by Whitelegge (1891, p. 185), Schröder (1900a, p. 19), Pavillard (1905, p. 59), Paulsen (1908, p. 19), Okamura (1912, p. 19), Faria and Cunha (1917, p. 74), and Forti (1922, p. 108). Bergh (1884, p. 385), Lemmermann (1899a, p. 373), and Jörgensen (1923, p. 24, 25, fig. 30) treat it as a variety of *D. caudata*. *D. inaequalis* Gourret (1883, p. 77, 78, 80, pl. 1, fig. 21) is regarded as identical with *D. caudata* by Whitelegge (1891, p. 185), Pavillard (1905, p. 59), Paulsen (1908, p. 19), Okamura (1912, p. 19), Faria and Cunha (1917, p. 74), and Jörgensen (1923, p. 24, 25). Bergh (1884, p. 385) regards it as a variety of *D. caudata*. Schröder (1900a, p. 19) is doubtful about its systematic status.

The systematic position of *Dinophysis tripos* Gourret (1883, p. 76, 80, pl. 3, fig. 53) must be regarded as unsettled. This form is treated as a variety of *D. caudata* by Bergh (1884, p. 385), Lemmermann (1899a, p. 373; 1901a, p. 374; 1905a, p. 36), Ostenfeld and Schmidt (1901, p. 170), Entz (1902b, p. 94; 1905,

p. 112), Schröder (1906a, p. 322, 340), and Lebour (1917a, tab. 1; 1917b, p. 184). Paulsen (1908, p. 19) and Okamura (1912, p. 19) suggest that *D. tripos* and *D. caudata* may be identical, and Stein (1883, pl. 21, fig. 3, 4) does not separate them systematically. Some of the authors mentioned in this paragraph change their attitude in this question and treat *D. tripos* as a distinct species; these authors are: Ostenfeld (1906, p. 18; 1909, p. 23; 1915, p. 6; 1916, p. 13), Schröder (1911, p. 25), and Paulsen (1912, p. 290). Other investigators who treat *D. tripos* as a distinct species are: Pavillard (1905, p. 59; 1909, p. 284; 1916, p. 57), Gough (1907, p. 190, 192), Gräf (1909, p. 155), Hensen (1911, p. 165), Schiller (1912, p. 27), Faria and Cunha (1917, p. 74), Forti (1922, p. 109), and Jörgensen (1923, p. 29, 30, fig. 38, 39). Pavillard (1909, p. 283) writes that the comparison of a great number of specimens collected during all seasons of the year "me permet de considérer comme nécessaire la séparation définitive de *D. Homunculus* Stein et *D. tripos* Gourret." Jörgensen (1923, p. 31) calls *D. tripos:* "this easily recognizable and very constant species." In the material of the Expedition a specimen (Figure 44: 3) was found which approached *D. tripos* f. *brevicauda* Jörgensen (1923, fig. 39) in the structure of the dorsal projection at the base of the peduncle, and which, on the other hand, showed a great similarity to some of the specimens (Figure 44 1) which in the present paper have been referred to *D. caudata*. In other words, specimens do exist which are more or less intermediate between *D. tripos* and *D. caudata*, as conceived in the present paper. Compare also Figure 40a and 40b, Plate 5, Okamura (1907). However, the evidence seems to be in favor of the opinion of those who regard *D. tripos* as a distinct species. The names of this form, therefore, have not been included in our bibliographical list of *D. caudata*.

Dinophysis homunculus var. *appendiculata* Zacharias (1906, p. 538, 540, 574) is a synonym of *D. tripos* (see Faria and Cunha, 1917, p. 74, and Jörgensen, 1923, p. 29).

Dinophysis homunculus var. *incurva* is a name applied by Lemmermann (1899a, p. 373) to the two specimens of *D. tripos* figured by Stein (1883, pl. 21, fig. 3, 4); see Jörgensen (1923, p. 30).

In this connection it may be mentioned that Whitelegge (1891, p. 185) supposed that "*D. homunculus* is identical with *D. inaequalis* Gourret, and *D. allieri* Gourret, and that all three are simply immature forms of *D. tripos* Gourret." This statement is explained by the fact that this investigator has confused the phylogenetic and the ontogenetic processes in the genus Dinophysis.

Dinophysis semicarinata Grenfell (1887, p. 560, pl. 11, fig. 12) agrees closely with *D. caudata* f. *pontica* Jörgensen (1923, fig. 34). It is mentioned only by Jörgensen (1923, p. 24), and should preliminarily be referred to *D. caudata* (see the section on the variations of this species).

The systematic status of *Dinophysis homunculus* f. *pedunculata* Schmidt (1901, p. 138, fig. 8) is somewhat doubtful. Lemmermann (1901a, p. 374), Schröder (1906a, p. 335), Okamura (1907, p. 131, pl. 5, fig. 40; 1912, p. 19), van Oye (1921, p. 215), and Jörgensen (1923, p. 25, 29) consider this form as a variety of *D. caudata*. Ostenfeld (1915, p. 6), on the other hand, writes that it "no doubt" is an independent species. The fact that this form seems to have a geographical distribution different from that of the other forms of *D. caudata* indicates that it is different genetically. It was first recorded by Schmidt (1901) from the Gulf of Siam; later van Oye (1921) reported it from Batavia, Java; Ostenfeld (1915) from the coast of Celebes; Schröder (1906a) from the Formosa Straits; and Okamura (1907, 1912) from Japanese waters. Jörgensen (1923, p. 29) found it on the coast of Arabia, and some of the specimens recorded by Whitelegge (1891) from Sydney, Australia, under the name of *D. homunculus*, probably belong to this form. The great majority of the specimens of *D. caudata* found in the material of the Expedition also belong to this form. However, in spite of its peculiar distribution, it seems most advisable to refer *D. pedunculata* to *D. caudata* until further evidence is available. See also the section on the variations.

Dinophysis homunculus var. *carinata* Zacharias (1906, p. 540) undoubtedly refers to a recently divided specimen of *D. caudata* in which the fission ridge on the dorsal side of the body has not yet been absorbed.

The two specimens figured from the Golden Horn and the Bosporus by Lindemann (1923, p. 220, fig. 11, 12) under the name of *Dinophysis homunculus* var. *latus* are referable to *D. caudata* f. *marmarae* and *D. caudata* f. *pontica*, respectively, figured by Jörgensen (1923) from the same waters.

The reader is referred to the section on the variations of this species for our reasons for including in the bibliographical list of *Dinophysis caudata* the following names: — Schröder's (1911) *D. homunculus* var. *gracilis* (also mentioned by Jörgensen, 1923, p. 27) and Jörgensen's (1923) *D. caudata* var. *allieri, D. caudata* var. *abbreviata*; *D. caudata* f. *marmarae*, and *D. caudata* f. *pontica*.

Under *Dinophysis caudata* f. *acutiformis* will be discussed the systematic status and synonymy of the following forms belonging to or at any rate close relatives of *D. caudata:* — *D. diegensis* Kofoid and its varieties *curvata* Kofoid and *caudata* Pavillard, *D. homunculus* var. *ventricosa* Pavillard, and *D. caudata* var. *subdiegensis* Jörgensen (= *D. kofoidi* Jörgensen).

Reinhard (1910, p. 26) wrote *Dinophysis homumnculus* for *D. homunculus.*

Hensen (1911, p. 164, tab. 15) used *D. hormunculus* and *D. hornunculus* for *D. homunculus.*

Occurrence: — *Dinophysis caudata* is recorded at fifty of the 127 stations. There are 16, 23, 3, 5, 0, and 3 stations on the six lines of the Expedition. Of these fifty stations, four (4571, 4574, 4580, 4583) are in the California Current; nine (4588, 4594, 4596, 4598, 4600, 4604, 4605, 4545, 4546) are in the Mexican Current; twelve (4609, 4611, 4613, 4615, 4617, 4631, 4634, 4637, 4638, 4639, 4640, 4644) are in the Panamic Area; nineteen (4647, 4649, 4650, 4651, 4652, 4655, 4657, 4659, 4660, 4663, 4666, 4667, 4668, 4669, 4670, 4671, 4675, 4676,

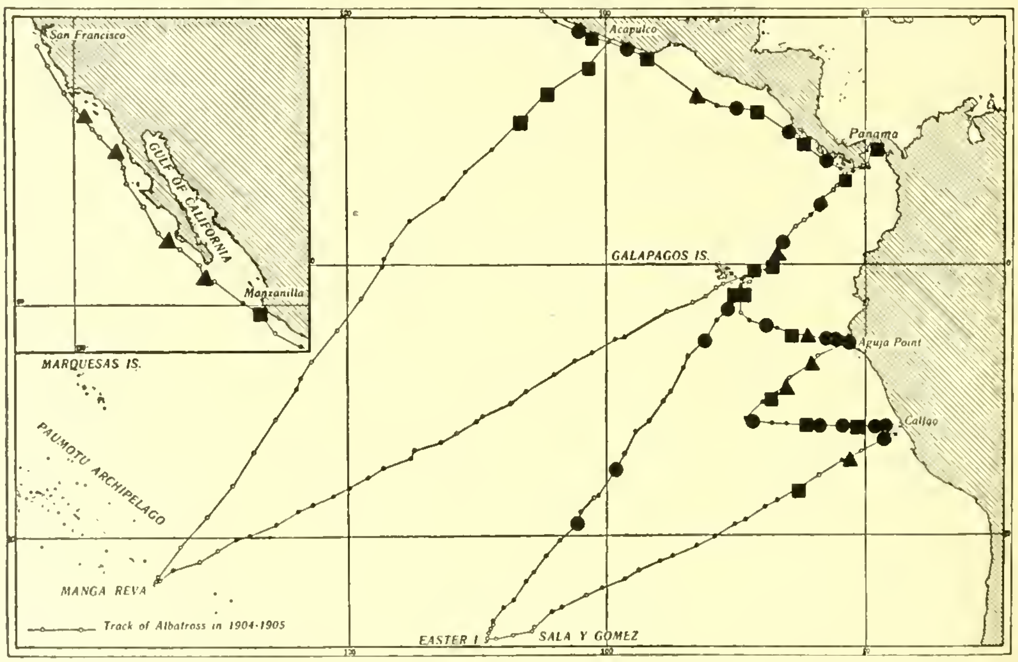

FIGURE 45.— Occurrence of *Dinophysis caudata* Saville-Kent. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4678) are in the Peruvian Current; two (4701, 4705) are in the South Equatorial Drift; three (4713, 4715, 4716) are in the Galapagos Eddy; one (4544) is in the North Equatorial Current. There are twenty-eight records from the surface (Stations 4571, 4574, 4580, 4583, 4588, 4596, 4600, 4604, 4611, 4615, 4631, 4638, 4639, 4640, 4644, 4649, 4650, 4657, 4659, 4660 [Salpa], 4666, 4669, 4676, 4678, 4716, 4544, 4545, 4546); at eight of these stations (4571, 4574, 4580, 4583, 4638, 4650, 4657, 4659) the species was taken in hauls from 300–0 fathoms as well as at the surface; and at one station (4676) it was taken in hauls from 300–0 fathoms and 800–0 fathoms as well as at the surface; at the remaining nineteen stations it was taken in surface hauls only. At one station (4652) the species is recorded from 100–0 fathoms; at one station (4655) in hauls from 300–0 fathoms and 400–0 fathoms; and at three stations (4647, 4651, 4670) in hauls from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The species is also recorded from surface waters in Panama Harbor, in the Panamic Area. This station is not included in the 127 stations mentioned above.

The temperature range of these fifty stations at the surface was 65°–85°; the average was 74.3°. At the twenty-eight stations in the surface catches of which this species was found, the surface temperature ranged from 67° to 84°; the average was 75.1°.

For the surface catches the following frequencies are recorded: — 72% at one station (4571), 29% at one station (4611), 11% at one station (4649), 10% at one station (4669), 9% at one station (4639), 6% at one station (4615), 5% at one station (4640), 3% at three stations (4657, 4659, 4676), 2% at three stations (4644, 4650, 4544), 1% at four stations (4574, 4588, 4666, 4716), and less than 1% at the remaining stations. For the catches from 100, 300, 400, or 800 fathoms to the surface the records of frequency are as follows: — 12% at one station (4659), 9% at one station (4571), 3% at one station (4650), 2% at nine stations (4574, 4598, 4609, 4638, 4651, 4655, 4671, 4675, 4676), 1% at nine stations (4613, 4617, 4637, 4647, 4657, 4663, 4667, 4670, 4715), and less than 1% at the remaining stations. In the catch from Panama Harbor thirty specimens were found.

This species was first recorded by Saville-Kent (1881) from the Adriatic Sea. From the North Sea it is reported by Cleve (1900c, 1903a), Apstein (1905a), Clark (1905), Ostenfeld (1906), and Paulsen (1912). It has never been found in the Baltic. Lemmermann's (1902a, p. 263) statement that Möbius (1887) recorded it from the western part of the Baltic is erroneous. Jörgensen (1905) found it near Bodö, on the west coast of Norway. It is mentioned as occurring in the Norwegian Sea by Cleve (1902a), Gran (1902), Ostenfeld (1906), Linko (1907), and Paulsen (1912). From the northern part of the Atlantic (*i.e.*, west of Scotland, south of the Faroe Islands and of Iceland, and in the Irminger Sea) it is reported by Hensen (1887, 1911), Möbius (1887), Ostenfeld (1898b, six stations; 1899, seven stations), and by Paulsen (1904, 1912). In the English Channel it was found by Cleve (1899a, 1900c) and Ostenfeld (1916b); on the west coast of France by Mangin (1912) and Jörgensen (1923); on the west coast of the Pyrenean peninsula by Jörgensen (1923); and west of Gibraltar by Gräf (1909). In the northern and middle parts of the Atlantic it has been recorded by the following investigators: — Cleve (1897a), at lat. 49° 53′ N., long. 28° 13′ W., and at lat. 37° 47′ N., long. 47° 31′ W.; Cleve (1901c) at about fifty stations between lat. 63° N. and lat. 10° N.; Cleve (1902b), at four stations between lat. 39° N. and lat. 21° S.; Cleve (1903b) at lat. 36° N., long. 6° W., and at lat. 37° N., long. 8° W.; Ostenfeld (1898a) at lat. 35° 44′ N., long. 38° 03′ W., and at the Canary Islands; Murray and Whitting (1899) at forty stations between lat. 48° N. and lat. 20° N.; Zacharias (1906) near the Azores and at lat. 31° N., long. 38° W.; Karsten (1906) at six stations between lat. 33° N. and 1° N.; Lohmann (1908a) between lat. 39° N., long. 46° W., and lat. 35° N., long. 53° W.; Stüwe (1909) at lat. 28° N., long. 40° W.; and Hensen (1911) at a great number of stations in the Labrador Current, Gulf Stream, Florida Current, Sargasso Sea, Canary Current, North Equatorial Current, Guinea Current, South Equatorial Current, and off the northeastern coast of Brazil. In the Caribbean Sea and among the West Indies this species has been found by Grenfell (1887), Murray and Whitting (1899), who record it at fourteen stations, and by Cleve (1901c) and Schröder (1909). From the South Atlantic we have the following records: — Cleve (1900f), "not rarely, in almost all samples from 37° S., 23° W. to 44° S., 4° E."; Cleve (1901c) off Rio de Janeiro; Cleve (1902b) at lat. 38° S., long. 20° W. to 44° S., long. 4° E.; Karsten (1906) at eleven stations between lat. 5° S. and lat. 35° S.; and Faria and Cunha (1907), Cunha and Fonseca (1907), off Rio de Janeiro. General statements about the occurrence of this species in the Atlantic are to be found in Stein (1883), Cleve (1899c, 1900f, 1901c), and Cleve, Ekman, and Pettersson (1901).

In the Mediterranean this species has been observed on a great number of occasions, viz.: at lat. 36° N., long. 5° W., by Cleve (1903b); at lat. 36° 46′ N., long. 2° 25′ E., by Ostenfeld (1902); in the Gulf of Lyons by Pouchet (1883), Gourret (1883), and Pavillard (1905, 1909, 1916); off Monaco by Nathansohn (1908, 1909, 1910a); in the Ligurian Sea by Forti (1922); off Naples by Daday (1888), Schröder (1900a), and Zacharias (1906); off Palermo and Algiers by Zacharias (1906); in the Adriatic Sea by Saville-Kent (1881), Stein (1883), Imhof (1886), Entz (1902b, 1905), Schröder (1906a, 1911), Zacharias (1906), Schiller (1911a, 1911b, 1912), and Carazzi and Grandori (1912). Jörgensen (1923) found it to be comparatively well represented throughout the Mediterranean. From the Marmora Sea, Golden Horn, and Bosporus it has been recorded by Zacharias (1906), Lindemann (1923), and Jörgensen (1923). In the Black Sea it was found by Minkiewitsch (1899), Reinhard (1910), and Jörgensen (1923).

From the Red Sea the species has been reported by Ostenfeld and Schmidt (1901), Cleve (1903b), and Karsten (1907); from the Gulf of Aden, by Ostenfeld and Schmidt (1901), Cleve (1903b), Schröder (1906a), and Karsten (1907); from "the coast of Arabia," by Jörgensen (1923, p. 29); from the Arabian Sea, by Ostenfeld and Schmidt (1901), Cleve (1903b), Schröder (1906a), Karsten (1907), and Czapek (1909); from the Indian Ocean, by Cleve (1900f, 1901a), Karsten (1907), and Gräf (1909). In the Antarctic Ocean, south of South Africa, it was found by Karsten (1905) at two stations, viz., at lat. 37° 31′ S., long. 17° 1′ E., and at lat. 41° 5′ S., long. 14° 51′ E.; and by Gräf (1909) at three stations, viz., lat. 39° 56′ S., long. 20° 7′ E., lat. 43° 39′ S., long. 23° 30′ E., and lat. 42° 21′ S., long. 31° 0′ E. Lemmermann (1899a) found it in the Peruvian Current.

Cleve (1901a) recorded this species from the Malay archipelago; van Oye (1921) from Batavia, Java; Gräf (1909) from the north coast of New Guinea; Schmidt (1901) from the Gulf of Siam; Ostenfeld (1915) from the coast of Celebes; Schröder (1906a) from the Formosa Strait; Okamura (1907, 1912) from Japanese waters; Stein (1883) from the "Südsee"; and Whitelegge (1891) from Sydney, on the east coast of Australia.

Karsten (1907) reported the species to have been taken with a closing net between 200 and 100 meters. Most of the remaining records refer to surface hauls.

Some investigators, *e.g.* Jörgensen (1923), have found this species to be "remarkably numerous" or even "abundant" at some localities.

According to the investigators who have contributed to our knowledge of the distribution of this species, it occurs in waters of the following temperatures and salinities. Ostenfeld (1898b): — temperature: range, 47.5°–53.6°; mean of six observations, 50.7°. Salinity: range, 35.25–35.50; mean of six observations, 35.39. Ostenfeld (1899): — temperature: range, 48.6°–53.4°; mean of seven observations, 50.6°. Salinity: range, 35.33–35.55; mean of seven observations, 35.43. Ostenfeld (1902): — temperature, 73.4°; salinity, 36.9. Murray and Whitting (1899): — temperature: range, 55°–86°; mean of 53 observations, 71.0°. Ostenfeld and Schmidt (1901): — temperatures, 80.1° and 79.1°. Cleve (1901a): — temperatures, 53.9° and 80.3°; salinities, 33.71 and 34.69. Cleve (1901c): — temperature: range, 42.8°–81.0°; mean of 100 observations, 65.3°. Salinity: range, 31.01–36.54; mean of 77 observations, 35.54. Cleve (1902a): — temperature, 48.2°; salinity, 35.42. Cleve (1902b): — temperature, 61.4° and salinity, 35.77 (means of 26 observations). Cleve (1903b): — temperature: range, 60.3°–84.7°; mean of seven observations, 73.2°. Salinity: range, 35.77–42.81; mean of seven observations, 37.95. Cleve, Ekman, and Pettersson (1901): — average temperature, 65.3°; average salinity, 35.54. Jörgensen (1905): — temperatures, 39.7° and 39.9°. Stüwe (1909): — temperature, 75.2°. Gräf (1909): — salinity: range, 34.09–36.33; mean of nine observations, 35.13. Van Oye (1921): — salinity, 31.5.

Of the authors mentioned in connection with the distribution of this species, only the following have given descriptions or figures, by means of which their determinations of this species may be checked: — Saville-Kent (1881), Pouchet (1883), Stein (1883), Gourret (1883), Entz (1902a), Czapek (1909), Reinhard (1910), Schröder (1911), Pavillard (1916), Forti (1922), Lindemann (1923), and Jörgensen (1923).

Dinophysis caudata is eupelagic and occurs in tropical, subtropical, and warm-temperate regions of all seas. It has been found in the northern part of the Atlantic, in the North Sea, and in the Norwegian Sea, but it is probably a warm-water species and not endogenetic in these relatively cool regions. The records of the International Council for the Investigation of the Sea "decidedly support the notion that the specimens found in these northern waters are of southern origin, carried to the north by the Gulf Stream" (Paulsen, 1912, p. 290). The species is eurythermal, with an exceptionally wide amplitude of thermal adaptation, viz., 39.7°–85.0°, and euryhaline, occurring in brackish water as well as in waters with a salinity as high as 42.81% (see Jörgensen, 1923, p. 27). It is probably one of the most common representatives of this family (see Cleve, 1901c, p. 240, and Jörgensen, 1923, p. 27). Its distribution in the Eastern Pacific, according to our data, is very peculiar, since almost all the record stations are located in the coastal currents. Its almost complete absence from the South Equatorial Drift is not directly due to the temperature, since this region is thermally intermediate between the relatively cool Peruvian Current and the very warm Mexican Current and Panamic Area, where the species is rather common. The comparatively frequent occurrence of this species in our surface catches (twenty-eight surface records) is another outstanding feature. Of *D. hastata,* which next to *D. caudata* is the most common species of this genus in our surface catches, we have only eight surface records. Furthermore, it should be remembered that some of our surface records of *D. caudata* showed exceptionally high frequencies.

DINOPHYSIS CAUDATA Saville-Kent f. ACUTIFORMIS, nom. f. nov.

Figure 46

Dinophysis homunculus var. *ventricosa* PAVILLARD, 1916, p. 56, fig. 15B. FORTI, 1922, p. 108, 190, 208, fig. 115.

Dinophysis caudata var. *ventricosa* JÖRGENSEN, 1923, p. 25, 27–29, fig. 32, 37.

Diagnosis: — This form, which is rather variable in shape, differs from the main species chiefly in its smaller size and its less-developed peduncle. The body measures 66.7–86.6 μ in length. The peduncle sometimes is fairly well developed, sometimes it is hardly distinguishable; when best developed, its length is about 0.25 the length of the body. The cingular and sulcal lists, as a rule, have less developed structural differentiation than in the main species.

Coastal waters in the Atlantic, Mediterranean, Arabian Sea, and the eastern tropical Pacific.

Dimensions: — Our specimens: Length of body, 71.5–86.6 μ (average, 81.4 μ). Greatest depth of body, 38.5–47.4 μ (average, 44.2 μ). The type specimen, as figured by Pavillard (1916, fig. 15B), was 82.5 μ long and 41.8 μ deep. The specimens figured by Jörgensen (1923, fig. 32, 37) were 66.7–74.0 μ long and 32.0–38.1 μ deep.

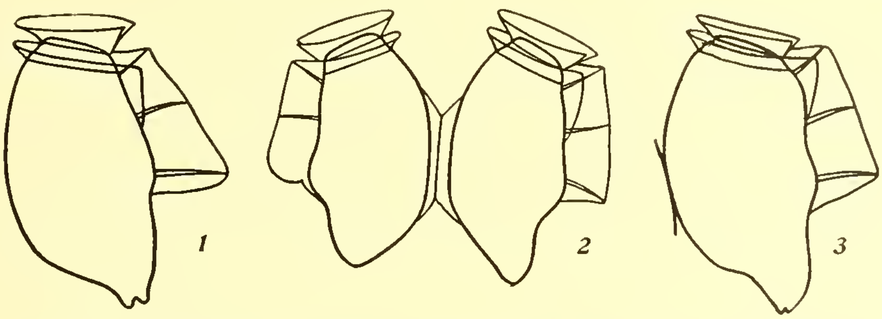

FIGURE 46.— *Dinophysis caudata* Saville-Kent f *acutiformis*, nom. f. nov., right lateral view. 2, two schizonts, not yet detached from each other; 3, two schizonts, one of which is indicated only by a portion of its dorsal margin. × 430. Station 4673 (300–0 fathoms).

Variations: — Judging by the seven specimens as yet figured, this form is rather variable in the size of the body, in the depth and shape of the anterior portion of the body, and in the size and shape of the peduncle. The anterior portion of the body may be rather deep and bulky (Jörgensen, 1923, fig. 32; our Figure 46: 3) or relatively slender (Figure 46: 2), and the peduncle may be well developed (Pavillard, 1916, fig. 15B; Jörgensen, 1923, fig. 32) or hardly distinguishable (the left specimen in Figure 46: 2).

Comparisons: — The specimens found in the material of the Expedition and in the present paper referred to *Dinophysis caudata* f. *acutiformis* agree rather closely with Pavillard's (1916, fig. 15B) figure of the type specimen of this form. They differ from the type and from the specimens figured by Jörgensen (1923, fig. 32, 37) mainly in having, to varying degrees, somewhat less-developed peduncles.

This form has an uncertain systematic status. It may be a distinct species; or it may be a subspecies of *Dinophysis caudata* as assumed in this paper. The evidence bearing on this question is anything but conclusive. Our tentative decision is based on the following facts: — (*1*) While the typical *D. caudata* is rather commonly found in waters far from the coast as well as in coastal waters, *D. caudata* f. *acutiformis* has never been recorded except from near the coast line, where the hydrographical conditions are more or less changeable and different from those of the open sea; (*2*) a series of specimens of *D. caudata* has been found, which is characterized by a gradual decrease in the size of the peduncle. As far as available records go, such specimens, too, have not been taken except near the coast; (*3*) Jörgensen (1923, fig. 37) has figured a specimen in which one valve has a fairly well-developed peduncle and the other valve only a slight indication of a peduncle. For further discussion of the systematic significance of this specimen, see *D. caudata*, the section on variations.

The systematic status of the following two species must also be regarded as uncertain: — *Dinophysis diegensis* Kofoid and its varieties *curvata* Kofoid and *caudata* Pavillard (the name of the last variety is preoccupied and therefore must be changed), and *D. subdiegensis* Jörgensen. These two species have been supposed to be nothing but modifications of *D. caudata*, but they may be independent species. Just as in the case of *D. caudata* f. *acutiformis*, the evidence bearing on the question is of uncertain value. It should be mentioned that, just as *D. caudata* f. *acutiformis*, these two species are not known to have been taken except near the coast line.

Dinophysis diegensis Kofoid is considered a distinct species by Kofoid (1907b, p. 313, pl. 33, fig. 57, 59, 60), Ostenfeld (1915, p. 7), Pavillard (1916, p. 57), and, with hesitation, by Jörgensen (1923, p. 28, fig. 36). It is held as a degenerate form of *D. caudata* by Jörgensen (1923, p. 22, 25, 27; see also Forti, 1922, p. 109). *D. diegensis* var. *curvata* Kofoid (1907b, p. 313, pl. 33, fig. 58, 61) and *D. diegensis* var. *caudata* Pavillard (1916, p. 57, pl. 3, fig. 2; 1923a, p. 881) are considered as degenerate forms of *D. caudata* by Jörgensen (1923, p. 27, 28).

Jörgensen (1923, p. 27, 28, 43, 44, fig. 35) is, at present, the only one who has treated *Dinophysis caudata* var. *subdiegensis*. He first established this form as a distinct species under the name of *D. kofoidi;* then, on page 28 of the mentioned paper, he changed his opinion and treated it as a degenerate form of *D. caudata* under the name of *D. caudata* var. *subdiegensis* (the last name has the priority).

Whatever the systematic status of *Dinophysis caudata* f. *acutiformis*, *D. diegensis*, and *D. subdiegensis* may be, there seems to be but little doubt that they are very closely related to *D. caudata*. Indeed, these forms most probably have overlapping ranges of variation. *D. caudata* f. *acutiformis* is in several respects intermediate between the typical *D. caudata* on the one hand and *D. diegensis* and *D. subdiegensis* on the other.

Synonymy: — This form was established by Pavillard (1916), who described and figured it under the name of *Dinophysis homunculus* var. *ventricosa*. Later Jörgensen (1923, fig. 32) figured it under the name of *D. caudata* var. *ventricosa* and (1923, fig. 37) as "a degenerate form" of *D. caudata*. Forti (1922, fig. 115) reproduced Pavillard's (1916) figure of the type specimen.

Unfortunately, the name *ventricosa*, suggested by Pavillard (1916), must be rejected on account of preoccupation by *Dinophysis ventricosa* Claparède and Lachmann (1858, p. 408).

Occurrence: — *Dinophysis caudata* f. *acutiformis* is recorded at only one (4673) of the 127 stations, on the second line of the Expedition, in the Peruvian Current, and very near the coast. The depth is 300–0 fathoms, the surface temperature 67°, and the frequency less than 1% (three specimens).

This form was first recorded by Pavillard (1916) from the Étang de Thau, an enclosed and very shallow part of the Gulf of Lyons. Later it was found by Forti (1922) in the Ligurian Sea, and by Jörgensen (1923) in the harbor of Lisbon, "in the innermost, less saline region" of the Mediterranean, and on the coast of Arabia, near Ras Dschibsch. There are no records of this form from waters far from the coast line.

Histiophysis, gen. nov.

Dinophysis Kofoid & Michener, 1911, p. 293 *partim*.

Diagnosis: — Body ovate in lateral outline. Epitheca low, about 0.26 as deep as hypotheca. Dorsally transverse furrow is about 0.19 the greatest depth of body and about twice as wide as ventrally. Posterior cingular list about 0.11 the length of body from apex. Anterior cingular list funnel-shaped, ribbed; its dorsal height about 0.30 the greatest depth of body. Posterior somewhat narrower and more inclined than anterior, reticulate but not ribbed. Right sulcal list long, narrow, and reticulated. Left sulcal list ends somewhat ventrally to antapex and increases gradually in width posteriorly, where it is angular and about 0.46 the greatest depth of body; the entire list reticulated; with no main rib behind fission rib.

The type species is *Histiophysis rugosa*.

Histiophysis rugosa (Kofoid and Michener)

Plate 5, fig. 5. Figure 93: 1

Dinophysis rugosa Kofoid & Michener, 1911, p. 293.

Diagnosis: — Body broadly ovate in lateral view; length: depth, 1.08: 1. Posterior cingular list about 0.11 the length of body from apex. Cingular lists funnel-shaped; anterior ribbed, 0.30 the depth of body; posterior finely reticulate, somewhat narrower. Left sulcal list ends somewhat ventrally to antapex; increases gradually in width posteriorly; dorsal margin gently sigmoid, 0.46 the depth of body, forming acute angle of 60° with ventral margin; with only one rib, the fission rib, which is 0.20 the depth of body; entire list reticulate; meshes decreasing in size posteriorly, where they are very small. Theca finely and deeply areolate. Length, 45.7 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, the body of which is broadly ovate in lateral view, broadly rounded posteriorly and rather narrowly rounded anteriorly. It is deepest just behind the middle, and the ratio between the length and the depth is about 1.08: 1. The longitudinal axis is subperpendicular, slightly deflected posterodorsally.

The epitheca is about 0.26 as deep as the hypotheca; its shape is unknown but is probably gently convex. Dorsally the transverse furrow is about 0.19 the greatest depth of the body and about twice as wide as ventrally; its shape is unknown. The posterior cingular list is about 0.11 the length of the body from the apex. The hypotheca is subcircular, somewhat narrower anteriorly than posteriorly, and its margins are confluent.

The anterior cingular list is sessile, with a well-developed funnel shape and an anterior inclination of about 35°; it flares about twice as much dorsally as ventrally, with the dorsal side more concave than the ventral; with flat, slightly inclined top; its height is about 0.30 the greatest depth of the body, and it has on each valve about 11–13 ribs; most of these are complete and simple, others are incomplete or anastomose proximally. The posterior cingular list is somewhat narrower and more inclined than the anterior; it lacks ribs but is finely and rather heavily reticulated throughout. The right sulcal list is long, narrow, and finely and rather heavily reticulated throughout; it extends to the fission rib of the left sulcal list, *i.e.*, to a point about two thirds the way from the apex to the antapex; it is of subuniform width throughout, and its width about equals 0.06 the greatest depth of the body. The left sulcal list ends somewhat ventrally to the antapex and increases gradually in width posteriorly. Its ventral margin is strongly and somewhat irregularly convex except anteriorly and posteriorly, where it is gently concave. Its dorsal margin (postmargin) has a posteroventral inclination of about 25°, is gently sigmoid, concave anteriorly and convex posteriorly, forms an acute angle of about 60° with the ventral margin, and its length is about 0.46 the greatest depth of the body. The list has only one rib, the fission rib, located at a point about two thirds the way from the apex to the antapex, deflected posteriorly at about 20°, and measuring 0.20 the greatest depth of the body. In front of this rib the list is irregularly and rather coarsely reticulated, most of the meshes being elongated transversely, and the margin is finely undulating. Behind this rib the list is finely and rather heavily reticulated, the meshes decreasing in size posteriorly, and the margin is not undulating but smooth.

The thecal wall is finely, deeply and regularly areolate. Across the middle of each valve there are about twenty-two areoles. Some phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen only, the type, were measured.

Dimensions: — Length of body, 45.7 μ. Greatest depth of body, 42.8 μ.

Comparisons: — Our description and figure are based on the type specimen.

Synonymy: — This species was established by Kofoid and Michener (1911) under the name of *Dinophysis rugosa*.

Occurrence: — *Histiophysis rugosa* is recorded from only one (4705) of the 127 stations, on the fourth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 72°. The frequency is less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4705 of the Expedition, which thus is the type locality.

2. AMPHISOLENIDAE, fam. nov.

Diagnosis: — Body divided, for purpose of description, into five regions: — head, neck, anterior process, midbody, and antapical (or antapicals). Sometimes strikingly elongated, straight, or somewhat sigmoid; with two long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process, the other posterior, forming the antapical; and with longitudinal axis of body passing through regions from which anterior process and antapical originate. Sometimes seemingly tripartite, with three long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process, and two posterior, the antapicals, one dorsal, the other ventral in origin; the three extensions generally subequal, approximately balanced, and their length 1.0–3.4 the dorsoventral diameter of midbody measured between bases of antapicals.

Head encircled by girdle; its axial length 0.11–1.00 the length of neck; its dorsoventral diameter (width) 0.5–10.0 its axial length. Epitheca very small; its axial length less than half that of head; its anterior face convex to concave. Neck elongated, cylindrical or slightly flattened bilaterally, 0.02–0.28 the length of body and 2.5–22.0 times longer than wide. Anterior process somewhat wider than neck; when set off from midbody, it is about as long as, or generally somewhat shorter than, neck. Midbody more or less compressed bilaterally, in lateral view of varying shapes, fusiform, ovoidal, subtriangular, subrotund, subellipsoidal or sack-shaped. Antapical (or antapicals) of varying lengths, 0.9–33.0 the length of neck, and about as wide as or slightly wider than neck.

Distal portion of girdle not displaced posteriorly. Transverse furrow flat or somewhat convex or concave, of subuniform width throughout and somewhat narrower than and slightly oblique to head. Longitudinal furrow at most but slightly impressed, extending from girdle to base of neck; it does not extend beyond the girdle, *i.e.*, into the epitheca. Cingular lists subequal or nearly so, of moderate height, 0.5–3.0 the width of transverse furrow, hyaline, and generally ribbed, the anterior one with midventral gap. Sulcal lists also of moderate height, extending to or somewhat beyond flagellar pore, simple, less differentiated than in other families, hyaline, and frequently without ribs; fission rib, when present, near flagellar pore. Flagellar pore displaced to posterior end of neck. Transverse flagellum extending from flagellar pore into girdle and around head. Longitudinal flagellum not observed with certainty.

Thecal wall in most cases apparently without structure, seldom striate, pitted or locally reticulate. Nucleus located in midbody. Pusule developed, opening into flagellar pore. Chromatophores, if present, pale yellowish green, brownish, or colorless.

Length of body ranging from 92 μ to 1520 μ.

Marine and eupelagic, probably of wide distribution in tropical, subtropical, and warm-temperate waters.

Subdivisions. Relationships between the Genera

In the present paper all the known species of the family Amphisolenidae have been assigned to either of two genera, Amphisolenia and Triposolenia. These two genera, which probably represent natural systematic units, are sharply set off from each other. Although, at the first glance, they appear to present two rather different types, there seem to be good reasons in favor of the supposition that they are closely related. Their close relationship is indicated by the following structural characteristics. (*1*) The anterior portion of the body, which for the purpose of description is divided into three regions, head, neck and anterior process, is prolonged and attenuated. (*2*) The head as a rule is short and is surrounded by the girdle. The epitheca is therefore very short. (*3*) The neck is comparatively long and narrow. (*4*) The flagellar pore is displaced to the posterior end of the neck. (*5*) The transverse furrow is somewhat narrower than and slightly oblique to the head. The longitudinal furrow extends from the girdle to the posterior end of the neck and does not extend into the epitheca. (*6*) The cingular lists are subequal or nearly so, of moderate height, 0.5–3.0 the width of the transverse furrow, hyaline, and generally ribbed. The sulcal lists are also of moderate height, simple, less differentiated than in the other families of this tribe, hyaline, frequently without ribs, and extend to or somewhat beyond the flagellar pore. The fission rib, when present, is near the flagellar pore. (*7*) Around the flagellar pore a cytopharyngeal protuberance generally is developed. (*8*) The portion of the body which is just behind the anterior process is inflated and contains the nucleus. (*9*) The posterior portion of the body is prolonged and attenuated. (*10*) In Triposolenia the middle portion of the body is always bifurcated. In the most highly differentiated species of Amphisolenia, viz., those belonging to the Bifurcata group, the posterior portion of the body has one or more branches. This constellation of characters differentiates these two genera from all other known genera of Dinophysoidae.

The distinctive characters of Triposolenia, when compared with those of Amphisolenia, are: — (*1*) the shape of the strongly bilaterally compressed midbody, (*2*) the presence of two antapical processes arising from the midbody, one dorsal, the other ventral in position, both in most species being almost similar in size and the one the mirror image of the other, and (*3*) the fact that the longitudinal axis of the body does not pass through the region of the midbody from which arises the antapical process that corresponds to the original posterior portion of the body. The relation which the midbody in Triposolenia bears to its three approximately balanced processes, viz., the anterior process with the neck and the head, and the two antapicals, strikingly distinguishes this genus from all the other known genera of Dinophysoidae. In Amphisolenia, (*1*) the midbody in most cases is decidedly less compressed bilaterally than in Triposolenia, (*2*) only one antapical process arises from the midbody, and (*3*) the longitudinal axis of the body passes through the region of the midbody from which the antapical originates.

With regard to the shape of the midbody transitional types between these two genera do exist, *e.g.*, *Amphisolenia inflata;* but with regard to the number and position of antapical processes no transitional types have been found as yet, but accessory antapical processes in Amphisolenia arise solely from the antapical and not from the midbody.

There seems to be but little doubt that, among the species of Amphisolenia hitherto described, *A. inflata* is the one that is most closely related to Triposolenia. It can be regarded as equally certain that, among the known species of Triposolenia, *T. truncata* is the one most closely related to Amphisolenia. These two species show important similarities in the following respects: — (*1*) the concavity of the anterior face of the epitheca, a character not found in any other species of these two genera; (*2*) the very distinct structural differentiation of the thecal wall which is almost identical in the two species in spite of its relative complexity and is unique as far as these two genera are concerned; (*3*) the well set off anterior process, and the relatively large, bilaterally compressed midbody; (*4*) the absence of antapical tubercles; (*5*) small size of the body. The coexistence of all these characters is most probably not the result of convergence but of common inheritance. If this statement is correct, then *Amphisolenia inflata* represents a type rather similar to the ancestral type of the genus Triposolenia; and *Triposolenia truncata* is the most primitive of all the known members of its genus. On the other hand, it does not follow that *Amphisolenia inflata* is necessarily the most primitive species of its genus. It is, of course, possible that Triposolenia originated from Amphisolenia after the latter had passed through a period of differentiation. The position of *Amphisolenia inflata* in the natural system must be judged in the light of facts gathered from a comparative morphological study of Dinophysoidae. Such a study shows that this species occupies a rather isolated position in Amphisolenia, and that it probably is one of the most primitive, possibly the most primitive, of the known species of this genus. The following of its characters appear to be more or less primitive: — (*1*) the small size of the body; (*2*) the straight longitudinal axis of the body; (*3*) the exceptionally large, bilaterally compressed midbody; (*4*) the simple, unbranched antapical; (*5*) the well-developed areolation and reticulation of the thecal wall; (*6*) the reticulation of the sulcal lists; (*7*) the continuation of the sulcal lists beyond the flagellar pore to the posterior end of the anterior process. The question as to whether or not the concavity of the anterior face of the epitheca of this species is primitive cannot be settled as yet. It is a peculiarity of this species and of *Triposolenia truncata* which has not been found in any of the primitive genera of Dinophysoidae. We also leave the question open as to whether or not the peculiarity of having the anterior process well set off from the midbody is a primitive feature.

The result of this analysis is therefore: — (*1*) that the genera Amphisolenia and Triposolenia are more closely related to each other than to any other genus of this tribe; (*2*) that Triposolenia probably originated from an ancestral form of about the same habitus as *Amphisolenia inflata;* and (*3*) that of the known species of these two genera *Amphisolenia inflata* and *Triposolenia truncata* probably are the most primitive.

Did Triposolenia originate from Amphisolenia by a sudden duplication of the antapical, or by a gradual development of the accessory antapical, in other words, in the same way as *Dinophysis miles* Cleve probably arose from the *Dinophysis caudata* type? This problem cannot be settled as yet. The first alternative appears to be supported by the fact that the antapicals are better balanced in *Triposolenia truncata* than in most of the remaining species of this genus. Furthermore, sudden duplication of parts is a phenomenon frequently met with in Nature. The second alternative is not supported by the shape and the relative size of the antapicals in any of the known species of Triposolenia. On the other hand, the geniculation at the junction of the anterior process and the neck may possibly indicate that the anterior portion of the body, in order to maintain a state of equilibrium, may have been tilted first ventrally and then dorsally during a gradual growth of the accessory antapical. The ventral antapical, which in this case would correspond to the original posterior portion of the body, for the same reason may have shifted ventrally at the same time.

Distribution

The two genera of the family Amphisolenidae probably are exclusively marine and eupelagic and seem to be confined to waters of tropical, subtropical, and warm-temperate nature or origin. Both of them probably have a world-wide distribution in these waters, but as yet the genus Triposolenia has been recorded only from the eastern portion of the Pacific, from the southwest coast of Portugal, from the Mediterranean and from the Marmora Sea.

Most of the species appear to be rare. Some of the species of Amphisolenia have been recorded rather frequently from surface waters, but the optimum habitat of both genera appears to be in the deeper levels of photosynthesis, predominantly above 200 meters.

Key to the Genera

1. Midbody with one antapical which is sometimes divided distally	Amphisolenia Stein, 1883.
2. Midbody with two antapicals....................................	Triposolenia Kofoid, 1907.

Amphisolenia Stein

Amphisolenia Stein, 1883, p. 24. Bütschli, 1889, p. 945, 1010. Schütt, 1896, p. 28. Delage & Hérouard, 1896, p. 385.

Diagnosis: — Body strikingly elongated, straight or somewhat sigmoid, often asymmetrical posteriorly. With two long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process, the other posterior, forming the antapical. Longitudinal axis of body passing through regions from which anterior and posterior extensions originate. In some species the posterior part of the antapical has one to four ventral branches.

The type species is *Amphisolenia globifera.*

Organology:—While for the sake of simplicity in quantitative determinations of structural features, in Triposolenia a more or less arbitrary longitudinal axis of the body has to be chosen, in Amphisolenia the original and, for most genera of Dinophysoidae, the typical axis can be utilized. In the species of Amphisolenia with an unbranched antapical, the longitudinal axis of the body either is straight or nearly so, or it has a slight or moderate sigmoid curvature, with the neck somewhat deflected dorsally and the antapical more or less concave ventrally. In some of these species the posterior portion of the antapical is bent ventrally, as in *A. astragalus* (see this species, the section on comparisons), or to the right, as in *A. clavipes* and *A. lemmermanni*, at an angle of about 25°–50°. In the species with a branched antapical, *e.g.*, in *A. quinquecauda*, the antapical often is characterized by a more or less strikingly developed sigmoid curvature in the dorsoventral plane; in other words, the longitudinal axis of the body may have a double sigmoid curvature. Sometimes the diversifications in the longitudinal axis of the body are accompanied by sinistral torsion.

The body is strikingly elongated, with two long and narrow extensions arising from midbody, one anterior made up of head, neck, and anterior process, the other posterior, forming the antapical. Just as in Triposolenia, the body in Amphisolenia frequently is characterized by a combination of asymmetry, both bilateral and dorsoventral, with a condition of balance.

The *head* (*hd.*, Figure 47) is composed of the very short epitheca, the girdle region, and a short, generally expanded region at the anterior end of the neck. It is encircled by the transverse furrow, which covers about two thirds or even more of its axial length. Its form and size vary rather strikingly in the different species. It is bilaterally compressed, and its transdiameter is not much greater than that of the neck. In most species it is small, its axial length being between 0.11 and 0.30 the length of the neck and its dorsoventral diameter (its "width," according to the terminology utilized in this paper) between 1.0 and 4.0 its axial length. In *Amphisolenia inflata* it is 0.38–0.50 the length of the neck and about twice as wide as long. In *A. laticincta* it is about 1.0 the length of the neck and 0.5 as wide as long. In *A. asymmetrica* it is 0.13–0.14 the length of the neck and not less than 9–10 times wider than long. In lateral view, the anterior face of the head, *i.e.*, the epitheca, is more or less convex in most species; sometimes it is flat and in one species, *A. inflata*, even quite concave. In a few species the head is subhorizontal, but generally it is more or less inclined, about 5°–45°, anteriorly, that is, its dorsal end is elevated.

The *neck* (*n.*, Figure 47) is an elongated, slender, and almost cylindrical extension of the anterior process. Its length, measured in a straight line from the posteroventral point of the head to the flagellar pore is 0.02–0.26 the length of the body. It is 2.5–22.0 times longer than wide, of nearly uniform caliber throughout, almost straight or gently curved dorsally, and generally slightly, 1°–20°, deflected dorsally from the longitudinal axis of the body. In most species the neck passes more or less abruptly into the head; in *Amphisolenia laticincta*, which has a head but slightly wider than the neck, the transition is gradual.

The *anterior process* (*ant.p.*, Figure 47), or the proabdomen according to Stein's (1883) terminology, is an anterior extension of the midbody. Contrary to the

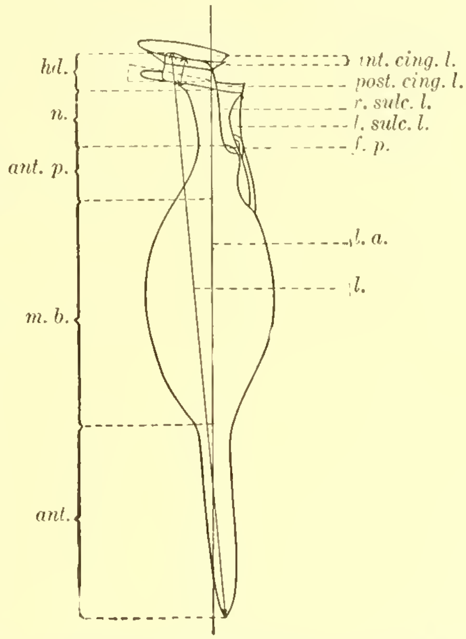

FIGURE 47.—*Amphisolenia inflata* Murray and Whitting, right lateral view. × 525. Station 4681 (300–0 fathoms). The length of body is measured in a straight line from foremost point of head to tip of antapical (in species with branched antapical, to tip of main stem of antapical). Our method of measuring the (axial) length of head is indicated by bicapitate barbed line crossing the head. The length of neck is the distance in a straight line from posteroventral point of head to flagellar pore. The length of anterior process is the distance in a straight line from midpoint of flagellar pore to midpoint of base of process. The lengths of midbody and antapical are measured in straight lines. (The lengths of antapical branches, on the other hand, are measured along curvatures from midpoints of bases of branches to tips.) Our method of measuring the anterior inclination of head is indicated by two dotted lines and a dotted arc; one of the lines is perpendicular to the longitudinal axis of body, the other runs parallel to dorsoventral midline of head.

Abbreviations:—*ant.*, antapical; *ant. cing. l.*, anterior cingular list; *ant. p.*, anterior process; *f.p.*, flagellar pore; *hd.*, head; *l.*, length of body; *l.a.*, longitudinal axis of body; *l. sulc. l.*, left sulcal list; *m.b.*, midbody; *n.*, neck; *post. cing. l.*, posterior cingular list; *r. sulc. l.*, right sulcal list.

anterior process in Triposolenia, it is usually very slightly, 1°–8°, deflected ventrally from the longitudinal axis of the midbody, which passes through the middle of its posterior end. Its length, measured in a straight line from the midpoint of the flagellar pore to the midpoint of the posterior end of the process (Figure 47), generally is very hard or even impossible to establish with accuracy. This is due to the fact that the process in most species merges gradually or even imperceptibly into the midbody. In a few species only, *e.g.*, in *Amphisolenia inflata*, the anterior process is rather well set off from the midbody. Sometimes, *e.g.*, in *A. inflata*, it is short and wide, 0.08–0.10 the length of the body and about as wide as long; sometimes, *e.g.*, in *A. schauinslandi*, it is long and narrow, approximately 0.16 the length of the body and about seven times longer than wide. Only exceptionally, as in *A. schauinslandi*, it is longer than the neck. It is almost cylindrical or slightly compressed bilaterally. In lateral view, it generally is 1.5–3.0 times wider than the neck. In some species it forms around the flagellar pore a more or less distinct *cytopharyngeal protuberance*. Just behind the flagellar pore there is in most species a longitudinal depression, which may be called the *cytopharyngeal depression* (Plate 13, fig. 1). As far as our experience goes, the shape and the size of this depression cannot be utilized as specific characters, and nothing is known as to the significance of this structure.

The *midbody* (*m.b.*, Figure 47), or abdomen according to Stein's (1883) terminology, sometimes, *e.g.*, in *Amphisolenia inflata*, is well set off from both the anterior process and the antapical; sometimes, *e.g.*, in *A. laticincta*, it is well set off from the antapical but merges imperceptibly into the anterior process; in most species it merges more or less gradually into both the anterior process and the antapical; in a few species, *A. bispinosa* and *A. palaeotheroides*, it passes even imperceptibly into both the anterior process and the antapical. In *A. inflata* it is strongly compressed bilaterally, in the other known species the bilateral compression is rather slight. Seen from the side, its width and its shape are rather variable, not only in the different species but also within the species; for a possible explanation of the variability of the width of the midbody within the species, see the section on "Adaptive and systematic value of the characters" (p. 63). In *A. inflata*, the midbody of which is relatively very wide, the ratio between the length and the greatest width of the body is 4.2–4.3: 1; in *A. bidentata*, which is characterized by a very narrow midbody, the corresponding ratio is 46.3 (30.3–67.7): 1. The relative length of the midbody is very variable. In *A. brevicauda* the total length of the anterior process and the midbody about equals 0.50 the length of the body; in *A. extensa*, which is an extreme in the opposite direction, the corresponding value is about 0.12. In *A. inflata* the midbody is ovoidal in lateral view; in *A. brevicauda* its dorsal margin is almost straight or even slightly concave, its ventral margin moderately convex; in all the other known species it is fusiform, generally narrowly fusiform.

The *antapical* (*ant.*, Figure 47), or postabdomen according to Stein's (1883) terminology, is a narrow, posterior extension of the midbody, a prolongation of the thecal wall with protoplasmic core. The longitudinal axis of the body passes through the middle of its anterior end. As mentioned in the last paragraph, the antapical sometimes is well set off from the midbody, sometimes it merges more or less gradually, even imperceptibly, into the latter. Its relative length is exceedingly variable. In *Amphisolenia brevicauda* it is only about 0.9 the length of the neck and 0.4 the total length of the anterior process and the midbody; in *A. extensa* it is 22–33 times longer than the neck and 4–7 times longer than the total length of the anterior process and the midbody. It is about as wide as or somewhat wider than the neck, of almost circular cross-section or but slightly flattened bilaterally, and in most species of uniform width throughout the greater part of its length; sometimes it tapers gently posteriorly, or its posterior part is more or less inflated, *e.g.*, in *A. thrinax* (Plate 12, fig. 6). In most of the species the antapical is unbranched, in some of them it is branched.

Species with unbranched antapical: — In the most primitive of the species with unbranched antapical, *e.g.*, in *Amphisolenia inflata*, the antapical is straight, and its two valves are symmetrical. In some species, *e.g.*, in *A. curvata*, the antapical is characterized by a slight or moderate ventral concavity; in others its posterior part is bent ventrally, as in *A. astragalus*, or to the right, as in *A. clavipes* and *A. lemmermanni*, at an angle of about 25°–50°. The posterior portion of the antapical exhibits a rather striking variety of types and is very important in the characterization of the species. In *A. brevicauda*, for instance, this portion of the antapical tapers to a simple, acute point, without spinules or other structural differentiations. In *A. laticincta* it is rounded, not inflated, and has one minute spinule on the antapex (in fully developed specimens probably one spinule on each valve). In the species of the Extensa group it is slightly club-shaped, subtruncate, without spinules or with four or fewer exceedingly minute spinules on the antapex. In *A. schauinslandi* and in *A. rectangulata* it is truncate, rectangular, sometimes slightly inflated, and furnished with four short, acute spinules on the antapex, one on each of the four corners and two on each valve. In *A. inflata* and in the species of the Bispinosa group it is not or but slightly inflated, truncate in dorsoventral view, and has two lateral spinules on the antapex, one on each valve. In the Globifera group it forms a knob-like expansion, in front of which there is a short, neck-like constriction; the antapex sometimes has four, sometimes two, and sometimes no spinules. In *A. schröderi* and *A. clavipes* it is more or less inflated and bent to the right, and has, on the antapex, two sagittal spinules, both probably belonging to the left valve. In the Palmata group the posterior part of the antapical is bent to the right, somewhat inflated, truncate, and furnished with the following spinules: — at the point of bending the left valve has a rather strong, pointed, heel-like spinule; sometimes, *e.g.*, in *A. bidentata*, the antapex has two short, pointed, and fairly strong spinules on the left valve, one on each corner, but no spinule on the right valve; in other species, *e.g.*, in *A. palmata*, it has, besides these spinules of the left valve, one spinule on the right valve placed between the two spinules on the left valve.

Species with branched antapical: — In the species with branched antapical, the antapical stem often is characterized by a more or less strikingly developed sigmoid curvature in the dorsoventral plane (Plate **12**, fig. 6). Species with one, two, three, and four branches have been found. The branches originate along the sagittal suture and in binary fission therefore are split in half. As far as we have been able to establish, they are always ventral in origin. Sometimes the branches are almost straight, but generally they are curved or gently sigmoid. When the antapical is bifurcate, the posterior end of the main antapical stem and of the branch have about the same shape and structure as the posterior end of the antapical in *Amphisolenia palmata*. (With regard to *A. projecta*, see this species.) When two, three, or four branches are developed, the posterior end of the main antapical stem and of the proximal branch have about the same shape and structure as the posterior end of the antapical in *A. palmata;* the remaining one to three branches have no heel-spinule but only two or three distal spinules (Plate **13**, fig. 9–13).

The *transverse furrow* (Plate **13**, fig. 1, 6, 8, 14) forms an equatorial band around the short head and covers about two thirds or even somewhat more of its axial length. Its distal portion is not displaced posteriorly, *i.e.*, the furrow does not form a spiral about the head. Sometimes it is almost perpendicular to the longitudinal axis of the body, but in most species it is inclined anteriorly, due to the anterior inclination of the head; however, its inclination, as a rule, is somewhat less than that of the head. Its floor is flat or somewhat concave or convex; this character seems to be variable even within the species.

The *longitudinal furrow* (Plate **13**, fig. 1, 14) is long and extends in about a straight line from the transverse furrow to or a little beyond the posterior end of the neck. Anteriorly it does not extend beyond the girdle, *i.e.*, into the epitheca. It is at most but slightly impressed.

The *lists of the furrows* are not excessively developed. They arise from low and narrow basal ridges (Plate 13, fig. 1, 8), and are hyaline and exceedingly delicate. Frequently (Plate 13, fig. 6) the basal ridges of the two cingular lists are connected by a varying number of simple, low, narrow, and often almost equidistant cross-ridges. In most species these cross-ridges are very regular, but sometimes they are more or less irregular (Plate 13, fig. 8).

The *anterior cingular list* (*ant. cing. l.*, Figure 47) is a flaring sheet, open ventrally, of moderate and almost uniform width throughout the greater part of its length, and as wide as or about two to three times wider than the transverse furrow. It has a number of cross-ribs, which in most cases are simple and nearly equidistant, but sometimes, as in *Amphisolenia inflata*, are branched and not equidistant. The number of cross-ribs is very variable; from two to more than twenty-five on each valve have been observed. Sometimes the list is subhorizontal, but on the dorsal side of the head it generally flares anteriorly at an angle of about 10° to 40° from the transverse plane of the girdle.

The *posterior cingular list* (*post. cing. l.*, Figure 47) either has about the same width, inclination, and structure as the anterior, or else it is somewhat narrower and less inclined anteriorly, and its ribs are less developed, sometimes even absent.

The *sulcal lists* (*r. sulc. l.*, and *l. sulc. l.*, Figure 47), which form a direct continuation of the posterior cingular list, run about parallel to each other along the whole length of the neck. Posteriorly they diverge a little to enclose the flagellar pore, which is on the right valve. The left list either ends at the side of the flagellar pore, or it crosses the sagittal suture near the pore and continues for a rather short distance along the ventral side of the right valve of the anterior process. The right list generally ends at the side of the flagellar pore, but sometimes, as in *Amphisolenia inflata*, it continues along the ventral side of the anterior process. Both lists are of moderate width and generally are somewhat narrower than the cingular lists; the right list, as a rule, is slightly narrower than the left. Their width and shape are variable, even within the species. In most cases these lists decrease in width posteriorly, but sometimes they are characterized by a moderate increase in width near the flagellar pore. In some species, *e.g.*, in *A. laticincta* and *A. curvata*, there is what we have termed an *accessory sulcal list* arising from the originally free edge of the left sulcal list. The significance and morphological value of this structure are not known. However, it probably is a part of the left sulcal list that is resorbed in binary fission and regenerated after the development of the other parts of the daughter individuals. With regard to the structural differentiation of the sulcal lists, the genus exhibits very little variety. In most cases the lists apparently are without structure, but sometimes the left list has a rib at the place where it crosses the sagittal suture. This rib is undoubtedly homologous with the *fission rib* of the left sulcal list in other genera of Dinophysoidae (Plate 13, fig. 6; see the section on the reproduction of the genus). Sometimes, as in *A. inflata*, the anterior parts of the lists are reticulated, or, *e.g.*, in *A. extensa*, they are furnished with irregular ribs. In *A. inflata* the left list has a characteristic thickened area near the flagellar pore and in front of this a cross-rib.

The *flagellar pore* (*f.p.*, Figure 47), or the mouth according to Stein's (1883) terminology, is a fairly large opening at the posterior end of the neck, or to express it in another way, at the anteroventral end of the anterior process. It leads into a narrow funnel, named the *flagellar fundus* by Willey and Hickson (1909, p. 187). It is located on the right valve (Plate 13, fig. 1), is ventrally surrounded by the cytopharyngeal protuberance, and its left lip is somewhat higher than the right; it therefore is directed anteriorly and somewhat to the right.

Nothing is known with certainty as to the characteristics of the *flagella*. However, in these structures Amphisolenia probably agrees with Triposolenia. In other words, the *transverse flagellum* probably arises in the flagellar pore, passes anteriorly between the sulcal lists, and encircles the head from the left around to the right as in all known girdled dinoflagellates. The *longitudinal flagellum* probably is rather short. The flagellum found in *Amphisolenia schauinslandi* (Plate 7, fig. 3) corresponds to the longitudinal flagellum in that it does not have the close-set sinuosities, which so often characterize the transverse flagellum when fixed in formalin.

The *thecal wall* is rather thin and of nearly uniform thickness, except in spinules and other structural differentiations of the antapical. In most species it is hyaline and, under comparatively low magnifications, apparently without structure. However, when these species are examined under high magnifications, the thecal wall proves to be faintly and minutely spotted or flecked. In *Amphisolenia inflata* it is characterized by plainly visible pits and reticulations; this undoubtedly is the more primitive condition. In a great number of species minute pores, frequently arranged in longitudinal rows, are found on the neck and on the posterior portion of the antapical. Sometimes minute pores also are found on the head, anterior process, and midbody. In the species with two or more branches on the antapical, the posterior part of the original antapical stem and of the proximal antapical branch is porulate, but the remaining antapical branch or branches lack pores.

The *sagittal suture* of the two valves is marked by a rather faint line and by pores (see the section on the reproduction of this genus). The three *plates*, epithecal, cingular, and hypothecal, of each valve have not been found parted in any of the specimens examined by us.

The *protoplasmic contents* are hyaline and coarsely granular. The *nucleus*, which is located in the midbody, has a moniliform chromatin reticulum, and is either ellipsoidal, more or less elongated in the major axis of the body, or somewhat irregular. Near the nucleus there is a *pusule*, which opens by a slender canal into the flagellar pore. When present, the *chromatophores* either are small and spherical to ellipsoidal, or they are rather large and cylindrical to rod-shaped (Plate **9**, fig. 6; Plate **11**, fig. 11). In most cases their color appears to be pale yellowish green; sometimes they are brownish or almost colorless. *Metaplasmic inclusions* of different sizes and nature often are found in the cytoplasm. Structures resembling phaeosomes have been found by us only in *Amphisolenia quadrispina*.

The *length of the body* is measured in a straight line from the foremost point of the head to the hindmost point of the antapicals, or, in species with branched antapical, to the hindmost point of the main stem of the antapical. It is a very variable character within the species as well as within the genus. For the genus as a whole the range of variation in length thus far established is 117 μ to 1520 μ.

Reproduction

Binary fission has been observed in a few species. The fission line, or the sagittal suture, has the following course. On the dorsal side of the body: — along the middle of the head, neck, anterior process, midbody, and antapical. On the ventral side of the body: — along the middle of the head, along the left side of the sulcus, crossing the left sulcal list at the fission rib just in front of the flagellar pore, to the left of the flagellar pore and the cytopharyngeal depression, along the middle of the anterior process, midbody and antapical, and in the case of species with branched antapical, along the middle of the antapical branch or branches. In other words, the right valve is slightly larger than the left and includes the whole longitudinal furrow, flagellar pore, and cytopharyngeal depression. The left sulcal list is divided; its anterior, larger part belongs to the left valve, its posterior part, behind the fission rib, belongs to the right valve (Plate **13**, fig. 1, 6, 8). The posterior part of the left sulcal list is not always developed. The fission line in Amphisolenia thus has about the same morphological course as in other genera of Dinophysoidae in which fission has been studied. It may be noted that while the fission rib is in front of the flagellar pore in Amphisolenia, it is behind this pore in most of the other genera of this tribe, *e.g.*, in Triposolenia, Phalacroma, and Dinophysis.

The cingular and the sulcal lists and the antapical spinules are not resorbed in binary fission (Plate 13, fig. 1, 6, 8; Plate 11, fig. 6). Nothing is known as to the time required for the formation of these structures on the new valve. However, the fact that most of the specimens of this genus examined by us had these structures fully developed seems to indicate that the structural differentiation of the new valve takes place rather rapidly. The question as to the time required for the complete development of the antapical spinules of the new valve is, of course, of the greatest importance to the systematist (see *Amphisolenia bidentata* and *A. truncata*). Its solution may throw light on the value of characters utilized in the separation of species in this genus.

It should be noted that what we have termed the accessory sulcal list may possibly be a part of the left sulcal list that is resorbed in binary fission and regenerated after the development of the other parts of the daughter individuals.

In some species the posterior part of the antapical is characterized by what we have interpreted as a hyaline sheath; see *Amphisolenia globifera, A. bidentata, A. lemmermanni*, and *A. asymmetrica*. The presence of such a sheath is possibly a sign of recent binary fission. The material of this region is possibly associated with the thickening of this part of the thecal wall.

Megacytic stages have not been recorded as yet in Amphisolenia. However, we have established that individuals taken shortly after the separation of the two daughter cells in binary fission are narrower, even in the dorsoventral plane, than other individuals of the same species, and that the dorsoventral width of the midbody is a very variable character (see *A. bidentata* and *A. asymmetrica*). These facts seem to indicate that there is a decrease in the width of the body during binary fission and a gradual increase in the width during the period between two consecutive binary fissions. If such an increase in width does take place, it is doubtless accomplished by means of intercalary growth along the sagittal suture edges of the two valves in the same way as in the megacytic stages of the genera Phalacroma and Dinophysis.

Sexual reproduction has not been observed as yet.

Distribution

A rather large number of writers have contributed to our knowledge of the distribution of the genus Amphisolenia, and the data available are fairly extensive. Unfortunately, only a few of these data are accompanied by drawings or descriptions by means of which the determinations may be checked (see the historical section).

The genus is marine and probably exclusively eupelagic and has a world-wide distribution in tropical, subtropical, and warm-temperate waters. There is no indication of its occurrence outside of waters of tropical, subtropical, or warm-temperate nature or origin.

Most of the species seem to be rare (Hensen, 1911, tab. 13), but occasionally some of them have been found in rather great numbers (see, for instance, Schröder, 1906a, p. 326). Some of the species occur rather frequently in surface waters, but most of them seem to be more or less limited to the deeper levels of photosynthesis (Karsten, 1907, p. 442, 444). However, it should be mentioned, that very few data based on catches made with closing nets are published at the present time. The following closing-net records from Karsten's (1907) report on the phytoplankton of the Valdivia expedition are the only ones published at the present time. *Amphisolenia bidentata* was found, at Station 268, in catches from 17–0 m., 24–4 m., 30–0 m., 63–46 m., and 105–88 m.; all the individuals were reported as "living." *A. palmata* was taken at Station 191; however, the depth recorded, 100–85 m., is indicated as questionable. *A. thrinax* was taken at the following stations: — Station 218, 80–40 m., dead, 80–60 m., living; Station 221, 185–145 m., "tot? doch mit Plasmainhalt"; Station 236, 100–65 m., living; Station 239, 60–45 m., living; Station 268, 21–4 m., living.

Representatives of *Amphisolenia* were found at 78 (61.4%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These 78 stations are distributed over the whole area covered by the Expedition in the following manner (Plate 26): —

4 (100.0%) out of the 4 stations in the California Current
9 (69.2%) out of the 13 stations in the Mexican Current
7 (41.2%) out of the 17 stations in the Panamic Area
9 (33.3%) out of the 27 stations in the Peruvian Current
7 (70.0%) out of the 10 stations in the Easter Island Eddy
1 (25.0%) out of the 4 stations in the Galapagos Eddy
35 (77.8%) out of the 45 stations in the South Equatorial Drift
3 (100.0%) out of the 3 stations in the South Equatorial Current

2 (100.0%) out of the 2 stations in the Equatorial Counter Current
1 (50.0%) out of the 2 stations in the North Equatorial Current

The numbers of these seventy-eight stations are as follows: 4571, 4574, 4580, 4583 (California Current); 4587, 4588, 4590, 4592, 4594, 4596, 4598, 4605, 4545 (Mexican Current); 4609, 4613, 4617, 4623, 4634, 4638, 4640 (Panamic Area); 4646, 4648, 4650, 4659, 4662, 4666, 4667, 4668, 4676 (Peruvian Current); 4689, 4691, 4694, 4695, 4697, 4699, 4700 (Easter Island Eddy); 4713 (Galapagos Eddy); 4679, 4681, 4683, 4688, 4701, 4705, 4707, 4708, 4709, 4711, 4712, 4717, 4718, 4719, 4720, 4721, 4722, 4723, 4724, 4725, 4727, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4735, 4736, 4737, 4738, 4739, 4740, 4741 (South Equatorial Drift); 4742, 4743, 4540 (South Equatorial Current); 4541, 4542 (Equatorial Counter Current); 4543 (North Equatorial Current).

At fifty of these seventy-eight stations Amphisolenia was taken in vertical hauls and at thirty-two stations in surface hauls. Most of the records from vertical hauls are from 300–0 fathoms, some are from 800, 150, 100–0 fathoms. Vertical hauls were made at only sixty-eight out of the 127 stations. The genus was thus found at 73.5% of the stations at which vertical hauls were made.

Disregarding the stations at which surface catches only were made, the record stations are distributed over the area covered by the Expedition in the following manner: —

4 (100.0%) out of the 4 stations in the California Current
5 (100.0%) out of the 5 stations in the Mexican Current
5 (83.3%) out of the 6 stations in the Panamic Area
8 (36.3%) out of the 22 stations in the Peruvian Current
5 (100.0%) out of the 5 stations in the Easter Island Eddy
1 (50.0%) out of the 2 stations in the Galapagos Eddy
21 (91.4%) out of the 23 stations in the South Equatorial Drift
1 (100.0%) out of the 1 station in the South Equatorial Current

There were no vertical hauls made in the Equatorial Counter Current or in the North Equatorial Current.

Surface catches and Salpa stomachs of specimens taken in surface waters (81 surface catches and 24 samples of Salpa stomachs) were examined from 82 stations. The genus, as previously mentioned, was taken in surface hauls at thirty-two stations, *i.e.*, at 39.0% of all the surface stations. Taking into consideration the surface stations only, these thirty-two record stations are distributed in the following manner: —

1 (25.0%) out of the 4 stations in the California Current
4 (44.5%) out of the 9 stations in the Mexican Current
3 (23.1%) out of the 13 stations in the Panamic Area

2 (10.0%) out of the 20 stations in the Peruvian Current
2 (40.0%) out of the 5 stations in the Easter Island Eddy)
0 (0.0%) out of the 2 stations in the Galapagos Eddy
15 (65.2%) out of the 23 stations in the South Equatorial Drift
2 (100.0%) out of the 2 stations in the South Equatorial Current
2 (100.0%) out of the 2 stations in the Equatorial Counter Current
1 (50.0%) out of the 2 stations in the North Equatorial Current

The numbers of these thirty-two surface stations are as follows: 4583 (California Current); 4588, 4592, 4596, 4545 (Mexican Current); 4623, 4638, 4640 (Panamic Area); 4648, 4676 (Peruvian Current); 4694, 4700 (Easter Island Eddy); 4688, 4708, 4712, 4718, 4720, 4723, 4725, 4727, 4729, 4731, 4733, 4735, 4738, 4740, 4741 (South Equatorial Drift); 4743, 4540 (South Equatorial Current); 4541, 4542 (Equatorial Counter Current); 4543 (North Equatorial Current).

On account of the prevalence of Amphisolenia in deeper waters, the table showing the distribution and the frequency of the record stations at which the genus was found in *vertical* hauls is probably a better indicator of the horizontal distribution of this genus in the area investigated by the Expedition than is the table in which all the record stations are included. The fifty stations at which Amphisolenia was taken in vertical hauls are scattered over the whole area covered by the Expedition (Plate 26). In the California Current, Mexican Current, Easter Island Eddy, and South Equatorial Current the genus occurred at all the stations at which vertical hauls were made and in the Panamic Area and the South Equatorial Drift at 83.3% and 91.4%, respectively, of the stations with vertical hauls. In the Peruvian Current, on the other hand, the genus occurred at only 8 (36.3%) out of the 22 stations with vertical hauls. If the number of records of species is considered, we find a strikingly small number of records of species of Amphisolenia in the relatively cool Peruvian Current and in the portion of the South Equatorial Drift that is under the direct influence of this current but a remarkably large number of records in the Easter Island Eddy and in the western and middle portions of the South Equatorial Drift. For a discussion of these data and a comparison between the horizontal distribution of Amphisolenia and that of Triposolenia, see the section on the distribution of Triposolenia.

Amphisolenia is most frequent in surface catches in the South Equatorial Drift, South Equatorial Current, and the Equatorial Counter Current. It was found very seldom at the surface in the Peruvian Current.

There are 210 records of species of Amphisolenia from vertical catches. Out of these 210 records, 1 (0.5%; Station 4648) showed a frequency of 8%; 1 (0.5%;

Station 4739) showed 6%; 3 (1.4%; Stations 4713, 4719, 4740) showed 4%; 6 (2.9%; Stations 4587, 4590, 4689, 4697, 4728, 4737) showed 3%; 10 (4.8%; Stations 4583, 4590, 4638, 4659, 4701, 4717, 4721, 4724, 4734, 4736) showed 2%; 43 (20.5%; Stations 4571, 4574, 4580, 4583, 4590 [2 records], 4594, 4598, 4605, 4609, 4613 [2 records], 4617 [2 records], 4638, 4646, 4662, 4666, 4667, 4668 [2 records], 4683, 4689, 4691 [2 records], 4695, 4699, 4701 [2 records], 4707, 4709, 4713, 4717 [2 records], 4719, 4721, 4722, 4730, 4732 [2 records], 4737, 4739, 4742) showed 1%; 146 (69.5%) showed a frequency of less than 1%.

There are 42 records of species of this genus from surface catches. Out of these 42 records, 4 (9.5%; Stations 4592, 4720, 4725, 4741) showed a frequency of 2%; 12 (28.6%; Stations 4596, 4638, 4640, 4648, 4676, 4688, 4712, 4718, 4731, 4738, 4743, 4543) showed 1%; 26 (61.9%) showed a frequency of less than 1%.

Coincident occurrence of different species of Amphisolenia in catches from 300 (800, 150)–0 fathoms is recorded at the following of the fifty stations mentioned above: 12 species occurred coincidently at 1 station (2.0%; Station 4737); 11 species at 1 station (2.0%; Station 4701); 9 species at 2 stations (4.0%; Stations 4739, 4740); 8 species at 3 stations (6.0%; Stations 4732, 4734, 4736); 7 species at 4 stations (8.0%; Stations 4587, 4605, 4699, 4728); 6 species at 5 stations (10.0%; Stations 4691, 4713, 4722, 4724, 4742); 5 species at 3 stations (6.0%; Stations 4583, 4590, 4697); 4 species at 4 stations (8.0%; Stations 4594, 4613, 4617, 4668); 3 species at 9 stations (18.0%; Stations 4580, 4634, 4667, 4695, 4709, 4711, 4717, 4719, 4721); 2 species at 11 stations (22.0%; Stations 4574, 4598, 4638, 4659, 4662, 4679, 4681, 4689, 4705, 4707, 4730).

Coincident occurrence of different species of this genus in surface catches is recorded at the following of the thirty-two surface stations mentioned above:—3 species occurred coincidently at 2 stations (6.3%; Stations 4733, 4741); 2 species at 6 stations (18.8%; Stations 4588, 4700, 4720, 4723, 4725, 4743).

It should be noted that out of the twenty-four surface catches in each of which only one species of Amphisolenia was found, not less than twenty contained *A. bidentata*. Other species of this genus than *A. bidentata* thus were found at only twelve out of the thirty-two surface record stations. *A. bidentata* was found at no less than twenty-eight out of these thirty-two surface stations. This indicates that of all the known species of this genus, *A. bidentata* is by far the most common in surface waters. Karsten (1907, p. 442) writes as follows: "Amphisolenia dürfte in ihren gewöhnlicheren Arten *palmata* und *bidentata* der Oberfläche angehören, dagegen ist *A. thrinax* Schütt häufiger in den tiefer gehenden Fängen wahrgenommen." Besides *A. bidentata* only the following species of this genus were found in surface catches: — *A. lemmermanni* (four stations), *A. schauinslandi* (three stations), *A. thrinax* (three stations), *A. palmata* (two stations), *A. globifera* (one station), and *A. truncata* (one station). Out of these six species *A. lemmermanni* and *A. palmata* are very closely related to *A. bidentata*.

Our records show that a great number of species of this genus may occur within a comparatively small area. Indeed, out of the twenty-seven possibly valid species of this genus known at the present time, not less than twenty-six have been found in the material of the Expedition. It seems rather improbable that the region investigated by us is unique in this respect. The fact that only seven species of this genus have been found in regions outside of the tropical and subtropical parts of the Eastern Pacific, although some of the previous investigators have had rather rich material of tropical and subtropical plankton at their disposal, seems to indicate that, at least in some cases, we should accept the published data on the distribution of the species of this genus with a certain reservation. However, it should be remembered that most writers who have treated this genus have had surface catches only at their disposal.

Historical Discussion

The genus Amphisolenia was established by Stein (1883, p. 24), who founded it on two new species, *A. globifera* and *A. palmata*. These two species were figured by Stein without any generic or specific diagnoses or descriptions. The first diagnosis of Amphisolenia was published by Bütschli (1885, p. 1010). It is very short and incomplete and is evidently based on Stein's (1883) drawings. Diagnoses of this genus have been published also by Schütt (1896, p. 28), Delage and Hérouard (1896, p. 385), Paulsen (1908, p. 20), and Willey (1909, p. 187). No thoroughgoing description and discussion of the genus have yet been published.

Besides the two species mentioned in the previous paragraph, the following species of Amphisolenia are to be found in the literature: — *A. thrinax* and *A. tripos* Schütt (1893), *A. bifurcata* and *A. inflata* Murray and Whitting (1899), *A. schauinslandi* Lemmermann (1899a), *A. bidentata* Schröder (1900a), *A. asymmetrica*, *A. bispinosa*, *A. brevicauda*, *A. clavipes*, *A. curvata*, *A. dolichocephalica*, *A. extensa*, *A. laticincta*, *A. lemmermanni*, *A. palaeotheroides*, *A. projecta*, *A. quadrispina*, *A. quinquecauda*, *A. rectangulata*, and *A. schröderi* Kofoid (1907a), *A. spinulosa* Kofoid (1907b), *A. astragalus*, *A. quadricauda*, and *A. truncata*

Kofoid and Michener (1911), *A. tridens* Gräf (1909), *A. furca* Hensen (1911), and *A. tenella* Gran (1912b). Thus thirty species of this genus were established before the publication of the present paper. In addition to these, two new species, *A. elongata* and *A. complanata* are described in this paper. In other words, not less than thirty-two species of Amphisolenia are named at the present time.

However, a number of these thirty-two species undoubtedly must be discarded. *Amphisolenia tripos* (Schütt, 1893, p. 299; Hensen, 1911, p. 159, 160), *A. furca* (Hensen, 1911, p. 159, 160), and *A. tridens* (Gräf, 1909, p. 173, 179, 192) were introduced into the literature as *nomina nuda*, and there is as yet no information published as to their organization. Kofoid (1906c, p. 93) suggests that *A. tripos* may refer to a species of the genus Triposolenia. *Amphisolenia bidentata* and *A. lemmermanni* are so similar that their specific separation must be regarded as tentative. The specific separation of *A. bidentata* and *A. palmata* also must be regarded as problematical. We regard *A. dolichocephalica* as a synonym of *A. asymmetrica*. *A. schröderi* and *A. clavipes* may represent giant and dwarf phases in a cytogenetic complex. The same is true in the case of *A. extensa* and *A. elongata*. *A. truncata* may be a representative of *A. complanata* in which the antapical spinules have not yet developed following binary fission, and *A. tenella* possibly may be synonymous with *A. globifera*. The question as to whether or not *A. projecta* is a valid species cannot be settled as yet. The type specimen of this species possibly may be a representative of *A. bifurcata* in which the dorsal antapical limb is broken.

As will be seen from the last paragraph, our knowledge of the separation and characterization of the species of Amphisolenia is still uncertain and tentative. All the descriptions of species published up to the present writing are short and incomplete and do not have data of variations for consideration. The descriptions published by Kofoid (1907a) and Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper.

Schröder (1900a, p. 20) divided Amphisolenia into two groups, viz., Simplices and Incisae. In the first group were included *Amphisolenia globifera*, *A. inflata*, *A. bidentata*, *A. palmata*, and *A. schauinslandi;* the second group comprised *A. bifurcata*, *A. tripos*, and *A. thrinax*.

A few remarks as to the adaptive value of the peculiar shapes of the body of the species of this genus have been made by the following writers: — Schütt (1893, p. 273), Kofoid (1906e, p. 133), Zacharias (1906, p. 563), Steuer (1910, p. 196), Carisso (1911, p. 89), Hjort (1911), Gran (1912 a and b), and Oltmanns (1923, p. 327).

Hensen (1911, p. 160, 161) discussed the systematic value of structural differences.

Contributions to our knowledge of the distribution of Amphisolenia are to be found in the following papers, not specifying those in which new species are described: — Hensen (1895), Cleve (1897a, 1900b, 1901a, 1901c, 1902b, 1903b), Schröder (1900b, 1906a, 1906b, 1909, 1911), Ostenfeld and Schmidt (1901), Schmidt (1901), Lemmermann (1901a, 1904, 1905a, 1908b), Ostenfeld (1902, 1915), Entz (1902b, 1905), Ostenfeld and Paulsen (1904), Zacharias (1906), Karsten (1906, 1907), Okamura (1907, 1912), Stüwe (1909), Schiller (1911a, 1912), Pavillard (1916), Forti (1922), Jörgensen (1923), and Lindemann (1924). Of these papers only those of Okamura (1907, 1912) and Jörgensen (1923) contain drawings by which the accuracy of the determinations may be judged. Forti (1922) gives reproductions of the original drawings of the type specimens. Some of the data on the distribution of this genus undoubtedly should be accepted with reservations.

Other papers in which problems of morphology, etc., in Amphisolenia are treated, are as follows: — Chun (1903), Kofoid (1906c), Doflein (1909, 1911, 1916), Hjort (1911), Gran (1912a), and West (1916).

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

The genus Amphisolenia, as previously mentioned, is confined to waters of tropical, subtropical, and warm-temperate nature or origin; in other words, to waters of comparatively low viscosity. The relatively low buoyancy of these waters is clearly reflected in the general organization of the genus. Amphisolenia belongs to the group of plankton organisms in which the floating capacity has been increased "durch Streckung des Körpers in einer Richtung und Ausbildung der Stabform" (Steuer, 1910, p. 190, 196). In the species of the Bifurcata group the surface of resistance to the downward movement has been further increased by the asymmetrical branching of the posterior part of the antapical.

The interpretation, made by Kofoid (1906e), of the asymmetry in Triposolenia also applies, *mutatis mutandis*, to Amphisolenia (Kofoid, 1906e, p. 133). In Amphisolenia, some species are almost straight, but generally the longitudinal axis of the body has a slight or moderate sigmoid curvature, with the neck somewhat deflected dorsally and the antapical having a more or less pronounced ventral concavity. In most species of this genus the head is inclined anteriorly, and sometimes the posterior part of the antapical is bent ventrally or to the right at an angle of 25°–50°. In the species of Amphisolenia with a branched antapical, the antapical stem is often characterized by a more or less striking sigmoid curvature in the dorsoventral plane; in other words, the longitudinal axis of the body may have a double sigmoid curvature. Sometimes the modifications in the longitudinal axis of the body are accompanied by torsion. When these peculiarities in Amphisolenia are studied in the light of Kofoid's (1906e) interpretation of the asymmetry in Triposolenia, their adaptive value is readily understood.

Gran's (1912b, p. 327) assumption that the antapical knob in *Amphisolenia globifera* is adaptive, inasmuch as it brings about a balanced condition of the body, seems rather plausible. Furthermore, the balanced condition of the body is a striking characteristic of several species of this genus, as for example in *A. inflata*, *A. schauinslandi*, and *A. schröderi*. In *A. inflata*, whose antapical on the one hand, and head, neck, and anterior process on the other, are well balanced, the center of gravity of the organism is in the middle of the large, regularly ovoidal midbody. Similar conditions are to be found in *A. schauinslandi* and *A. schröderi*. On the other hand, in *A. brevicauda*, whose relatively long neck and large head outweigh the very short antapical, the center of gravity of the organism is behind the middle of the midbody. Reference is also made to Plate **12**, figure 6, of *A. thrinax* in which the posterior branches and enlarged posterior region modify the balance.

The asymmetry which frequently is found in the sulcal lists about the flagellar pore may be considered as adaptive; it favors a progressive dexiotropic movement of the organism (Kofoid, 1906e, p. 129).

Schütt (1893, p. 273) writes as follows: "Uebrigens wirkt die Körperverlängerung durch die häufig an den Hörnern angebrachten Stacheln auch direkt als Waffe, wie z. B. bei Amphisolenia." We know little, however, of the selective utilization of the microplankton by plankton-feeding organisms.

According to Hensen (1911, p. 160) the genus Amphisolenia is a "biological" unit. He considers it improbable that any "important biological value" can be attached to the structural differences in the antapical, on which most of the species have been established and "die durch keine oder jedenfalls äusserst seltene Uebergangsformen gestört wird." "Solange solche Unwahrscheinlichkeit bei sich sonst sehr nahe stehenden Arten bestehen bleibt, ist es mir richtig, sie als biologisch nicht trennbar zu behandeln."

The existence of "systematisch gut scheidbare Besonderheiten der Anzahl und des Vorkommens" Hensen (1911, p. 160, 161) considers in the light of the following possibilities: — the "variety" is *(1)* dying out, *(2)* originating, *(3)* an abnormality, *(4)* a seasonal variation, *(5)* a temperature variety, *(6)* a life-cycle variation, *(7)* a geographical variety, *(8)* a sport, *(9)* a relic, or *(10)* senile. The first two possibilities he rejects because "es sich dabei um mindestens drei Arten handelt und diese Arten noch weit verbreitet sind. Für solchen Fall müsste eine enge Verbreitung postuliert werden." The third possibility is rejected because abnormalities are easily recognized as such and, furthermore, are not constant. The fourth is also rejected, seasonal changes being very slight in the warm regions of the sea, where the genus occurs. The fifth possibility is left open. "Einflüsse der Wasserwärme könnten vermutet werden, da *A. tripos* das etwas kühlere Gebiet des Südarms des Golfstroms bevorzugt." The possibility *(6)* of life-cycle variation, *i.e.*, of cyclic polymorphism, Hensen does not reject *a priori*, because of the conditions in *Ceratium tripos*. The rare occurrence of three out of the four species could thus be accounted for. "Für den Vorgang fehlt zurzeit noch das Verständnis, indessen kann gesagt werden, dass die polymorphen Gestaltungen von *Ceratium tripos* soweit von der Mutterform abweichen, wie es den geringen Formverschiedenheiten der Amphisolenien nicht entspricht." The seventh possibility is rejected because the distributional data brought together by the Plankton Expedition do not conform to the distribution that, according to the author, would result from this mode of origin. The eighth possibility is rejected for two reasons: — "Für Zufallsvarietäten kann ein besonders gutes Gedeihen nicht erwartet werden." "Wenn der Zufall Erzeuger ist, scheint gefordert werden zu müssen, dass gleichzeitig viele Uebergänge gefunden werden, was aber nicht der Fall ist." An attempt to explain the absence of transitional forms by the assumption that these forms either are unable to maintain themselves or that they revert to the original type and that only "die vollendeten Formen" survive would necessitate the further assumption "dass die Zelle selbst und nicht nur der Stiel Modifikationen erlitten habe, die das Bestehen der Art sichern." The ninth possibility, *i.e.*, that we are concerned with relics from "the time when the polar waters were warm," is not considered as excluded. However, "es ist bemerkenswert, dass bei dieser Annahme die selteneren Arten nicht, wie bisher als die jüngeren, sondern als die älteren erscheinen, daher *A. palmata* als die jüngere und zugleich als die best angepasste aufzufassen wäre." The tenth possibility, "dass die Formen der *Amphisolenia palmata* sich mit dem Altern der Zellen verändern," is also left open. "In dieser Richtung liegen für die Peridiniales meines Wissens bisher keine Beobachtungen vor, aber das beweist noch nicht die Unmöglichkeit solchen Verhaltens, nur müssten sich dann viele Uebergänge finden."

As will be seen from the above summary, Hensen rejects six out of the ten discussed possible explanations for the existence of the established "systematisch gut scheidbare Besonderheiten der Anzahl und des Vorkommens." The four remaining possibilities, viz., (*5*) that the morphological differences observed are temporary (?) and due to changes in temperature, (*6*) due to cyclic polymorphism, (*9*) related to conditions in prequaternary times, or (*10*) due to senile changes of the cells of a single species, *Amphisolenia palmata*, are neither accepted nor rejected.

According to our opinion, Hensen's discussion of diversity of form in Amphisolenia is based upon an inadequate study of the species and their distinctive characters and on untenable considerations of the problem of structural changes as related to reproductive and ecological phenomena. He appears to have confused the ontogenetic and the phylogenetic development. His opinion that this genus is a "biological" unit also appears to be untenable in the light of the differences which we have found in the vertical and horizontal distribution of the species.

The characters by which the species of Amphisolenia have been distinguished from each other in the present paper are principally the size of the body, the shape of the longitudinal axis of the body, the shape and inclination of the head, the relative length and width of the neck, the shape and relative length and width of the midbody, the curvature and relative length and width of the antapical, the number of antapical branches, and the structure of the posterior end of the antapical. Pronounced structural differentiation of the thecal wall appears only in *Amphisolenia inflata* among the known species of this genus.

A comparatively high systematic value has been attributed by us to the shape and structure of the posterior part of the antapical. Indeed, most of the systematic subdivisions of the genus as established in this paper, *e.g.*, the Globifera group and the Palmata group, are based largely on the type of this part of the body. Another character to which high systematic value has been attached is the branching of the posterior part of the antapical. On the basis of this characteristic the Bifurcata group has been established.

As many characters as possible should be taken into account in the establishment of the species. In most cases several characters are required for certainty in the identification of species. Exceptions from the last-mentioned rule, which is well illustrated by the key to Amphisolenia given in this paper, are, as far as our present knowledge goes, *A. inflata*, *A. laticincta*, *A. brevicauda*, *A. asymmetrica*, and the species of the Bifurcata group.

Our knowledge of the separation and characterization of the species of Amphisolenia is still uncertain and tentative. The main reason for this uncertainty is that almost all characters are subject to fluctuations in different degrees of amplitude. No extensive investigation of the variability of the individual characters has as yet been carried out. Another reason is that nothing is known as to the time required, following binary fission, for the complete development of the antapical spinules of the new valve (see *A. bidentata* and *A. truncata*).

The variations in the relative width of the body may result in part from two factors: — first, a decrease of the width as a result of binary fission and, second, a gradual increase of the width during the period between two consecutive fissions (see the section on the reproduction of the genus).

In the case of several species the narrowness of the body makes it difficult to determine the degree of tilting of a specimen examined under the microscope. Pressure exerted on the cover-glass in order to bring a specimen into a desired position is likely to shift the angle of presentation and thus to modify the outline of the asymmetrical body as seen by the observer (Figure 48). The variations in the shape and inclination of the head and in the width and shape of the midbody in some species as presented in this paper probably to some extent are apparent and due to the tilted positions of some of the specimens examined.

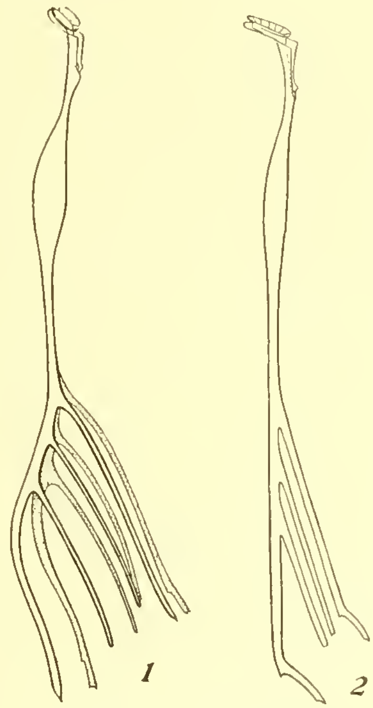

FIGURE 48.— *Amphisolenia quadricauda* Kofoid. 1, right lateral view, showing parting of valves of antapical; head somewhat tilted; 2, sublateral view of specimen represented by 1, showing result of pressure and tilting on width of midbody, shape of antapical stem, and shape and relative lengths of antapical branches, as seen by observer. Type specimen. Station 4695 (300–0 fathoms). × 125.

The following principles have been used by us in describing the species of this genus: —

(*1*) When not otherwise stated, all characteristics refer to specimens in lateral view.

(*2*) In describing the proportions of the body, the length of the neck, measured in a straight line from the posteroventral point of the head to the flagellar pore (Figure 47), has been used as a unit.

(*3*) The methods of measuring lengths, proportions, and angles used in this paper are shown in Figure 47.

(*4*) The lengths of the antapical branches, in contrast to the lengths of the other parts of the body, are not measured in straight lines but are measured along the curvatures from the midpoints of the bases of the branches to the tips.

(*5*) The thecal wall is without structure in all the species in whose diagnoses this character is not mentioned.

(*6*) The antapical is unbranched in all the species in whose diagnoses this character is not mentioned.

(*7*) In the species with branched antapical the anterior antapical branch is called the first branch, the next one the second, and so on.

Subdivisions. Relationships among the Species

Schröder (1900a, p. 20), who is the only writer to attempt a subdivision of the genus Amphisolenia, established two groups: "A. Simplices. Hinteres Ende unverzweigt, kugelig oder mit 2–4 Stacheln: *globifera, inflata, bidentata, palmata, schauinslandii;* B. Incisae. Hinteres Ende getheilt, doppelt oder dreifach gegabelt: *bifurcata, tripos* und *thrinax.*"

Incisae probably represent a natural systematic unit. Simplices, on the other, hand, comprise rather heterogeneous elements, and its subdivision is highly desirable. On account of the incompleteness of the data available, such a subdivision encounters great difficulties. Our attempt should be regarded as tentative rather than as final. According to our opinion, the twenty-seven possibly valid species of *Amphisolenia* may be divided as follows: —

1. Species of uncertain, or of more or less isolated position: — *A. inflata, A. laticincta, A. brevicauda, A. schauinslandi, A. rectangulata, A. astragalus* and *A. spinulosa.*

2. Extensa group: *A. extensa* and *A. elongata.*

3. Globifera group: *A. globifera* and *A. quadrispina.*

4. Bispinosa group: *A. bispinosa* and *A. curvata.*

5. Schröderi group: *A. schröderi, A. clavipes, A. complanata,* and *A. truncata.*

6. Palmata group: *A. bidentata, A. lemmermanni, A. palmata, A. palaeotheroides,* and *A. asymmetrica.*

7. Bifurcata group (Incisae Schröder): *A. bifurcata, A. projecta, A. thrinax, A. quadricauda,* and *A. quinquecauda.*

In the following will be given a short characterization and discussion of these species and groups: —

1. Species of uncertain or more or less isolated position. *Amphisolenia inflata.* This species occupies a rather isolated position and is probably more primitive than any other known species of its genus. The following characters separate it from other members of its genus: — (*1*) the decided concavity of the anterior face of the epitheca; (*2*) the well set off anterior process; (*3*) the relatively large and bilaterally compressed midbody; (*4*) the very distinct structural differentiation of the thecal wall; (*5*) the structures of the cingular and sulcal lists. With regard to characters indicating primitiveness and close relationship to *Triposolenia truncata,* see the section on the subdivisions of the family Amphisolenidae and the section on the comparisons of this species.

Amphisolenia laticincta. This species also occupies a rather isolated position. The narrowness of the head and the wideness of the transverse furrow, as well as the simple, rounded antapex give it an exceptional appearance. The small size, the straight longitudinal axis of the body, the rather well-developed midbody set off from the antapical, and the very simple, unbranched antapical seem to indicate that this species is fairly low in the scale of the evolutionary development of the genus.

Amphisolenia brevicauda. The peculiar asymmetry of the midbody, the relative shortness of the antapical, and the simple, pointed antapex place this species also in a rather isolated position. The small size of the body and the simple, unbranched antapical well set off from the midbody appear to be primitive features. The species may possibly be a representative of an evolutionary branch that split off at a fairly early stage in the phylogenetic differentiation of the genus, and in which the tendency to posterior elongation has been inhibited.

Amphisolenia schauinslandi. The systematic position of this species is uncertain. The anterior process, which is relatively longer than in any other known species of this genus, gives to the species a rather unique appearance. The shape and the structure of the posterior end of the antapical are suggestive of *A. rectangulata.* The straight longitudinal axis of the body, the fairly well-developed midbody which in most specimens is rather distinctly set off from the antapical, and the simple, unbranched antapical appear to be primitive features of this species.

Amphisolenia rectangulata. The systematic position of this species is also uncertain. The shape and the structure of the posterior part of the antapical recall *A. schauinslandi.* The simple, unbranched type of the antapical appears to be a primitive feature, but in most other respects this species probably is rather highly differentiated.

Amphisolenia astragalus. The systematic position of this highly differentiated species is unknown. The abrupt ventral bending of the posterior foot-like part of the antapical is a characteristic of this species, which is not found in any other member of the genus. The single distal spinule and the rounded lateral protuberance contribute to the peculiar appearance of the posterior part of the antapical; see also the discussion of this species.

Amphisolenia spinulosa. No well-founded suggestion as to the systematic position of this species can be given as yet, due to our lack of knowledge of the relation of the antapical spinules to the thecal valves. The deflection to the right of the posterior portion of the antapical and the presence of three spinules on the antapex suggest relationship to the PALMATA group. However, the species of this group always are characterized by a strong lateral spinule, the heel-spinule, located on the left valve at some distance from the antapex, and such a spinule is not developed in *A. spinulosa.* On the other hand, the proportions, the curvature of the antapical, and the weakness of the antapical spinules indicate relationship to the EXTENSA group; indeed, *A. spinulosa* and *A. elongata* are of about the same habitus.

2. EXTENSA group. This group is characterized by the great elongation of the antapical, by the club-shaped posterior portion of the antapical and the subtruncate antapex, and by the slight development of the antapical spinules. The simple, unbranched type of the antapical appears to be a primitive feature of the group. On the other hand, the more or less pronounced sigmoid curvature of the longitudinal axis of the body, the slenderness of the midbody, the tendency of the midbody to merge into the antapical, and the excessive elongation of the antapical probably are advances in differentiation.

3. GLOBIFERA group. The posterior portion of the antapical is knob-like; just in front of the knob, there is, in most cases, a short, neck-like constriction. The straight longitudinal axis of the body and the unbranched antapical appear to be primitive features of this group. The gradual merging of the midbody into the antapical, and the differentiation of the posterior portion of the antapical probably are later acquisitions.

4. BISPINOSA group. This group is characterized by the sigmoid curvature of the longitudinal axis of the body (most strikingly developed in *A. curvata*), by the bilateral position of the two spinules on the antapex, one spinule on each valve, and by the longitudinal ridges on the neck. The simple, unbranched type of the antapical appears to be a primitive feature of this group. The gradual merging of the midbody into the antapical and the sigmoid curvature of the longitudinal axis of the body probably are advances in differentiation.

5. SCHRÖDERI group. The characterization of this group is rather difficult. The species exhibit a general similarity in several characters rather than a close agreement in a few features. The midbody is fusiform, slender, and merges very gradually into the anterior process and into the midbody. The posterior portion of the antapical shows a tendency to become bent to the right; the bending is slight in *A. complanata* and *A. schröderi*, very striking in some specimens of *A. clavipes;* in *A. truncata* the posterior part of the antapical is straight. The antapex has two sagittal spinules, except in *A. truncata* in which no spinules are developed (see the discussion of this species); both of these antapical spinules probably belong to the left valve; this asymmetry is the most striking characteristic of the group. The chromatophores probably always are large and rod-shaped. The straight longitudinal axis of the body and the simple, unbranched type of the antapical appear to be primitive features of this group. The slenderness and the very gradual merging of the midbody into the antapical are probably advances in differentiation. *A. schröderi* and *A. clavipes* probably are more closely related to each other than to the two remaining species of this group. *A. complanata* and *A. truncata* are probably also very close relatives.

6. Palmata group. The posterior part of the antapical is asymmetrical and bent to the right. At the point of bending the left valve has a rather strong, pointed spinule, the heel-spinule. The antapex is truncate and more or less inflated, and has either two or three spinules. When only two spinules are present, both of them belong to the left valve and are placed near the suture. When three spinules are developed, the additional spinule belongs to the right valve and is placed between the two spinules of the left valve. The unbranched antapical is a primitive feature of this group. The slight sigmoid curvature of the longitudinal axis of the body, the gradual merging of the midbody into the antapical, and the differentiation of the posterior part of the antapical probably are later acquisitions. Of the five species that belong to this group, *Amphisolenia bidentata* and *A. lemmermanni* have only two spinules on the antapex. The fact that in the Schröderi group the antapex probably has the same number and arrangement of spinules appears to indicate that this is the more primitive condition. *A. asymmetrica*, which is characterized by a unique and peculiar shape of head, occupies a somewhat isolated position within the group.

7. Bifurcata group (Incisae Schröder). The head is three to four times wider than long and inclined anteriorly at an angle of 20°–30°; the epitheca is flat or gently convex. The midbody is fusiform, rather narrow or of moderate width and merges gradually into the anterior process and into the antapical. The posterior part of the antapical has one to four branches. The distal portion of the main antapical stem and of the first antapical branch have about the same shape and structure as in *Amphisolenia palmata;* in other words, the left valve has a heel-spinule at some distance from the tip, and the tip has three spinules, two on the left valve and one on the right valve. When two to four antapical branches are developed, all the branches except the proximal one lack the heel-spinule. *A. bifurcata*, *A. thrinax*, *A. quadricauda*, and *A. quinquecauda* form an orthogenetic series of an increasing number of ventral branches, the smallest and presumably the youngest phylogenetic addition being interpolated at the posterior end of the series of branches. It is possible that the series lies within a single variable species. In the absence of known sexual reproduction and in view of the seeming necessities in skeletal completion at binary fission, we treat the units of the series as species.

The Extensa, Globifera, Bispinosa, Schröderi, and Palmata groups should not be considered as subdivisions of Schröder's Simplices but as units of the same systematic value as his Incisae (the Bifurcata group).

To attribute subgeneric value to the groups established above is avoided since our knowledge of the genus is still rather incomplete, and, as mentioned previously, the classification suggested should be regarded as tentative rather than as final.

With regard to the relationships of these groups, we are unable to contribute anything but a few suggestions. The Extensa, Globifera, and Bispinosa groups are small, and seem to occupy rather isolated positions; an attempt to settle their relationships at the present time would be premature. The Schröderi, Palmata, and Bifurcata groups, on the other hand, appear to form a phylogenetic series of orthogenetic facies in which the Schröderi group probably represents the most primitive and the Bifurcata group the most advanced stage. This supposition is based mainly on the shape and structure of the posterior portion of the antapical. In *Amphisolenia schröderi* and *A. clavipes* the posterior portion of the unbranched antapical is bent to the right; on the antapex there are two sagittal spinules, both probably belonging to the left valve; no heel-spinule is developed. In the Palmata group the posterior part of the unbranched antapical is bent to the right; at the point of bending the left valve has a heel-spinule. The antapex has either two or three spinules; when only two spinules are present, both of them belong to the left valve and are placed near the suture; when three spinules are developed, the additional spinule belongs to the right valve and is placed between the two spinules of the left valve. In the Bifurcata group the antapical is branched and its posterior end has the same shape and structure as in *A. palmata.*

No characters are known that do not harmonize with the assumption that these three groups form a phylogenetic series marked by increasing complexity in the antapical region.

On account of the uncertainty as to the systematic positions of the species mentioned in the first group and of the EXTENSA, GLOBIFERA, and BISPINOSA groups, we are unable to reconstruct as yet the phylogenetic development of the genus Amphisolenia.

Key to the Species of Amphisolenia

1. Antapical not branched . . . . . . 2.
1. Antapical branched . . . . . . (BIFURCATA group) 23.
2. Posterior part of antapical with crude resemblance to foot; its valves asymmetrical; the left with three spinules, one, the "heel-spinule," at some distance from antapex and two on antapex; the right with one spinule on antapex or without spinules . . . . . . (PALMATA group) 19.
2. Posterior part of antapical not foot-shaped, except in *A. astragalus;* left valve of antapical without "heel-spinule" . . . . . . 3.
3. Epitheca quite concave; thecal wall profusely and strikingly pitted . . *inflata* Murray and Whitting.
3. Epitheca convex or more or less flattened; thecal wall structureless or almost so . . . . . . 4.
4. Width of transverse furrow exceeds dorsoventral diameter of head; head about twice longer than wide . . . . . . *laticincta* Kofoid.
4. Width of transverse furrow less than dorsoventral diameter of head; head about as wide as or wider than long . . . . . . 5.
5. Dorsal margin of midbody almost straight, ventral margin with well-developed convexity; antapical shorter than neck; antapex pointed, without spinules . . . . . . *brevicauda* Kofoid.
5. Midbody and antapical of other types . . . . . . 6.
6. Antapical about as long as or slightly shorter or longer than anterior process and midbody; its posterior part straight, expanding to a knob-like termination; generally with neck-like constriction just in front of knob . . . . . . 7.
6. Antapical of other types . . . . . . 8.
7. Antapex with none to two spinules . . . . . . *globifera* Stein.
7. Antapex with four spinules . . . . . . *quadrispina* Kofoid.
8. Antapical 2–7 times longer than anterior process and midbody; its posterior part straight, somewhat club-shaped, subtruncate; antapical spinules, if present, exceedingly small, hardly distinguishable 9.
8. Antapical of other types . . . . . . 10.
9. Antapical 4–7 times longer than anterior process and midbody; length of body, 1292–1520 μ. *extensa* Kofoid.
9. Antapical 2–3 times longer than anterior process and midbody; length of body, 438–464 μ. *elongata*, sp. nov.
10. Antapex with four spinules, two on each valve . . . . . . 11.
10. Antapex with less than four spinules . . . . . . 12.
11. Antapical shorter than anterior process and midbody . . . . . . *schauinslandi* Lemmermann.
11. Antapical about twice as long as anterior process and midbody . . . . . . *rectangulata* Kofoid.
12. Antapex with three spinules . . . . . . *spinulosa* Kofoid.
12. Antapex with less than three spinules . . . . . . 13.
13. Posterior part of antapical foot-shaped, bent ventrally, with one distal spinule and one lateral rounded protuberance . . . . . . *astragalus* Kofoid and Michener.
13. Posterior part of antapical of other types . . . . . . 14.
14. Longitudinal axis of body with more or less pronounced sigmoid curvature; antapical spinules, if present, lateral in position, one on each valve . . . . . . 15.
14. Longitudinal axis of body straight or with but slightly developed sigmoid curvature; antapical spinules, if present, sagittal in position (belonging to left valve?) . . . . . . 16.
15. Antapical spinules comparatively strong; ratio between length and greatest width of body, 35–40: 1. *bispinosa* Kofoid.

15. Antapical spinules, if present, very small; ratio between length and greatest width of body, 12–13: 1. *curvata* Kofoid.
16. Antapical without spinules . . . . *truncata* Kofoid and Michener.
16. Antapical with two spinules . . . . 17.
17. Head about three times wider than long . . . . *complanata*, sp. nov.
17. Head spheroidal, about as long as wide . . . . 18.
18. Length of body, 230–263 μ; posterior part of antapical more or less strongly bent to the right. *clavipes* Kofoid.
18. Length of body, about 510 μ; posterior part of antapical but slightly bent to the right. *schröderi* Kofoid.
19. Antapex with two spinules; right valve without antapical spinule . . . . 20.
19. Antapex with three spinules; right valve with one antapical spinule . . . . 21.
20. Length of body, 716–990 μ; ratio between length and greatest width of body, 30.3–67.1: 1. *bidentata* Schröder.
20. Length of body, 522–669 μ; ratio between length and greatest width of body, 13.4–33.8: 1. *lemmermanni* Kofoid.
21. Head 9–10 times wider than long . . . . *asymmetrica* Kofoid.
21. Head about 1.5–3.0 times wider than long . . . . 22.
22. Antapical 1.5–2.3 times longer than anterior process and midbody . . . . *palmata* Stein.
22. Antapical shorter than anterior process and midbody . . . . *palaeotheroides* Kofoid.
23. Antapical with one branch . . . . 24.
23. Antapical with more than one branch . . . . 25.
24. One of the antapical limbs strikingly shorter than the other, clavate, without spinules. *projecta* Kofoid.
24. Antapical limbs subequal, both with spinules . . . . *bifurcata* Murray and Whitting.
25. Antapical with two branches . . . . *thrinax* Schütt.
25. Antapical with three branches . . . . *quadricauda* Kofoid and Michener.
25. Antapical with four branches . . . . *quinquecauda* Kofoid.

1. Species of Uncertain or More or Less Isolated Position. Out of the seven species that belong to this group, six have been found in the material of the Expedition. These six species have been treated in the following order, which is partly indicative of their relative positions in the scale of the evolutionary development of the genus: — *Amphisolenia inflata*, *A. laticincta*, *A. brevicauda*, *A schauinslandi*, *A. rectangulata*, and *A. astragalus.*

Amphisolenia inflata Murray and Whitting

Plate 6, fig. 2, 7. Figure 47, 49: 1

Amphisolenia inflata Murray & Whitting, 1899, p. 332, tab. 8, pl. 31, fig. 2a, b. Lemmermann, 1899a, p. 373; 1905a, p. 37. Schröder, 1900a, p. 20; 1906a, p. 324, 328. Cleve, 1903b, p. 339. Ostenfeld & Paulsen, 1904, p. 164, 173. Paulsen, 1908, p. 21, fig. 24.

Diagnosis: — Straight. Head twice as wide as long. Epitheca concave. Midbody very large, ovoidal, well set off from anterior process and antapical; subequal in length to antapical and somewhat longer than anterior part of body. Ratio between length and width of body, 4.2–4.3: 1. Antapical straight, not inflated posteriorly. Antapex with two lateral spinules. Wall profusely pitted, neck reticulate. Length, 143–233 μ.

Probably of world-wide distribution in tropical, subtropical, and warm-temperate regions of the sea.

Description: — The longitudinal axis of the body is almost straight. The head is subhorizontal or inclined anteriorly at an angle of about 10°; its axial length is 0.38–0.50 the length of the neck; and it is about twice as wide as long. The anterior face of the epitheca is distinctly concave. The transverse furrow is 0.4 as wide as the dorsoventral diameter of the head, somewhat concave, and without cross-ridges. The cingular lists are about twice as wide as the transverse furrow; the anterior flares anteriorly at an angle of 10°–20° and has, dorsally and ventrally only, a few branched ribs; the posterior is subhorizontal and lacks ribs.

The neck is short and thick, 0.10–0.11 the length of the body, and 2.5–3.5 times longer than wide. The sulcal lists continue beyond the flagellar pore to the midbody. They are reticulated anteriorly, and the left has, near the flagellar pore, a characteristic thickened area with a cross-rib in front of the pore.

The anterior process is 0.64–0.69 the length of the neck and about as long as wide.

The midbody is relatively very large, ovoidal, compressed laterally, and well set off from the anterior process and from the antapical. Its length is 3.5–3.6 and its width 2.1–2.2 the length of the neck. The ratio between the length and the greatest width of the body is 4.2–4.3: 1. In lateral view the midbody is about twice as wide as in dorsoventral view.

The antapical is unbranched, straight, 3.1–3.8 the length of the neck and 7–12 times longer than its average width. When viewed laterally, it tapers to a point posteriorly; when seen dorsoventrally, it tapers very little and terminates in two spreading, rather stout lateral spinules.

The thecal wall is characterized by a very distinct structural differentiation. On the antapical and on the midbody it has numerous closely placed, scattered, minute pits (pores?). On the anterior process the pits are larger and more widely spaced; on the neck they widen to a coarse reticulum, about three meshes wide on each valve.

The nucleus is large and oval. The chromatophores are numerous, of various sizes, and dark brown in color.

The proportions of two specimens, the type (Murray and Whitting, 1899, pl. 31, fig. 2a) and one taken by the Expedition, were measured.

Dimensions: — Our specimen: Length of body, 143 μ. Length of head, 8.0 μ. Length of neck, 16 μ. Length of anterior process, 11 μ. Length of midbody, 58 μ. Width of midbody, 33 μ. Length of antapical, 50 μ. Type specimen (Murray and Whitting, 1899, pl. 31, fig. 2a): Length of body, 233 μ. Length of head, 9.5 μ. Length of neck, 25 μ; apparently it is somewhat shorter because of the fact that the thickened area of the left sulcal list has been drawn as if it belonged to the anterior process. Length of anterior process, 16 μ. Length of midbody, 88 μ. Width of midbody, 56 μ. Length of antapical, 94 μ.

Variations: — Judging by the two specimens thus far figured, the type specimen (Murray and Whitting, 1899, pl. 31, fig. 2a) and the specimen represented by our Plate 6, figure 7, this species appears to be rather constant. Most variable are the length of the body, and the relative width of the midbody and of the antapical.

Comparisons: — The three specimens referred to *Amphisolenia inflata* in this paper agree rather closely with the type of this species as figured by Murray and Whitting (1899). They differ from the type specimen mainly in the length of the body, and in the relative width of the midbody and of the antapical.

Amphisolenia inflata occupies a rather isolated position. We do not know which of the described species of Amphisolenia is its closest relative. It appears to be one of the most primitive, possibly the most primitive, species of this genus at present known. The following of its characters appear to be more or less primitive: — (*1*) the small size of the body; (*2*) the straight longitudinal axis of the body; (*3*) the exceptionally large, bilaterally compressed midbody; (*4*) the simple, unbranched antapical; (*5*) the well-developed structural differentiation of the thecal wall, fine areoles, and reticulation; (*6*) the reticulation of the sulcal lists; (*7*) the continuation of the sulcal lists beyond the flagellar pore. The question as to whether or not the concavity of the anterior face of the epitheca is primitive cannot be settled as yet. This is a peculiarity of this species and of *Triposolenia truncata* that has not been found in any other species of these two genera or in the primitive genera of this tribe. As to the relationship between *Amphisolenia inflata* and *Triposolenia truncata*, see the section on the subdivisions of this family.

Synonymy: — The species was established by Murray and Whitting (1899) under the name of *Amphisolenia inflata*. Paulsen (1908) reproduces the figure of the type specimen.

Occurrence: — The species is recorded at three of the 127 stations with a total of three specimens. There are 0, 0, 1, 1, 1, and 0 stations on the six lines of the Expedition. One of these three stations (4713) is in the Galapagos Eddy; the two others (4681, 4724) are in the South Equatorial Drift. One of the catches (4681) was from 800–0 fathoms, the two others from 300–0 fathoms.

The temperature range of these three stations at the surface was 68°–79°; the average was 73.3°. The frequency is less than 1%.

The species was first recorded by Murray and Whitting (1899) from the

Sargasso Sea, lat. 34°–39° N., long. 39°–32° W., the type locality. Later it was reported from lat. 59° N., long. 21° W. (the Gulf Stream) by Ostenfeld and Paulsen (1904); from lat. 15° N., long. 52° E. (the Arabian Sea) by Cleve (1903b); and from the Gulf of Aden and the Indian Ocean, between Ceylon and Singapore, by Schröder (1906a). All the samples in which the species was found were from surface waters.

The species occurs in waters of the following temperatures and salinities: — Murray and Whitting (1899): temperature, 66°–60°; Ostenfeld and Paulsen (1904): temperature, 49.3°; salinity, 35.30; Cleve (1903b): temperature, 74.3°; salinity, 36.02.

Ostenfeld and Paulsen (1904), Cleve (1903b), and Schröder (1906a) do not give any information as to the structure of their specimens.

The species is probably eupelagic and of world-wide distribution in tropical and subtropical waters and only occasionally is carried by currents to the colder regions of the sea.

Amphisolenia laticincta Kofoid

Plate 6, fig. 6, 8, 9. Figure 49: 2, 50: 10

Amphisolenia laticincta Kofoid, 1907a, p. 198, pl. 13, fig. 80.

Diagnosis: — Straight. Head but slightly wider than neck, almost twice as long as wide, hourglass-shaped. Epitheca boldly convex. Midbody fusiform, gradually merging into anterior process but set off from antapical. Distance from flagellar pore to antapical not quite half as long as body and somewhat longer than antapical. Ratio between length and width of body, 12: 1. Antapical straight, not inflated posteriorly. Antapex round with one short spinule (in typical specimens probably with one spinule on each valve). Length, 117–136 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight. The head is but slightly wider than the neck, of which it forms a continuation in a nearly straight line; its axial length is almost twice its width and subequal to or rather slightly shorter than the length of the neck. The epitheca is oblique and much more convex dorsally than ventrally. The transverse furrow is very broad, somewhat wider than the dorsoventral diameter of the head; it is rather strikingly concave, which gives to the head the shape of an hourglass, and without cross-ridges. The anterior cingular list is subhorizontal or it flares anteriorly at an angle of 10°; its width is 0.5 the width of the transverse furrow and subequal to the width of the neck; it has, on each valve, two to three simple ribs. The poste-

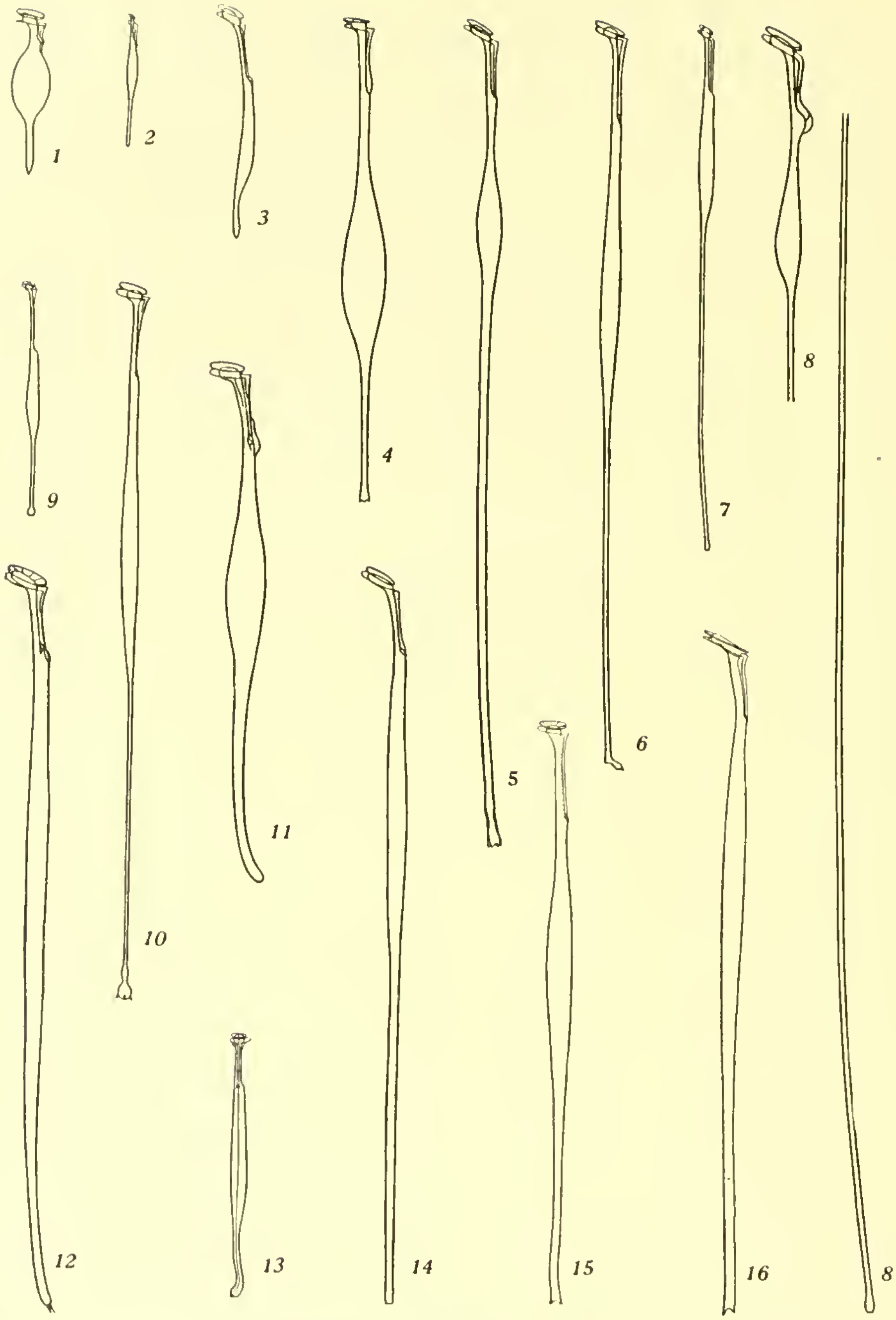

FIGURE 49.— 1, *Amphisolenia inflata* Murray and Whitting. Station 4681 (300–0 fathoms). 2, *A. laticincta* Kofoid. Station 4740 (300–0 fathoms). 3, *A. brevicauda* Kofoid. Station 4740 (300–0 fathoms). 4, *A. schauinslandi* Lemmermann. Station 4736 (300–0 fathoms). 5, *A. rectangulata* Kofoid. Station 4740 (300–0 fathoms). 6, *A. astragalus* Kofoid and Michener. Station 4713 (300–0 fathoms). 7, *A. elongata*, sp. nov. Station 4681 (800–0 fathoms). 8, *A. extensa* Kofoid, posterior portion of antapical is a direct continuation of anterior. Station 4699 (300–0 fathoms). 9, *A. globifera* Stein. Station 4742 (300–0 fathoms). 10, *A. quadrispina* Kofoid. Station 4711 (300–0 fathoms). 11, *A. curvata* Kofoid. Station 4605 (300–0 fathoms). 12, *A. bispinosa* Kofoid. Station 4605 (300–0 fathoms). 13, *A. clavipes* Kofoid. Station 4736 (300–0 fathoms). 14, *A. truncata* Kofoid and Michener. Station 4733, surface. 15, *A. schröderi* Kofoid. Station 4737 (300–0 fathoms). 16, *A. complanata*, sp. nov. Station 4739 (300–0 fathoms). Figure 2, 3, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16 from type specimens; right lateral view. × 150.

rior cingular list flares anteriorly at an angle of 20°–30°, is somewhat wider than the anterior, and has no ribs.

The neck is rather short and thick, 0.09 the length of the body and 4.5 times longer than wide. The sulcal lists extend to the flagellar pore. An accessory list, arising from the originally free edge of the left sulcal list and about as wide as the neck, extends along the whole length of the neck and continues for a short distance behind the pore. The lists are without ribs; the fission rib has not been seen.

The midbody is fusiform and merges gradually into the anterior process but is fairly well set off from the antapical. The distance between the flagellar pore and the antapical is about 16 times longer than the neck. The midbody is widest somewhat in front of the middle of the body, and its greatest width is subequal to the length of the neck. The ratio between the length and the greatest width of the body is 12: 1.

The antapical is unbranched, straight, 4.5 times longer than the neck, 20 times longer than wide, as wide as the neck, of uniform width throughout its whole length, not inflated posteriorly. The antapex is rounded and has a single, minute spinule (in typical specimens probably one on each valve).

The thecal wall is apparently without structure except for a few fine pores along the base of each of the sulcal lists.

The nucleus is elongated, ellipsoidal. The chromatophores are numerous, small, spheroidal, and of a yellowish-green color.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 117–136 μ (type, 117 μ; not 112 μ as stated in the original description). Length of head, 9 μ. Length of neck, 9 μ. Length of anterior process and midbody, 56 μ. Width of midbody, 9 μ. Length of antapical, 40 μ.

Comparisons: — The description given above is based on the type material. The small size, the straight longitudinal axis of the body, the fairly well-developed midbody set off from the antapical, and the simple, unbranched antapical seem to indicate that this species is fairly low in the scale of the evolutionary development of the genus. The narrowness of the head and the wideness of the transverse furrow, on the other hand, are secondary features, as is shown by the relative wideness of the head and narrowness of the transverse furrow in the presumably primitive *Amphisolenia inflata* as well as in most of the other species of this genus.

This species occupies an isolated position in the genus Amphisolenia. It may be noted in this connection that it resembles *A. curvata* in having on the left sulcal list an accessory list continuing for a short distance behind the flagellar pore. In other respects, however, these two species are very different (see the section on the reproduction of this genus).

Occurrence: — The species is recorded at two of the 127 stations with a total of two specimens. One of these two stations (4701) is on the fourth, the other (4740) on the fifth line of the Expedition, and both are in the South Equatorial Drift. The catches are from 300–0 fathoms.

The temperature of these two stations at the surface was 72° and 81°.

The frequency is less than 1%.

The species was first reported by Kofoid (1907a) from Station 4740 of the Expedition, which thus is the type locality.

Amphisolenia brevicauda Kofoid

Plate 6, fig. 1, 4. Figure 49: 3, 50: 6

Amphisolenia brevicauda Kofoid, 1907a, p. 197, pl. 13, fig. 79.

Diagnosis: — With moderate sigmoid curvature. Head 2.5–3.0 times wider than long. Epitheca flat. Midbody elongated; gradually merging into anterior process but well set off from antapical; slightly widened posteriorly; its dorsal margin slightly concave, flat, or, at any rate, less convex than its ventral margin. Distance from flagellar pore to antapical about half as long as body. Ratio between length and width of body, 16: 1. Antapical straight, somewhat shorter than neck, not inflated posteriorly. Antapex acute and without spinules. Length 202 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body has a moderate sigmoid curvature, with the neck somewhat deflected dorsally and the antapical ventrally.

The head is inclined anteriorly at an angle of 40°; it is 0.16–0.17 the length of the neck and 2.5–3.0 times wider than long. The anterior face of the epitheca is flattened, very slightly convex. The transverse furrow is 0.20 as wide as the dorsoventral diameter of the head, somewhat convex and without cross-ridges. The cingular lists are 1.3 as wide as the transverse furrow; the anterior flares anteriorly at an angle of 20°; the posterior is subhorizontal; each list has, on each valve, five to six fine, simple ribs.

The neck is rather long and narrow; it is 0.25 the length of the body and 10–12 times longer than wide. The sulcal lists end near the flagellar pore and have no ribs.

The anterior process and the midbody are perfectly merged, elongated, irregularly fusiform, and about half as long as the body or somewhat more than twice as long as the neck. The midbody is slightly widened posteriorly; it is widest at a distance from the apex equaling about two thirds the length of the body or at a distance from the flagellar pore 1.5 the length of the neck. Its great-

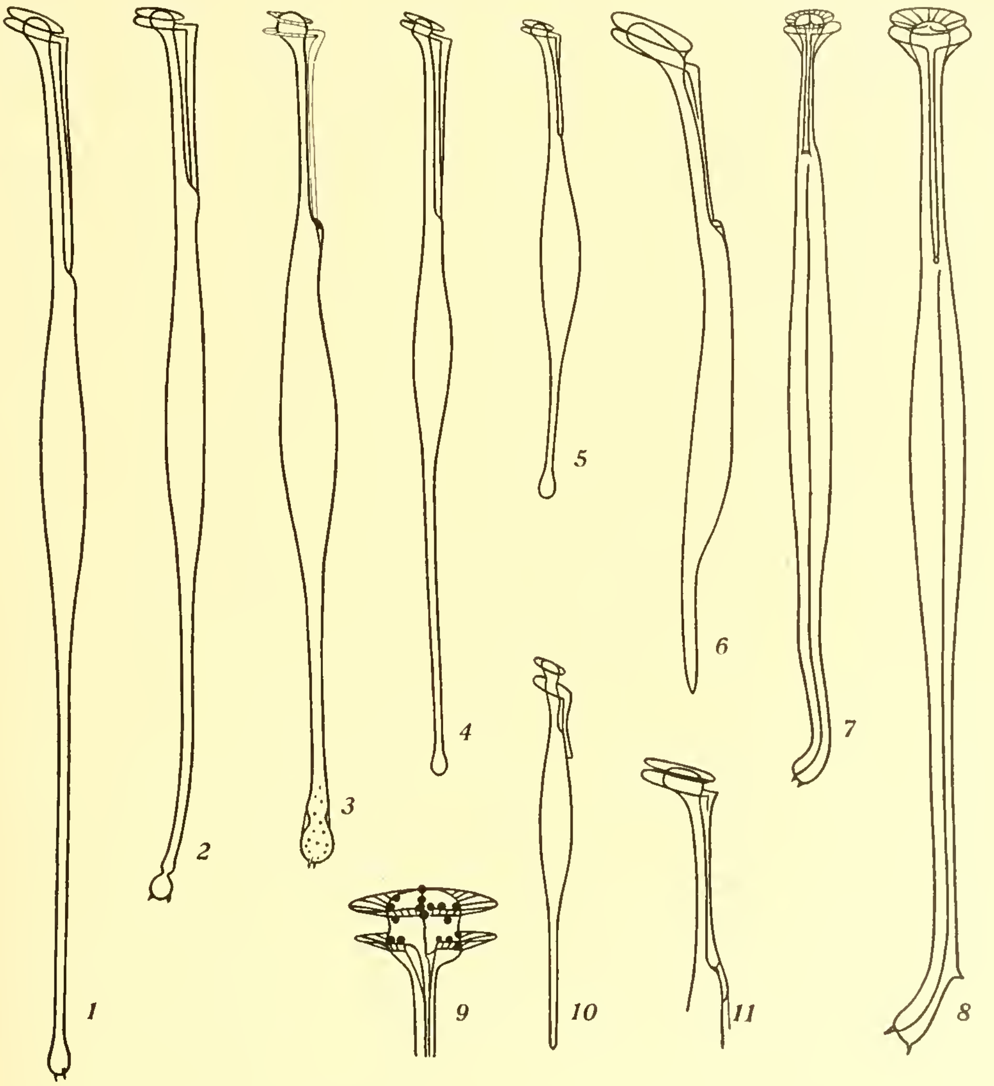

FIGURE 50.— 1–5, *Amphisolenia globifera* Stein, right lateral view showing the striking variability of the size and shape of this species. × 430. 1, 2, from Station 4742 (300–0 fathoms); 3, from Station 4613 (300–0 fathoms); 4, from Station 4721 (300–0 fathoms); 5, from Station 4711 (300–0 fathoms). 6, *A. brevicauda* Kofoid, right lateral view of type specimen. × 430. Station 4740 (300–0 fathoms). 7, *A. clavipes* Kofoid, ventral view of type specimen. × 430. Station 4736 (300–0 fathoms). 8, *A. lemmermanni* Kofoid, ventral view. × 430. Station 4734 (300–0 fathoms). 9, *A. quadrispina* Kofoid, ventral view of anterior portion of body showing phaeosomes. × about 650. Station 4711 (300–0 fathoms). 10, *A. laticincta* Kofoid, right lateral view of type specimen. × 430. Station 4740 (300–0 fathoms). 11, *A. elongata*, sp. nov., right lateral view of anterior portion of body. × 430. Station 4737 (300–0 fathoms).

est width is 0.27 the length of the neck. The ratio between the length and the greatest width of the body is about 16: 1. The dorsal margin of the midbody is slightly concave, almost straight or at least less convex than the ventral margin.

The antapical is well set off from the midbody, unbranched, straight, and exceptionally short, about 0.19 the length of the body or somewhat shorter than the neck; about ten times longer than wide or about as wide as the neck. It tapers posteriorly to a simple, acute antapex, without spinules or other differentiations.

The thecal wall is apparently structureless.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 202 μ. Length of head, 8 μ. Length of neck, 45 μ. Length of anterior process and midbody, 104 μ. Width of midbody, 12 μ. Length of antapical, 37 μ.

Comparisons: — The description given above is based on the type material.

The small size of the body and the simple, unbranched antapical, well set off from the midbody appear to be primitive features. The peculiar asymmetry of the midbody is unique for this genus. The relative shortness of the antapical and the simple, pointed antapex also contribute to the exceptional appearance of this species.

The species occupies a rather isolated position. It may possibly be a representative of an evolutionary branch which split off at a fairly early stage in the phylogenetic differentiation of the genus and in which the tendency to posterior elongation has been inhibited.

Occurrence: — The species is recorded at two of the 127 stations with a total of two specimens. One (4736) of these two stations is on the fifth, the other (4740) on the sixth line of the Expedition. Both are in the South Equatorial Drift. The samples are from 300–0 fathoms.

The temperature of these two stations at the surface was 81°.

The frequency is less than 1%.

The species was first recorded by Kofoid (1907a) from Station 4740 of the Expedition which thus is the type locality.

Amphisolenia schauinslandi Lemmermann

Plate 7, fig. 1–8. Figure 49: 4, 51

Amphisolenia schauinslandii Lemmermann, 1899a, p. 317, 350, 373, pl. 1, fig. 18, 19; 1901a, p. 376; 1904, p. 609, 611, 643. Schröder, 1900a, p. 20; 1906a, p. 328. Ostenfeld & Schmidt, 1901, p. 162.

Diagnosis: — Straight. Head capitate, 1.3–1.5 times wider than long. Epitheca convex or somewhat flattened. Midbody fusiform; fairly well set off from or gradually merging into anterior process and antapical; its length 2.8–3.5 the length of neck, of moderate width or rather slender. Ratio between length and width of body, 10–15: 1. Anterior process exceptionally long, 1.3–1.6 the length of neck. Antapical straight, 2.3–3.0 the length of neck; its posterior end sometimes slightly inflated, truncate, rectangular. Antapex with a short spinule at each of the four corners. Length, 391–434 μ.

Tropical and subtropical regions of Pacific, Indian Ocean, Gulf of Aden.

Description: — The longitudinal axis of the body is straight. The head is subhorizontal or inclined anteriorly at an angle of 25°; its axial length is 0.19 the length of the neck; capitate, 1.3–1.5 times wider than long. The anterior face of the epitheca is convex or somewhat flattened. The transverse furrow is 0.3–0.4 as wide as the dorsoventral diameter of the head, somewhat convex, and without cross-ridges. The cingular lists are about as wide as or somewhat wider than the transverse furrow; the anterior flares anteriorly at an angle of 10°–20°; the posterior flares somewhat less; the anterior has, on each valve, seven or eight simple, equidistant ribs; the posterior has the same number or somewhat less.

The neck is rather long and narrow; it is 0.11–0.13 the length of the body and eight to nine times longer than wide. The sulcal lists end at the flagellar pore; they lack ribs except for the fission rib of the left list.

The midbody is fusiform and either fairly well set off from or gradually merging into the anterior process and the antapical. When the anterior process is more or less distinctly set off from the midbody, it is exceptionally long, 1.3–1.6 the length of the neck; its exceptional length gives to this species its peculiar and characteristic habitus. The distance between the flagellar pore and the anterior end of the antapical is four to five times the length of the neck. The midbody is of moderate length, 2.8–3.5 the length of the neck, and of moderate width or rather slender, widest near or somewhat behind the middle of the body; its greatest width is 0.60–0.75 the length of the neck. The ratio between the length and the greatest width of the body is 10–15: 1.

The antapical is unbranched and straight. When set off from the midbody, it is 2.3–3.0 the length of the neck or 0.28–0.35 the length of the body, 20–25 times longer than wide and about as wide as the neck. Its distal end is truncate, rectangular, of about the same width as its middle portion or sometimes slightly inflated. The antapex has a short, strong spinule at each of its four corners.

The thecal wall is faintly porulate. On the neck there are two rows of pores on each valve, one along the base of the sulcal list, and one along the dorsal suture.

The nucleus is rather large. The chromatophores are fairly numerous, rodlike and yellowish brown.

The proportions of one specimen from the material of the Expedition and of the type specimen were measured.

Dimensions: — Length of body, 391–434 μ (average, 416 μ). Length of head, 10 μ. Length of neck, 50 μ. Length of anterior process, midbody, and antapical, 365 μ. Approximate length of anterior process, 85 μ. Approximate length of midbody, 152 μ. Approximate length of antapical, 128 μ. Width of midbody, 38 μ. The length of the type specimen is unknown. According to a statement in the original description, it would be 544 μ; according to the size of the original drawing (Lemmermann, 1899a, pl. 1, fig. 19), the magnification of which is 305 diameters, it would be 232 μ.

Variations: — The species appears to be rather constant. The size of the body and the width of the midbody are the most variable characters. The posterior end of the antapical is sometimes slightly inflated, sometimes not.

Comparisons: — The specimens referred to *Amphisolenia schauinslandi* in this paper agree closely with the type of this species as figured by Lemmermann (1899a, pl. 1, fig. 19). In some of them the midbody is somewhat wider relatively than in the type specimen, and the posterior end of the antapical is somewhat inflated.

The straight longitudinal axis of the body, the fairly well-developed midbody, which in most specimens is rather distinctly set off from the antapical, and the simple, unbranched antapical appear to be primitive features of this species. The anterior process, which, secondarily, is longer than in any other known member of this genus, gives to the species a rather unique habitus.

Amphisolenia schauinslandi occupies a rather isolated position. The shape and the structure of the posterior end of its antapical are suggestive of *A. rectangulata.*

Occurrence: — The species is recorded at fourteen of the 127 stations. There are 3, 0, 0, 2, 8, and 1 stations on the six lines of the Expedition. Of these fourteen stations, three (4587, 4588, 4590) are in the Mexican Current; one (4699) is in the Easter Island Eddy; and ten (4701, 4722, 4725, 4732, 4734, 4735, 4736, 4737, 4739, 4740) are in the South Equatorial Drift. At three stations (4588, 4725, 4737) the species was found in surface catches only. At Station 4732 it is recorded from 800–0 fathoms and 300–0 fathoms, at Station 4737 from 100–0 fathoms and 300–0 fathoms. All the other records refer to catches from 300–0 fathoms only.

The temperature range of these fourteen stations at the surface was 72°–83°;

the average was 79.2°. At the three stations in the surface samples of which this species was found, the surface temperature ranged from 77° to 82°; the average was 80.0°.

The frequency does not exceed 1%, which occurs at one station only (4590).

The species was first recorded by Lemmermann (1899a, 1904) from the tropical region of the Pacific, between Laysan Island and the Hawaiian Islands, the type locality. Later it was recorded by Ostenfeld and Schmidt (1901) from the Gulf of Aden, lat. 12° 35′ N., long. 55° 55′ E.; and by Schröder (1906a) from

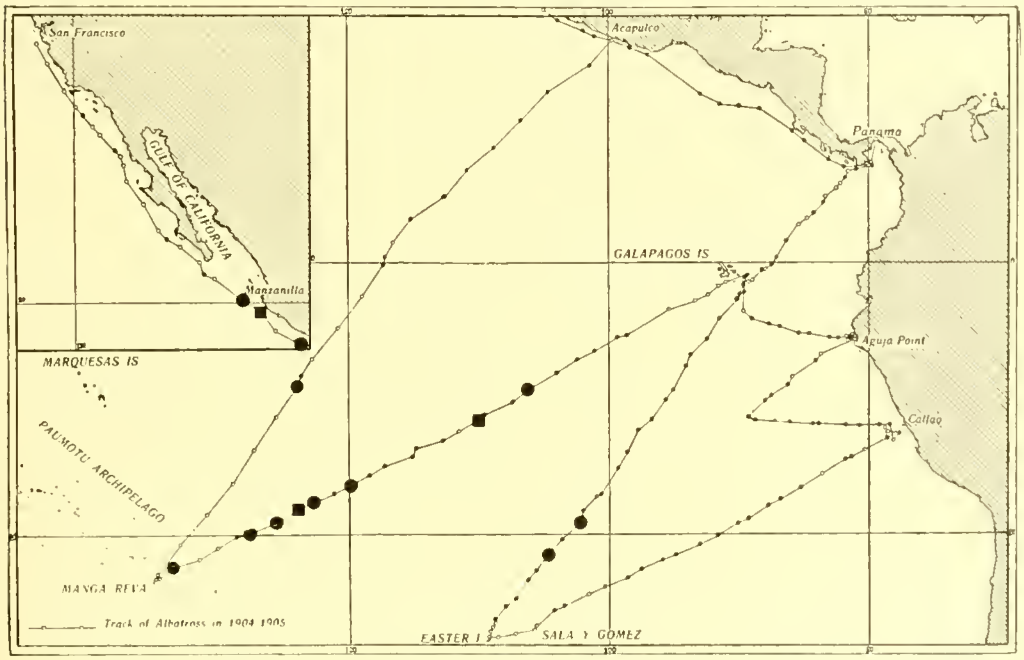

FIGURE 51.— Occurrence of *Amphisolenia schauinslandi* Lemmermann. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

the Indian Ocean, south of Ceylon. The sample in which Ostenfeld and Schmidt (1901) found this species was from a depth of 20 feet; Lemmermann's (1899a) and Schröder's (1906a) samples probably were taken near the surface.

Ostenfeld and Schmidt (1901) found the species in water of a temperature of 82.4°.

Ostenfeld and Schmidt (1901) and Schröder (1906a) do not give any information as to the structure of their specimens.

This is probably a eupelagic species of world-wide distribution in tropical and subtropical seas. The most striking features of its occurrence in the Eastern Pacific, according to our records, are its predominance in the western portion of the South Equatorial Drift and in the Mexican Current, and its absence from the California Current, the Panamic Area, and the Peruvian Current. The average temperature of its habitat is exceptionally high (79.2°).

Amphisolenia rectangulata Kofoid

Plate 8, fig. 3, 5, 6, 7, 9. Figure 49: 5

Amphisolenia rectangulata Kofoid, 1907a, p. 200, pl. 14, fig. 83.

Diagnosis: — With slight sigmoid curvature. Head 2.0–3.0 times wider than long. Epitheca flat. Midbody fusiform, gradually merging into anterior process and antapical. Distance from flagellar pore to antapical, 4.6 the length of neck. Ratio between length and width of body, 34: 1. Antapical slightly and evenly concave ventrally, ten times longer than neck; its posterior end sometimes slightly widened, truncate, rectangular. Antapex with a short spinule on each of the four corners. Length, 531–734 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The longitudinal axis of the body has a slight sigmoid curvature, with the neck slightly deflected dorsally, and the antapical slightly concave ventrally.

The head is inclined anteriorly at an angle of 20°–30°; its axial length is 0.15–0.18 the length of the neck, and it is 2.0–3.0 times wider than long. The anterior face of the epitheca is flat. The transverse furrow is 0.20 as wide as the dorsoventral diameter of the head, somewhat convex, and without cross-ridges. The cingular lists are about twice as wide as the transverse furrow; the anterior flares anteriorly at an angle of 20° and has, on each valve, seven or eight equidistant, simple ribs; the posterior is subhorizontal and has, on each valve, five or six similar ribs.

The neck is of moderate length and narrow; it is 0.06 the length of the body and ten times longer than wide. The sulcal lists end at the flagellar pore and lack ribs.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 4.6 the length of the neck. The midbody is rather slender, widest at a distance from the apex equaling about 0.25 the length of the body or at a distance from the flagellar pore 2.5 times longer than the neck; its greatest width is subequal to 0.5 the length of the neck. The ratio between the length and the greatest width of the body is about 34: 1.

The antapical is unbranched, slightly and evenly concave ventrally; long, ten times longer than the neck and twice the total length of the anterior process and the midbody; 55–60 times longer than wide and somewhat wider than the neck. The posterior end of the antapical is sometimes slightly widened, truncate, rectangular; its ventral face is somewhat narrower than its lateral face (Plate 8, fig. 5, 6); on each of the four corners there is a short, acute antapical spinule.

The thecal wall is apparently without structure. The posterior end of the antapical is porulate on its lateral sides, and has a row of pores along either side of the sagittal-suture line.

The nucleus is long and narrow. The chromatophores are spheroidal and numerous.

The proportions of one specimen, the type, were carefully measured. In the case of the head and the neck, one more specimen was measured.

Dimensions: — Length of body, 531–734 μ (type, 734 μ). Length of head, 7–9 μ. Length of neck, 47 μ. Length of anterior process and midbody, 217 μ. Width of midbody, 23 μ. Length of antapical, 453 μ.

Variations: — Very little is known about the variability of this species. The size of the body, the width of the head, and the degree of inflation of the posterior end of the antapical vary in our material.

Comparisons: — The description given above is based on the type material.

The simple, unbranched type of the antapical appears to be a primitive feature of this species. On the other hand, the slightly sigmoid curvature of the longitudinal axis of the body, the relatively great width of the head, the slenderness of the midbody, the merging of the midbody into the antapical, and the great elongation of the antapical probably are advances in differentiation.

Amphisolenia rectangulata resembles *A. schauinslandi* in the symmetrical and subrectangular posterior portion of its antapical and in its truncate antapex with four symmetrically arranged spinules, one on each of the four corners, and two on each valve. However, in other respects the last species differs very strikingly from the first, *e.g.*, in the narrowness of the head, in the extreme elongation of the anterior process, and in the moderate length of the antapical.

Another species with symmetrical posterior portion of the antapical and with four symmetrically arranged spinules, two on each valve, is *A. quadrispina*. This species, which resembles *A. rectangulata* also in the slenderness of its midbody, differs very conspicuously in the wide, knob-like termination of its antapical and in the neck-like constriction and slight inflation in front of the terminal knob. The four symmetrically arranged spinules on the antapex and the slenderness of the midbody are probably not the results of common inheritance but of independent differentiation. *A. quadrispina* probably originated from a form very similar to *A. globifera, i.e.*, a form of moderate size, fairly wide midbody, moderately long antapical, and with but two antapical spinules. We are without clue as to the ancestral relationships of *A. rectangulata*.

Great elongation of the antapical and symmetrical development of the posterior portion of this part of the body are characteristics of *A. rectangulata* that are found also in *A. extensa*. In the shape and structure of the posterior portion of the antapical these two species are quite different.

Occurrence: — *Amphisolenia rectangulata* is recorded at five of the 127 stations. There are 2, 0, 0, 0, 2, and 1 stations on the six lines of the Expedition. Of these five stations, one (4587) is in the Mexican Current; one (4617) is in the Panamic Area; three (4734, 4739, 4740) are in the South Equatorial Drift. All the catches are from 300-0 fathoms.

The temperature range of these five stations at the surface was 78°-81°; the average was 80.2°.

The frequency is less than 1%. The species was first reported by Kofoid (1907a) from Station 4740 of the Expedition which thus is the type locality.

This is probably a eupelagic species of tropical and subtropical nature. The most outstanding peculiarities in its distribution in the Eastern Pacific, according to our data, are its occurrence in the Mexican Current, Panamic Area, and South Equatorial Drift, and its absence from the Peruvian Current. The average temperature of its habitat is exceptionally high (80.2°).

Amphisolenia astragalus Kofoid and Michener

Plate 10, fig. 1, 6, 8, 10. Figure 49: 6

Amphisolenia astragalus Kofoid & Michener, 1911, p. 293.

Diagnosis: — With very slight sigmoid curvature. Head 1.2 times wider than long. Epitheca gently convex. Midbody fusiform, gradually merging into anterior process but rather well set off from antapical. Distance from flagellar pore to antapical 4.0 the length of neck. Ratio between length and width of body, 45: 1. Antapical 4.6 times longer than neck, almost straight except posteriorly, where it is bent ventrally at an angle of 50°; at point of bending there is a rounded dorsal heel which gives to posterior part a foot-like shape. Antapex rounded, with a distal spinule and a rounded lateral projection. Length, 658 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is very slightly sigmoid, the neck being slightly deflected dorsally, and the antapical having a very slight ventral concavity. The tip of the antapical has a very abrupt ventral bend.

The head is inclined anteriorly at an angle of 15°–20°; its axial length is 0.15 the length of the neck; and it is 1.2–1.3 times wider than long. The anterior face of the epitheca is gently convex. The transverse furrow is 0.33 as wide as the dorsoventral diameter of the head, very slightly concave, and has, on each valve, five or six almost equidistant cross-ridges, some of which may be somewhat irregular. The anterior cingular list is about twice as wide as the transverse furrow, flares anteriorly at an angle of about 15° and has, on each valve, ten simple, equidistant ribs. The posterior cingular list is somewhat narrower, subhorizontal, and has the same or a somewhat smaller number of similar ribs.

The neck is of moderate length, 0.10 the length of the body, and rather narrow, about 16 times longer than wide. On each valve, somewhat dorsally to the middle, it has a low, narrow longitudinal ridge, which in the type specimen extends from the girdle along the anterior quarter of the length of the neck. The sulcal lists end at the cytopharyngeal pore; in the type specimen the right list has a marginal rib along the anterior quarter of its margin.

The midbody is fusiform and merges gradually into the anterior process but is fairly well set off from the antapical. The distance between the flagellar pore and the antapical is 4.0 the length of the neck. The midbody is very slender, widest at a distance from the apex equaling two fifths of the length of the body, or at a distance from the flagellar pore 2.5 times longer than the neck; its greatest width is 0.24 the length of the neck. The ratio between the length and the greatest width of the body is 45: 1.

The antapical is unbranched, with a very gentle ventral concavity except near the posterior end where it is bent abruptly ventrally at an angle of 50°. It is 4.6 times longer than the neck and 1.2 the total length of the anterior process and the midbody. It is of almost uniform width throughout its whole length except near the posterior end where it is slightly widened; its average width is about the same as that of the neck, and it is about 70 times longer than wide. At the point of the abrupt bending, near the antapex, there is a well-developed, rounded, heel-like dorsal protuberance, which gives to the distal part of the antapical, in lateral view, a foot-like appearance. Seen laterally, the foot-like part is somewhat less than three times longer than wide. The antapex is rounded and has a rather strong distal spinule and a rounded lateral projection.

The thecal wall is almost without structure. On the posterior end of the antapical there is a row of pores on either side of the ventral suture line and some scattered pores on the foot-like part of the antapical. The porulation of the neck is unknown (see also the description of the neck).

The nucleus is of moderate size and elongated. The chromatophores are rather few, round or ellipsoidal; some of them are yellowish.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 658 μ. Length of head, 9.5 μ. Length of neck, 66 μ. Length of anterior process and midbody, 268 μ. Width of midbody, 16.5 μ. Length of antapical, 314 μ.

Comparisons: — The description given above is based on the type material.

This highly differentiated species has an uncertain position within the genus Amphisolenia. The abrupt ventral bending of the posterior foot-like portion of its antapical is unique as far as the known species of this genus are concerned. It should be mentioned, however, that our interpretation of the direction of this bending is somewhat uncertain since the course of the posterior portion of the sagittal suture has not been followed with certainty. Our decision in this case is based on the position of what appear to be the pores of this suture. The ventral bending may be apparent; it may be a bending to the right combined with ventral torsion. If this be the case, then *A. astragalus* in this respect agrees with *A. bidentata*. However, even so, the single distal spinule and the rounded lateral protuberance on the posterior portion of the antapical give to *A. astragalus* an appearance quite different from that of *A. bidentata*. Furthermore, *A. astragalus* differs from all the species of the Palmata group in not having any "heel-spinule" on the antapical. In this respect it is somewhat closer to the Schröderi group, from which the Palmata group presumably originated. It should be remembered however, that the species of the Schröderi group have no indication of an antapical heel, while in *A. astragalus* a large, *rounded* heel is developed.

Occurrence: — *Amphisolenia astragalus* is recorded at only one of the 127 stations. This station (4713) is on the fourth line of the Expedition and in the Galapagos Eddy. The depth is 300-0 fathoms, the surface temperature 73°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) at Station 4713 of the Expedition which thus is the type locality.

2. Extensa Group. Both the species belonging to this group, viz., *Amphisolenia extensa* and *A. elongata*, have been found in the material of the Expedition.

Amphisolenia extensa Kofoid

Plate 6, fig. 3, 5. Figure 49: 8, 52

Amphisolenia extensa Kofoid, 1907a, p. 198, pl. 13, fig. 78. Doflein, 1909, p. 464, fig. 403e; 1911, p. 531, fig. 462e; 1916, p. 437, fig. 374e. Jörgensen, 1923, p. 41, fig. 60.

Diagnosis: — With more or less pronounced sigmoid curvature. Head 1.4–2.5 times wider than long. Epitheca gently convex. Midbody fusiform, gradually merging into anterior process and antapical, or fairly well set off from antapical. Distance from flagellar pore to antapical 3.5–5.0 the length of neck. Ratio between length and width of body, 55–65: 1. Antapical concave ventrally, 22–33 times longer than neck; its posterior end slightly club-shaped, subtruncate. Antapex mostly without spinules or with one to four exceedingly small ones. Length, 1292–1520 μ.

Tropical and subtropical regions of Eastern Pacific; Mediterranean.

Description: — The longitudinal axis of the body has a more or less pronounced sigmoid curvature, with the neck slightly deflected dorsally, and the antapical more or less concave ventrally. In the specimens examined by us the ventral curvature of the antapical is slight or moderate (Figure 49: 8); in the specimen figured by Jörgensen (1923, fig. 60) it is very pronounced.

The head is inclined anteriorly at an angle of 40°; its axial length is 0.15–0.16 the length of the neck; and it is 1.4–2.5 (in our specimens, 2.0–2.5) times wider than long. The anterior face of the epitheca is gently convex. The transverse furrow is 0.20 as wide as the dorsoventral diameter of the head, flat; it has, on each valve, nine equidistant cross-ridges. The anterior cingular list is subhorizontal or flares anteriorly at an angle of 10°–15°; it is 1.5–3.0 as wide as the transverse furrow and has, on each valve, 10–11 equidistant, simple ribs. The posterior cingular list is subhorizontal, about as wide as or somewhat narrower than the anterior list and has about the same number of equidistant, simple ribs as the latter.

The neck is of moderate length and narrow; it is 0.02–0.04 the length of the body and 11–17 (in our specimens 16–17) times longer than wide. The sulcal lists extend to the flagellar pore and have anteriorly two to three longitudinal, irregular, and sometimes anastomosing ribs.

The midbody is fusiform and either merges gradually into the anterior process and into the antapical or is fairly well set off from the antapical. The distance between the flagellar pore and the anterior end of the antapical is 3.5–5.0 the length of the neck. The midbody is more or less slender, widest at a distance from the apex equaling 0.08–0.15 the length of the body or at a distance from the flagellar pore 2.0–3.0 times longer than the neck; its greatest width is subequal to or slightly less than 0.5 the length of the neck. The ratio between the length and the greatest width of the body is 55–65: 1.

The antapical is unbranched, evenly and either slightly or more or less strikingly (Jörgensen, 1923, fig. 60) concave ventrally. It is exceptionally long and narrow, 22–33 times longer than the neck and four to seven times longer than the total length of the anterior process and the midbody; it is as wide as the neck and of uniform width throughout its whole length except near the posterior end where it is slightly club-shaped. The antapex is subtruncate and in most cases without spinules, sometimes with one to four exceedingly small ones.

The thecal wall is apparently without structure; the posterior part of the antapical is porulate.

The nucleus is large, ovoidal or elongated. The chromatophores are numerous and spheroidal. In the midbody colorless plastids and some oil drops also are to be found.

The proportions of three of our specimens and of the specimen figured by Jörgensen (1923, fig. 60) were measured.

Dimensions: — Our specimens: Length of body, 1325–1520 μ (average, 1426 μ; type, 1400 μ). Length of head, 9 μ. Length of neck, 40–58 μ (average, 47 μ; type, 58 μ). Length of anterior process and midbody, 171–205 μ (average, 186 μ; type, 171 μ). Width of midbody, 18–23 μ (average, 21 μ; type, 23 μ). Length of antapical, 1070–1287 μ (average, 1172 μ; type, 1160 μ). Jörgensen's (1923) specimen: Length of body, 1292 μ. Width of midbody, 17 μ.

Variations: — The species appears to be fairly constant. The following characters are the most variable: — the size of the body, the curvature of the longitudinal axis of the body, the dorsoventral width of the head, and the relative length and width of the midbody.

Comparisons: — The description given above is based on the type material. The specimen figured by Jörgensen (1923, fig. 60) under the name of *Amphisolenia extensa* differs from our specimens of this species in the following respects: — the body is slightly shorter; the antapical has a more pronounced ventral concavity; the dorsoventral width of the head is only 1.4 the axial length of the head; and the neck is slightly wider. In spite of these differences it seems rather probable that Jörgensen's assignment of this specimen is correct.

The simple, unbranched type of the antapical appears to be a primitive feature of this species. On the other hand, the more or less pronounced sigmoid curvature of the longitudinal axis of the body, the slenderness of the midbody, the tendency of the midbody to merge into the antapical, and the excessive elongation of the antapical probably are secondary differentiations. No other known species of this genus has such a long and attenuated antapical.

Amphisolenia extensa is probably very closely related to *A. elongata* as is shown by the almost identical shape and structure of the posterior portions of the antapicals of these two species. The two forms most probably are specifically distinct, but, on the other hand, the possibility that they are but giant and dwarf variants of the same species should not be considered as excluded. The basis of separation of the two species lies not only in the much smaller size of *A. elongata* (438–464 μ) as compared with *A. extensa* (1292–1520 μ) but also in the proportions of the different parts. The head in *A. elongata* is only 1.5 times and in the Pacific specimens of *A. extensa* 2.0–2.5 times wider than long. In *A. elongata* the greatest width of the midbody is 0.30–0.40 the length of the neck, and the ratio between the length and the greatest width of the body is 30–35: 1. In *A. extensa* the corresponding values are 0.50 and 55–65: 1. The antapical is very short in *A. elongata* (six times longer than the neck and about twice the total length of the anterior process and the midbody) as compared with *A. extensa* (22–23 times longer than the neck and four to seven times longer than the total length of the anterior process and the midbody).

It should be noted that the specimen of *Amphisolenia extensa* figured by Jörgensen (1923, fig. 60) is in some respects intermediate between our specimens of this species and *A. elongata*, *e.g.*, in the shape of the head and of the midbody. The head of this specimen is only 1.4 times wider than long, in other words, even slightly narrower than the head in *A. elongata*.

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia extensa*. Reproductions of Kofoid's (1907a) figure of the type specimen are given by Doflein (1909, 1911, 1916).

Occurrence: — *Amphisolenia extensa* is recorded at thirty-three of the 127 stations. There are 7, 5, 3, 7, 9, and 2 stations on the six lines of the Expedition. Of these thirty-three stations, two (4580, 4583) are in the California Current; four (4587, 4594, 4598, 4605) are in the Mexican Current; three (4613, 4634, 4638) are in the Panamic Area; three (4650, 4667, 4668) are in the Peruvian Current; three (4691, 4697, 4699) are in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; sixteen (4679, 4683, 4701, 4707, 4709, 4711, 4719, 4721, 4722, 4724, 4728, 4732, 4734, 4736, 4739, 4740) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current. At four stations (4701, 4721, 4728,

4732) the species is recorded from 800–0 fathoms; at one station (4713) from 150–0 fathoms. All the other records refer to catches from 300–0 fathoms.

The temperature range of these thirty-three stations at the surface was 67°–85°; the average was 76.4°.

The frequency is 2% at one station (4638), 1% at seven stations (4583, 4598, 4683, 4701, 4707, 4709, 4721), and less than 1% at the remaining stations.

The species was first recorded by Kofoid (1907a) from Station 4699 of the Expedition, which thus is the type locality. Jörgensen (1923) reported it from the Tyrrhenian Sea.

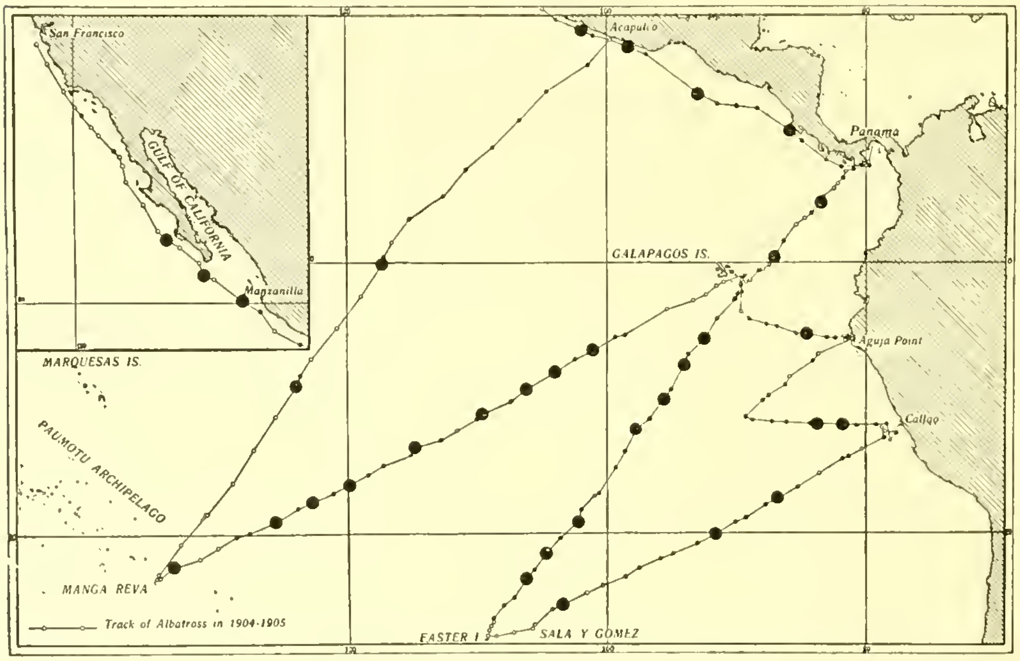

FIGURE 52.—Occurrence of *Amphisolenia extensa* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

This is probably a eupelagic species, extensively distributed in tropical and subtropical seas and sometimes occurring in warm-temperate waters. According to our records, it is fairly evenly distributed throughout the area investigated by the Expedition. Although it appears to be very highly adapted to flotation, it has not been taken as yet in surface catches.

AMPHISOLENIA ELONGATA, sp. nov.

Figure 49: 7, 50: 11

Diagnosis: —With slight sigmoid curvature. Head 1.5 times wider than long. Epitheca moderately convex. Midbody fusiform, gradually merging into anterior process and antapical or fairly well set off from antapical. Distance from flagellar pore to antapical 3.0 the length of neck. Ratio between length and width of body, 30–35: 1. Antapical gently concave ventrally, six times longer than neck; its posterior end as in *Amphisolenia extensa*. Length, 438–464 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The longitudinal axis of the body is slightly sigmoid, with the neck slightly deflected dorsally and the antapical slightly concave ventrally.

The head is inclined anteriorly at an angle of 25°–30°; its axial length is 0.15–0.16 the length of the neck, and it is 1.5 times wider than long (slightly tilted in Figure 49: 7). The anterior face of the epitheca is moderately convex. The transverse furrow is 0.38 as wide as the dorsoventral diameter of the head, flat. The cingular lists are subequal, about 1.5–2.0 times wider than the transverse furrow; the anterior flares anteriorly at an angle of about 10°, the posterior is subhorizontal.

The neck is of moderate length and rather narrow; it is 0.1 the length of the body and 18 times longer than wide. The left sulcal list either ends at the flagellar pore, or it continues a short distance behind the flagellar pore; in the latter case a fission rib is developed.

The midbody is fusiform and merges gradually into the anterior process and antapical, or it is fairly well set off from the antapical. The distance between the flagellar pore and the anterior end of the antapical is 3.0 the length of the neck. The midbody is slender, widest at a distance from the apex equaling 0.27 the length of the body or at a distance from the flagellar pore 1.5 the length of the neck; its greatest width is 0.30–0.40 the length of the neck. The ratio between the length and the greatest width of the body is 30–35: 1.

The antapical is unbranched and slightly concave ventrally. It is rather long, six times longer than the neck or about twice the total length of the anterior process and the midbody; it is as wide as the neck and of uniform width throughout its whole length except near the posterior end where it is slightly club-shaped. The antapex is subtruncate and, as far as known, without spinules.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 438–464 μ (type, 464 μ). Length of head, 9 μ. Length of neck, 45 μ. Length of anterior process and midbody, 129 μ. Width of midbody, 15 μ. Length of antapical, 281 μ.

Variations: — Judging by the two specimens found in the material of the Expedition, the species appears to be rather constant in form and dimensions.

Comparisons: — *Amphisolenia elongata* is founded on outline drawings of two specimens. Unfortunately, our knowledge of its structural characteristics is incomplete in some respects, *e.g.*, the finer structure of the cingular and sulcal lists and of the transverse furrow is unknown.

The species is probably very closely related to *Amphisolenia extensa*, as is indicated by the great similarity between the posterior portions of the antapicals of these two species (see *A. extensa*, the section on comparisons).

Occurrence: — The species is recorded at two of the 127 stations with a total of two specimens. One of these two stations (4681, the type locality) is on the third, the other (4737) on the fifth line of the Expedition, and both are in the South Equatorial Drift. The sample from Station 4681 was taken from 300–0 fathoms, the other sample (Station 4737) from 300–0 fathoms.

The surface temperatures at these two stations were 68.0° and 81.5°. The frequency is less than 1%.

3. Globifera Group. Both the species belonging to this group, viz., *Amphisolenia globifera* and *A. quadrispina* have been found in the material of the Expedition.

Amphisolenia globifera Stein

Plate 8, fig. 1, 2, 4, 8. Figure 49: 9, 50: 1–5, 53

Amphisolenia globifera Stein, 1883, p. 24, pl. 21, fig. 9, 10. Bütschli, 1885, pl. 55, fig. 4a. Schütt, 1896, p. 28, fig. 40. Murray & Whitting, 1899, tab. 8. Lemmermann, 1899a, p. 373; 1901a, p. 376; 1905a, p. 36. Schröder, 1900a, p. 20. Cleve, 1901a, p. 13; 1903b, *partim*, p. 339. Ostenfeld & Paulsen, 1904, p. 164, 173. Zacharias, 1906, p. 564. Paulsen, 1908, p. 20, fig. 23. Willey, 1909, p. 184, fig. 7. Hjort, 1911, fig. 12: 2. Hensen, 1911, p. 159, 160, tab. 13. Jörgensen, 1923, p. 41, fig. 61.

Amphisolenia globosa Gran, 1912a, p. 935, fig. 8a (*lapsus pennae*); 1912b, fig. 232a.

Amphisolenia tenella Gran, 1912a, p. 935, fig. 8b; 1912b, fig. 232b.

Diagnosis: — Straight or slightly curved. Head subspheroidal or subrectangular, about as long as wide. Epitheca strongly convex. Midbody fusiform, gradually merging into anterior process and antapical. Distance from flagellar pore to antapical 1.4–2.6 the length of neck. Ratio between length and width of body, 9–25: 1. Antapical generally straight, sometimes concave dorsally, 1.3–2.2 times longer than neck; its posterior part knob-like, generally with constriction just in front of knob. Antapex without or with but two spinules. Length, 142–319 μ.

Probably of world-wide distribution in tropical, subtropical, and warm-temperate waters.

Description: — The longitudinal axis of the body is in most cases straight; in one of our specimens (Figure 50: 5) it had a slight and even dorsal concavity; in another (Figure 50: 2) the posterior half of the antapical was gently concave dorsally.

The head is subhorizontal or somewhat inclined anteriorly, in exceptional cases even at an angle of 25°. It is subspheroidal or subrectangular; its axial length is 0.13 (0.11–0.17; type, 0.15) the length of the neck; and it is about as wide as long. The anterior face of the epitheca is boldly convex. The transverse furrow is 0.30–0.40 as wide as the dorsoventral diameter of the head; generally somewhat convex, sometimes flat or even slightly concave; it has no cross-ridges. The anterior cingular list flares anteriorly at an angle of 20°–30°; the posterior is subhorizontal; both are somewhat wider than the transverse furrow and have simple, equidistant ribs; the anterior list has, on each valve, seven to eight, the posterior, as a rule, six to seven ribs.

The neck is very long, 0.21 (0.17–0.26; type, 0.20) the length of the body, and narrow, 12–22 times longer than wide. The sulcal lists end at or just behind the flagellar pore and have no ribs; the fission rib has not been seen.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 1.9 (1.4–2.6; type, 2.4) the length of the neck. The midbody is of moderate width or more or less slender. It is widest near the middle of the body, as in the type specimen, or somewhat in front of the middle; sometimes it is widest at a distance from the apex equaling two fifths of the length of the body. Its greatest width is 0.19–0.50 the length of the neck; in the type specimen (Stein, 1883, pl. 21, fig. 9) the corresponding ratio is 0.41; in Gran's (1912b) figures 232a and 232b it is 0.50 and 0.20, respectively; in Jörgensen's (1923) figure 61a, 0.30; in our specimens, 0.24 (0.19–0.39). The ratio between the length and the greatest width of the body is 9–25: 1.

The antapical is unbranched, and, in most specimens, straight (see above). It is 1.7 (1.3–2.2; type, 1.6) the length of the neck, in other words, on the average slightly shorter than the total length of the anterior process and the midbody. It is about as wide as or slightly wider than the neck and of uniform width throughout its whole length except at the posterior end, where it expands into a knob-like, globular termination, the diameter of which is 2.0–3.5 the average width of the antapical. Just in front of the knob, the antapical widens slightly, and then contracts into a short neck, before expanding into the knob (Plate 8, fig. 1, 4). This neck-like constriction is frequently easily overlooked because of the fact that it is surrounded by a translucent sheath. The constriction probably does exist in most or perhaps even in all specimens; however, we are not able to make any final statement on this point. The antapex is either smooth, without any spinules, as in the type specimen, or it has two short, narrow, and pointed spinules. Jörgensen (1923, p. 41) writes about these spinules: "These are small and easily overlooked; also, the species seems to vary in this respect."

The thecal wall is apparently without structure. The posterior part of the antapical is porulate. Along the base of the sulcal lists there is a row of pores; and on the head a number of scattered pores also are to be found.

The nucleus is medium-sized and ellipsoidal. The chromatophores are small, irregular, greenish yellow.

The proportions of six of our specimens and of the specimens drawn by Stein (1883), Gran (1912b), and Jörgensen (1923) were measured.

Dimensions: — Our specimens: Length of body, 142–318 μ (average, 236 μ). Length of head, 4.5–8.0 μ (average, 6.8 μ). Length of neck, 30–68 μ (average, 51 μ). Length of anterior process and midbody, 66–117 μ (average, 94 μ). Width of midbody, 10–16 μ (average, 12 μ). Length of antapical, 42–126 μ (average, 86 μ). The size of the type specimen (Stein, 1883, pl. 21, fig. 9) is not known. Stein does not give the magnification of this figure; however, in an introductory note to the explanations of the plates, he states that his magnifications range from 450 to 690 diameters. The length of body of the type specimen is therefore between 214 μ and 328 μ. The specimens represented by Gran (1912b, fig. 232a and b) are 179 μ and 153 μ long, respectively. Greatest width of midbody, 20 μ and 7 μ, respectively. Jörgensen (1923, p. 40) states that the specimens examined by him measured about 200 μ in length or somewhat less.

Variations: — As conceived in the present paper, *Amphisolenia globifera* exhibits a rather remarkable variability. The following characters are more or less strikingly variable: — the length of the body, the shape of the longitudinal axis of the body, the shape and inclination of the head, the relative length of the neck, the relative width of the midbody, the relative length of the antapical, and the shape and structure of the posterior part of the antapical. Future investigations, based on a material richer than ours, may prove it necessary and feasible to divide this species into two or more systematic units.

Comparisons: — Some of the specimens found in the material of the Expedition and referred to *Amphisolenia globifera* in this paper, agree fairly closely with the type specimen of this species as drawn by Stein (1883, pl. 21, fig. 9). On the other hand, the determination of some of our remaining specimens is somewhat doubtful (see the previous section). It may be noted that in none of our specimens is the anterior cingular list quite so wide as in Stein's figures of the type specimen.

The specimen of this species figured by Hjort (1911, fig. 12: 2) agrees very closely with the type specimen. The same is true with regard to the specimens represented by Gran (1912b, fig. 232a; reproduced in Gran, 1912a, fig. 8a) and by Jörgensen (1923, fig. 61). On the other hand, the specimen figured by Gran (1912b, fig. 232b; reproduced in Gran, 1912b, fig. 8b) under the name of *Amphisolenia tenella* differs very strikingly from the type specimen of *A. globifera* in the narrowness of its midbody (see the following section).

The small size, the straight longitudinal axis of the body, and the unbranched antapical appear to be primitive features of this species. The gradual merging of the midbody into the antapical and the differentiation of the posterior part of the antapical are probably later acquisitions.

Amphisolenia globifera is undoubtedly very closely related to *A. quadrispina.* This relationship is indicated especially by the globular shape of the posterior part of the antapical in these species. *A. globifera* is easily distinguished from *A. quadrispina* by its smaller size (142–318 μ as compared with 630 μ) and by having two or no antapical spinules instead of four.

Synonymy: — The species was established by Stein (1883) under the name of *Amphisolenia globifera.* It is the type species of the genus. Of later writers only Hjort (1911) and Jörgensen (1923) have contributed to our knowledge of the structure of the species. Bütschli (1885), Schütt (1896), Paulsen (1908), and Willey (1909) give reproductions of Stein's figures of the type specimen.

With regard to *Amphisolenia globifera* Cleve (1903b), see the section on the distribution of this species.

In Gran (1912a and b) the name of *Amphisolenia globosa* was used for this species, evidently due to a *lapsus pennae.*

We have considered it most advisable, for the time being, to accept Jörgensen's (1923, p. 41) decision that *Amphisolenia tenella* Gran (1912b, fig. 232b) is identical with *A. globifera.* The characters on which *A. tenella* evidently is founded (no diagnosis or description accompany the figure), are variable to such an extent as to render a differentiation of these two forms impossible at the present time. However, it seems to be far from improbable that future investigations, based on a material richer than ours, will prove *A. tenella* and *A. globifera* specifically distinct.

Occurrence: — The species is recorded at seventeen of the 127 stations. There are 3, 3, 0, 4, 6, and 1 stations on the six lines of the Expedition. Of these seventeen stations, one (4571) is in the California Current; one (4590) is in the Mexican Current; one (4613) is in the Panamic Area; three (4662, 4666, 4668) are in the

Peruvian Current; one (4699) is in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; eight (4701, 4711, 4717, 4721, 4722, 4724, 4732, 4733) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current. At one station (4733) the species was found in the stomach of Salpa from surface waters, the only record from the surface in the material of the Expedition. At three stations (4662, 4666, 4717) it occurred in catches from 800–0 fathoms; at one station (4701) in a catch from 800–0 fathoms as well as in catches from 300–0 fathoms; at one station (4713) in a catch from 150–0 fathoms as well as in one from 300–0 fathoms. The remaining records refer to catches from 300–0 fathoms only."

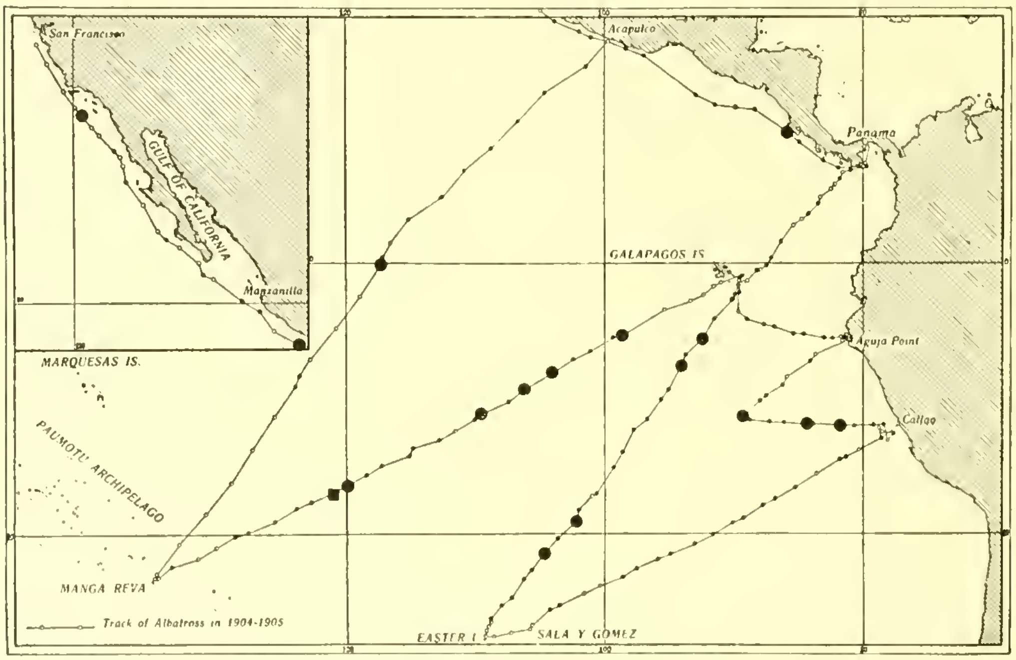

FIGURE 53.—Occurrence of *Amphisolenia globifera* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

The temperature range of these seventeen stations at the surface was 67°–83°; the average was 74.5°.

A frequency of 1% is recorded at seven stations (4571, 4613, 4662, 4666, 4668, 4713, 4717). In the remaining cases the frequency is less than 1%.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer." Hjort (1911) and Gran (1912b) mentioned it as taken in the North Atlantic by the MICHAEL SARS Expedition, 1910. It was recorded from the Gulf Stream, lat. 59° N., long. 22° W., by Ostenfeld and Paulsen (1904); from the Sargasso Sea, lat. 34°–30° N., long. 39°–32° W., by Murray and Whitting (1899); from the

North and South Equatorial Currents of the Atlantic by Hensen (1911); from the Bay of Cadiz, near the Straits of Messina, and east of Sardinia by Jörgensen (1923); from the Malay archipelago by Cleve (1901a). The samples of Ostenfeld and Paulsen (1904), Murray and Whitting (1899), and Cleve (1901a) were taken near the surface. Jörgensen (1923) found the species in catches from 80–200 meters.

The species occurs in waters of the following temperatures and salinities: — Ostenfeld and Paulsen (1904): temperature, 49.3°; salinity, probably about 35.30; Murray and Whitting (1899): temperature 66°–60°; Cleve (1901a): the temperature range of six samples, 83.7°–77.5°, average 82.2°; the salinity range of these samples was 33.06–31.62, and the average 32.46.

Murray and Whitting (1899), Ostenfeld and Paulsen (1904), and Cleve (1901a) do not give any information as to the structure of their specimens. In Hjort (1911), Gran (1912b), and Jörgensen (1923), on the other hand, drawings of this species are to be found.

Cleve (1903b) reported "*Amphisolenia globifera* Stein (incl. *A. bidentata* Schröder)" from the Red Sea, lat. 20° N., long. 39° E., and from the Arabian Sea, lat. 21° N., long. 62° E., and lat. 19°–15° N., long. 59°–52° E. The temperature range of five surface stations was 81.3°–74.3°, with an average of 75.6°; the salinity range of these stations was 38.78–36.02, and the average 36.94. These localities have not been included among those given above because of the fact that *A. globifera* Cleve (1903b) possibly may be a *lapsus pennae* for *A. palmata* (see Schröder, 1906a, p. 371). In any case, Cleve has confused two distinct species.

This species is eupelagic and has a world-wide distribution in tropical, subtropical, and warm-temperate waters, and only occasionally is carried by currents to the colder regions of the seas. Our record stations are fairly evenly distributed over the district investigated by the Expedition.

Amphisolenia quadrispina Kofoid

Plate 9, fig. 2–4. Figure 49: 10, 50: 9

Amphisolenia quadrispina Kofoid, 1907a, p. 200, 201, pl. 14, fig. 86.

Diagnosis: — Straight; head subspheroidal, 1.1–1.5 times wider than long. Epitheca strongly convex. Midbody fusiform, gradually merging into anterior process and antapical. Distance from flagellar pore to antapical 4.6 the length of neck. Ratio between length and width of body, 40–45: 1. Antapical straight, about five times longer than neck; its posterior part knob-like, with constriction just in front of knob. Antapex with four spinules. Length, 607–693 μ.

Eastern tropical and subtropical Pacific.

Description: — The longitudinal axis of the body is straight. The head is subspheroidal and inclined anteriorly at an angle of 10°–15°; its axial length is 0.20 the length of the neck; and it is about as wide as long or even 1.5 times wider than long. The anterior face of the epitheca is strongly convex. The transverse furrow is 0.50 as wide as the dorsoventral diameter of the head, either slightly convex, flat, or gently concave; it has no cross-ridges. The cingular lists flare anteriorly at an angle of 10°–20°, or the posterior is subhorizontal; they are about as wide as or somewhat wider than the transverse furrow, and each of them has, on each valve, six to eight simple, equidistant ribs.

The neck is rather long and narrow; it is 0.09 the length of the body, and 15 times longer than wide. The sulcal lists end at or just behind the flagellar pore and have no ribs; the fission rib has not been seen.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 4.6 the length of the neck. The midbody is very slender, widest at a distance from the apex equaling two fifths of the length of the body, or at a distance from the flagellar pore three times longer than the neck; its greatest width is 0.23 the length of the neck. The ratio between the length and the greatest width of the body is 40–45: 1.

The antapical is unbranched and straight. It is about five times longer than the neck and slightly longer than the total length of the anterior process and the midbody. It is about as wide as the neck and of uniform width throughout its whole length except at its posterior end where it expands into a knob-like, globular termination, the diameter of which is between three and four times the average width of the antapical. Just in front of the knob, the antapical widens slightly, and then contracts into a short neck before expanding into the knob. The antapex is characterized by four equidistant, short, narrow, and pointed spinules, placed in such a way that in fission two go with each valve.

The thecal wall is apparently without structure. The posterior part of the antapical is porulate.

The nucleus is rather large, elongated, and somewhat irregular. In the midbody as well as in the antapical there are numerous small, spheroidal chromatophores.

In the girdle and on the epitheca of one specimen was found a moderate number of small spheroidal bodies of about the same type as the phaeosomes of other genera of this tribe. Such bodies have not been found in any other species of Amphisolenia and their significance is unknown.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 607–693 μ (type, 630 μ). Length of head, 11 μ. Length of neck, 60 μ. Length of anterior process and midbody, 270 μ. Width of midbody, 13 μ. Length of antapical, 287 μ.

Variations: — Apart from variations in size, the species appears to be rather constant.

Comparisons: — The description given above is based on the type material. See the section on the comparisons of *Amphisolenia globifera.*

Occurrence: — This species is recorded at eleven of the 127 stations. There are 6, 1, 0, 1, 2, and 1 stations on the six lines of the Expedition. Of these eleven stations, three (4574, 4580, 4583) are in the California Current; one (4605) is in the Mexican Current; three (4613, 4617, 4634) are in the Panamic Area; three (4711, 4722, 4728) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current. At one station (4728) the species is recorded from 800–0 fathoms as well as from 300–0 fathoms. At the remaining stations it is recorded from 300–0 fathoms only.

The temperature range of these eleven stations at the surface was 69°–85°; the average was 77.7°.

The frequency is less than 1% except at two stations (4574, 4617), where it is 1%.

The species never has been found except in the material of the Expedition. It was first recorded by Kofoid (1907a) from Stations 4613 and 4722 of the Expedition. However, the type specimen (Kofoid, 1907a, pl. 14, fig. 86) is from Station 4711 of the Expedition, which thus is the type locality.

The most remarkable peculiarities in the distribution of this species in the Eastern Pacific, according to our data, are its relatively frequent occurrence in the California Current and its absence from the Peruvian Current. It appears to be eupelagic in warm seas.

4. Bispinosa Group. Both the species belonging to this group, viz., *Amphisolenia bispinosa* and *A. curvata,* have been found in the material of the Expedition.

Amphisolenia bispinosa Kofoid

Plate 9, fig. 1, 6, 7, 8. Figure 49: 12

Amphisolenia bispinosa Kofoid, 1907a, p. 197, 201, pl. 14, fig. 85.

Diagnosis: — With moderate sigmoid curvature. Head 2.2 times wider than long. Epitheca slightly convex. Midbody fusiform, passing imperceptibly into anterior process and antapical. Ratio between length and width of body, 35–40: 1. Antapical with gentle and even ventral concavity; its posterior part very slightly inflated. Antapex rounded in lateral view; with two stout, pointed, lateral spinules, one on each valve. Length, 646–652 μ.

Eastern tropical and subtropical Pacific.

Description: — The longitudinal axis of the body has a moderate sigmoid curvature, due to the slight dorsal deflection of the neck and the gentle and even ventral concavity of the antapical. The ventral deflection of the antapical is about 5°.

The head is inclined anteriorly at an angle of 30°; its axial length is 0.22 the length of the neck, and it is 2.2 times wider than long. The anterior face of the epitheca is slightly convex. The transverse furrow is 0.14 as wide as the dorsoventral diameter of the head, flat or slightly convex, and has, on each valve, five to six almost equidistant cross-ridges. The anterior cingular list is about three times wider than the transverse furrow, flares anteriorly at an angle of 25° and has, on each valve, five to six fairly regularly spaced, simple ribs. The posterior cingular list is somewhat narrower, subhorizontal, and has about the same number of similar ribs.

The neck is of moderate length, 0.07 the length of the body, and about seven times longer than wide. On each valve, near the middle, it has a low, narrow, somewhat irregular, sometimes broken, longitudinal ridge, which in some individuals extends from the girdle to near the flagellar pore. The sulcal lists extend a little behind the flagellar pore and have no ribs; the fission rib has not been seen.

The midbody is fusiform, and merges very gradually into the anterior process and into the antapical. It is very slender and widest at a distance from the apex equaling two fifths of the length of the body or at a distance from the flagellar pore four times longer than the neck; its greatest width is 0.43 the length of the neck. The ratio between the length and the greatest width of the body is 35–40: 1.

The antapical is unbranched, and gently and evenly concave ventrally. Its length cannot be determined, even approximately, because of the fact that it merges so gradually into the midbody. It grows gradually narrower posteriorly, but its posterior end, which is somewhat wider than the neck, is slightly inflated. In lateral view the antapex is rounded; in dorsoventral view it is truncate. It has two stout, pointed, lateral antapical spinules, one on each valve; the length of these spinules approaches the distal width of the antapical.

The thecal wall is almost without structure. Along the base of each of the sulcal lists and on either side of the dorsal suture line of the neck there is a row of closely set pores. On the posterior part of the antapical there is a row of pores on either side of the dorsal as well as of the ventral suture line and also some scattered pores (see also the description of the neck).

The nucleus is elongated and somewhat irregular. The chromatophores are numerous, small, and ellipsoidal.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 646–652 μ (type, 652 μ, not 670 μ as stated in the original description). Length of head, 11 μ. Length of neck, 43 μ. Length of anterior process, midbody, and antapical, 587 μ. Width of midbody, 20 μ.

Variations: — In the few specimens examined as yet, this species appears to be rather constant.

Comparisons: — The description given above is based on the type material.

The simple, unbranched type of the antapical appears to be a primitive feature of this species. On the other hand, the slenderness of the midbody, the very gradual merging of the midbody into the antapical, and the sigmoid curvature of the longitudinal axis of the body probably are later differentiations.

Amphisolenia bispinosa presumably is closely related to *A. curvata*. This relationship is indicated by the sigmoid curvature of the longitudinal axis of the body, by the shape of the posterior part of the antapical, by the lateral position of the spinules on the antapex, and by the longitudinal ridges on the neck. *A. bispinosa* differs from *A. curvata* mainly in the small size of its body, in the narrowness of its midbody, and in the relatively large size of its antapical spinules.

Occurrence: — *Amphisolenia bispinosa* is recorded at eight of the 127 stations. There are 3, 2, 0, 1, 2, and 0 stations on the six lines of the Expedition. Of these eight stations, one (4583) is in the California Current; one (4605) is in the Mexican Current; one (4617) is in the Panamic Area; two (4662, 4668) are in the Peruvian Current; one (4713) is in the Galapagos Eddy; two (4736, 4737) are in the South Equatorial Drift. At one station (4662) the species is recorded from 800–0 fathoms. All the remaining records refer to catches from 300–0 fathoms.

The temperature range of these eight stations at the surface was 67°–85°; the average was 77.2°.

The frequency is less than 1% except at one station (4668) where it is 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4605 of the Expedition, which thus is the type locality.

Amphisolenia curvata Kofoid

Plate 9, fig. 5, 9, 10. Figure 49: 11

Amphisolenia curvata Kofoid, 1907a, p. 197, pl. 14, fig. 87.

Diagnosis: — With rather strong sigmoid curvature. Head 1.5 times wider than long. Epitheca flat or slightly convex. Midbody fusiform, merging gradually into anterior process but rather well set off from antapical. Approximate distance from flagellar pore to antapical, 4.7 the length of neck. Ratio between length and width of body, 12–13: 1. Antapical with rather strong, even, ventral concavity, approximately four times longer than neck; its posterior end very slightly widened. Antapex rounded with minute spinule on left valve (normally with one on each valve?). Length, 463 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body has a rather strong sigmoid curvature, due to the moderate dorsal deflection of the neck and the rather strong and even ventral concavity of the antapical. The ventral deflection of the antapical is about 7°.

The head is inclined anteriorly at an angle of 20°; its axial length is 0.24 the length of the neck, and it is 1.5 times wider than long. The anterior face of the epitheca is flat or slightly convex. The transverse furrow is 0.25 as wide as the dorsoventral diameter of the head and flat; it has, on each valve, five to six almost equidistant cross-ridges. The cingular lists are twice as wide as the transverse furrow and flare anteriorly at an angle of 10°; each of them has, on each valve, six fairly regularly spaced, simple ribs.

The neck is of moderate length, 0.10 the length of the body, and seven to eight times longer than wide. On each valve, near the middle, it has a low, narrow, somewhat irregular, longitudinal ridge, which in the type specimen extends from the girdle to the flagellar pore. The sulcal lists extend to the flagellar pore and have no ribs. An accessory list, arising from the originally free edge of the left sulcal list, extends along the posterior third of the left sulcal list and ends somewhat behind the flagellar pore; its greatest width, which is subequal to that of the neck, is at the flagellar pore; anteriorly and posteriorly it tapers, rather suddenly posteriorly, very slowly anteriorly; at the flagellar pore it has a cross-rib, the fission rib.

The midbody is fusiform and merges gradually into the anterior process but is rather well set off from the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is 4.7 the length of the neck.

The midbody is of moderate width, widest at a distance from the apex equaling two fifths of the length of the body, or at a distance from the flagellar pore three times the length of the neck; its greatest width is 0.8 the length of the neck. The ratio between the length and the greatest width of the body is 12–13: 1.

The antapical is unbranched, with a rather strong and even ventral concavity, and approximately four times longer than the neck or 0.8 the total length of the anterior process and the midbody. Posteriorly it grows gradually narrower, except near the posterior end where it widens very slightly; its posterior end is about 1.5 times wider than the neck. In lateral view the antapex is rounded; in dorsoventral view it probably is truncate in completely developed specimens with a minute lateral spinule on each valve; in the type specimen the right valve is rounded and without any spinule, the left truncate with a minute lateral spinule.

The thecal wall is almost without structure. On the posterior end of the antapical there is a row of pores on either side of the dorsal as well as of the ventral suture line and also some scattered pores. In front of these, there is an irregular reticulum of low and narrow ridges (see also the description of the neck). The porulation of the neck is probably as in *Amphisolenia bispinosa*, but there is no information on this point.

The nucleus is small and ellipsoidal. The chromatophores are numerous, ellipsoidal and spheroidal.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 463 μ. Length of head, 11 μ. Length of neck, 45 μ. Length of anterior process, midbody, and antapical, 397 μ. Approximate length of anterior process and midbody, 220 μ. Width of midbody, 35 μ. Approximate length of antapical, 177 μ.

Comparisons: — The description given above is based on the type specimen. As to the relationships between this species and the other members of this genus, see *Amphisolenia bispinosa*, the section on comparisons.

Occurrence: — *Amphisolenia curvata* is recorded at only one of the 127 stations. This station (4605) is on the first line of the Expedition and in the Mexican Current. The depth is 300–0 fathoms, the surface temperature 85°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4605 of the Expedition, which thus is the type locality.

5. Schröderi Group. All the four species that belong to this group have been found in the material of the Expedition. They have been treated in this paper in the following order indicative of relationships: — *Amphisolenia schröderi*, *A. clavipes*, *A. complanata*, and *A. truncata*.

Amphisolenia schröderi Kofoid

Plate 10, fig. 2–4. Figure 49: 15

Amphisolenia schroederi Kofoid, 1907a, p. 201, pl. 13, fig. 81.

Diagnosis: — Straight. Head spheroidal, about as long as wide. Epitheca boldly convex. Midbody fusiform merging very gradually into anterior process and antapical. Ratio between length and width of body, 25: 1. Antapical almost straight; its posterior part slightly bent ventrally and to the right and not or only slightly widened. Antapex rounded in dorsoventral view and truncate in lateral view; with two short spinules, one dorsal and one ventral, both probably belonging to left valve. Length, 510 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The longitudinal axis of the body is almost straight; only the posterior part of the antapical is slightly bent. The head is spheroidal, about as wide as long or but slightly wider than long; its axial length is 0.18–0.19 the length of the neck. The anterior face of the epitheca is boldly convex. The transverse furrow is about 0.5 as wide as the dorsoventral diameter of the head, somewhat convex, and has on each valve one to four cross-ridges. The anterior cingular list is about twice as wide as the transverse furrow, flares anteriorly at an angle of 30°–40°, and has, on each valve, five to six equidistant, simple ribs. The posterior cingular list is slightly narrower, subhorizontal or inclined anteriorly about 10°, and has no ribs.

The neck is rather long, 0.13 the length of the body, and nine times longer than wide. The sulcal lists end at the flagellar pore and have no ribs.

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. It is rather slender and widest at a distance from the apex equaling two fifths of the length of the body or at a distance from the flagellar pore about twice as long as the neck; its greatest width is 0.30 the length of the neck. The ratio between the length and the greatest width of the body is 25: 1.

The antapical is unbranched and almost straight; its posterior part is slightly bent ventrally and to the right. Its length cannot be determined even approximately, because of the fact that it merges so gradually into the midbody. It grows gradually narrower posteriorly, and its posterior part is not or only slightly widened; its width near the posterior end is about 1.5 the average width of the neck. In dorsoventral view the antapex is rounded, in lateral view it is truncate. It has two short spinules, one dorsal and one ventral, both probably belonging to the left valve; the length of the spinules is about 0.25 the dorsoventral width of the posterior end of the antapical.

The thecal wall is apparently without structure. On the posterior part of the antapical there is a row of fine pores on either side of the ventral suture line, and a similar row is found along the base of each of the sulcal lists.

The nucleus and the chromatophores are as in *Amphisolenia clavipes.*

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 510 μ. Length of head, 10 μ. Length of neck, 68 μ. Length of anterior process, midbody, and antapical, 431 μ. Width of midbody, 20 μ.

Comparisons: — The description given above is based on the type material The straight longitudinal axis of the body and the simple, unbranched type of the antapical are primitive features of this species. The slenderness and the very gradual merging of the midbody into the antapical probably are advances in differentiation.

The closest-known relative of *Amphisolenia schröderi* is undoubtedly *A. clavipes*. Indeed, it even may be questionable whether or not these two forms are specifically distinct, and their specific separation should be regarded as tentative. *A. schröderi* differs from *A. clavipes* mainly in the following respects: — (*1*) its midbody is slightly narrower, with the ratio between length and width of body 25: 1, as compared with 15–19: 1; (*2*) the posterior portion of its antapical generally is somewhat less inflated and less strongly bent to the right (see *A. clavipes,* the section on variations); (*3*) its transverse furrow and its epitheca appear to lack porulation; (*4*) it is decidedly larger, 510 μ as compared with 230–263 μ. The difference in size appears to be the most important. However, it should be remembered that dwarfs and giants have been found in a rather large number of species in Dinophysoidae.

Another close relative of *Amphisolenia schröderi* is *A. complanata.* The former species differs from the latter mainly in the smaller width of its head (ratio between length and width of its head about 1: 1 as compared with 1: 3) and in the smaller size of its antapical spinules.

Amphisolenia schröderi is probably also rather closely related to *A. truncata,* from which it is easily distinguished by the narrowness of its head and by having antapical spinules (as to the systematic value of the latter difference, see *A. truncata*, the section on comparisons).

Amphisolenia schröderi, A. clavipes, A. complanata, and *A. truncata* form a presumably natural systematic group, the Schröderi group. Their closest relatives, outside the group, probably are to be found in the Palmata group.

Occurrence: — *Amphisolenia schröderi* is recorded at seven of the 127 stations. There are 2, 1, 0, 1, 3, and 0 stations on the six lines of the Expedition. Of these seven stations, two (4598, 4605) are in the Mexican Current; one (4659) is in the Peruvian Current; four (4701, 4736, 4737, 4739) are in the South Equatorial Drift. At one station (4737) the species is recorded from 100–0 fathoms as well as from 300–0 fathoms. All the other records refer to catches from 300–0 fathoms only.

The temperature range of these seven stations at the surface was 69°–85°; the average was 78.8°.

The frequency is less than 1% at all stations.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4737 of the Expedition, which thus is the type locality.

Amphisolenia clavipes Kofoid

Plate 11, fig. 8–11. Figure 49: 13, 50: 7

Amphisolenia clavipes Kofoid, 1907a, p. 197, pl. 14, fig. 90. Doflein, 1909, p. 464, fig. 403d; 1911, p. 531, fig. 462d; 1916, p. 437, fig. 374d.

Diagnosis: — Almost straight except near antapex. Head spheroidal, about as long as wide. Epitheca boldly convex. Midbody fusiform, merging very gradually into anterior process and antapical. Ratio between length and width of body, 15–19: 1. Antapical almost straight except near antapex where it is slightly curved ventrally and more or less strongly bent to the right; posterior end but slightly or more or less strikingly widened. Antapex rounded in dorsoventral view and truncate in lateral view; with two short spinules, one dorsal and one ventral, both probably on left valve. Length, 230–263 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight; the neck is slightly deflected dorsally and the posterior end of the antapical is more or less bent.

The head is spheroidal, about as wide as long, or rather slightly wider than long (width: length, 1.0–1.3: 1); its axial length is 0.23 (0.19–0.27) the length of the neck. The anterior face of the epitheca is boldly convex. The transverse furrow is about 0.5 as wide as the dorsoventral diameter of the head, somewhat convex or flat and has, on each valve, three to four cross-ridges. The anterior cingular list is about as wide as or somewhat wider than the transverse furrow, flares anteriorly at an angle of 30°–40°, and has, on each valve, four to six equidistant, simple ribs. The posterior cingular list is generally slightly narrower, subhorizontal or inclined anteriorly at an angle of 10°–20° and has no or only a few simple ribs.

The neck is rather long, 0.14–0.15 the length of the body, and six to seven times longer than wide. The sulcal lists end at or just behind the flagellar pore and have no ribs; the fission rib has not been seen. Sometimes they have about the same shape as in Plate **10**, figure 3, of *Amphisolenia schröderi;* sometimes a rather broad accessory list arises near the flagellar pore from the originally free edge of the left sulcal list and continues somewhat behind the pore (Plate **11**, fig. 8).

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. It is rather slender or of moderate width and widest somewhat in front of the middle; its greatest width is 0.38–0.45 the length of the neck. The ratio between the length and the greatest width of the body is 15–19: 1.

The antapical is unbranched and almost straight except posteriorly; its posterior part is slightly curved ventrally and more or less strongly bent to the right. Its length cannot be determined even approximately because of the fact that it merges so gradually into the midbody. It grows gradually narrower posteriorly, except near the antapex where it sometimes is slightly or moderately widened; its width near the antapex somewhat exceeds the average width of the neck. In dorsoventral view the antapex is rounded, in lateral view it is truncate; it has two short spinules, one dorsal and one ventral, both probably belonging to the left valve. The length of the spinules is about 0.25 the dorsoventral width of the posterior end of the antapical.

The thecal wall has the same structure as in *Amphisolenia schröderi*, but the transverse furrow and the epitheca are porulate.

The nucleus is large, elongated, and somewhat irregular. The chromatophores are rather large and cylindrical (Plate **11**, fig. 11).

The proportions of five specimens from the material of the Expedition were measured.

Dimensions: — Length of body, 230–263 μ (average, 248 μ; type, 230 μ). Length of head, 7.0–8.5 μ (average and type, 8.0 μ). Length of neck, 31–39 μ

(average, 36 μ; type, 31 μ). Length of anterior process, midbody, and antapical in the type specimen, 190 μ. Width of midbody, 12–16 μ (average, 15 μ; type, 12 μ).

Variations: — The species appears to be relatively constant. The shape of the posterior portion of the antapical is the most variable character. Sometimes, as in the type specimen (Figure 50: 7), this portion is rather strikingly inflated, and strongly and rather abruptly bent to the right. In other cases these peculiarities are less developed, and this portion even may have almost the same shape as in *Amphisolenia schröderi, i.e.,* it may be but slightly or even not at all inflated and only slightly bent to the right (Plate 10, fig. 4).

Comparisons: — The description given above is based on the type material. With regard to the relationships of this species, see *Amphisolenia schröderi,* the section on comparisons (p. 401).

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia clavipes.* Reproductions of Kofoid's (1907a) figure of the type specimen are given by Doflein (1909, 1911, 1916).

Occurrence: — *Amphisolenia clavipes* is recorded at two of the 127 stations. These two stations (4736, 4737) are on the fifth line of the Expedition and in the South Equatorial Drift. At Station 4737 the species is recorded from 100–0 fathoms and from 300–0 fathoms; at Station 4736 from 300–0 fathoms only.

The surface temperatures of these two stations were 81.0° and 81.5°, respectively. The frequency is less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4736 of the Expedition, which thus is the type locality.

Amphisolenia complanata, sp. nov.

Plate 10, fig. 5, 7, 9. Figure 49: 16

Diagnosis: — With slight sigmoid curvature. Head three times wider than long. Epitheca flat. Midbody fusiform, merging very gradually into anterior process and antapical. Ratio between length and width of body, 32–39: 1. Antapical with very slight ventral concavity; approximately five to eight times longer than neck; its posterior end slightly widened, almost straight. Antapex rounded in dorsoventral view and truncate in lateral view; with two rather strong spinules, one dorsal and one ventral, both probably on left valve. Length, 600–785 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is slightly sigmoid, the neck somewhat deflected dorsally, and the antapical evenly and very slightly concave ventrally.

The head is inclined anteriorly at an angle of 30°; its axial length is about 0.12 the length of the neck, and it is three times wider than long. The anterior face of the epitheca is flat or but slightly convex. The transverse furrow is 0.25 as wide as the dorsoventral diameter of the head, somewhat convex, and has, on each valve, six to seven equidistant cross-ridges. The cingular lists are about twice as wide as the transverse furrow or somewhat less; the anterior is inclined anteriorly at an angle of 20° and has, on each valve, eight equidistant, simple ribs; the posterior is subhorizontal and has, on each valve, six to seven similar ribs.

The neck is of moderate length, 0.06–0.09 the length of the body, and eight to nine times longer than wide. The sulcal lists sometimes extend to the flagellar pore and have no ribs (Plate **10**, fig. 5); sometimes an accessory list of moderate width arises near the flagellar pore from the originally free edge of the left sulcal list and continues somewhat behind the pore. The accessory list has a fission rib at the pore (compare Plate **11**, figure 8, of *Amphisolenia clavipes*).

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is five to eight times the length of the neck. The midbody is very slender, widest at a distance from the apex equaling one third of the length of the body, or at a distance from the flagellar pore 2.5–3.5 times the length of the neck; its greatest width is 0.35–0.40 the length of the neck. The ratio between the length and the greatest width of the body is 32–39: 1.

The antapical is unbranched, with a very slight ventral concavity; its posterior part is almost straight. It is approximately five to eight times longer than the neck and subequal to the total length of the anterior process and the midbody. Posteriorly it grows slightly narrower, except near the posterior end where it widens slightly; its posterior end is about 1.8–2.2 times wider than the neck. In dorsoventral view the antapex is rounded; in lateral view it is truncate; it has two rather strong spinules, one dorsal and one ventral, both probably on the left valve; the length of the spinules is about 0.50 the dorsoventral width of the posterior end of the antapical or somewhat less.

The thecal wall is apparently without structure. On the posterior part of the antapical there is a row of fine pores on either side of the dorsal as well as of the ventral suture line and some pores between these rows. On the neck no pores have been observed.

The nucleus and the chromatophores are probably as in *Amphisolenia clavipes*.

The proportions of two specimens were measured.

Dimensions: — Length of body, 600–785 μ (type, 600 μ). Length of head, 7.0–7.5 μ (type, 7.0 μ). Length of neck, 46–53 μ (type, 53 μ). Length of anterior process, midbody, and antapical of type specimen, 432 μ. Width of midbody, 20 μ.

Variations: — In the two specimens examined, this species was constant, except in the size of the body and the relative length of the neck.

Comparisons: — The species certainly is very closely related to *Amphisolenia schröderi* and *A. clavipes*, as is shown by the similar differentiation of the posterior portion of the antapical in these three species. It is easily distinguished from these two species by the greater width of its head and by the larger size of its two antapical spinules. However, *A. complanata* probably is most closely related to *A. truncata*, from which it differs mainly in having antapical spinules. For further discussion of the relationships of these four species, see *A. schröderi*, the section on comparisons (p. 401).

Occurrence: — *Amphisolenia complanata* is recorded at two of the 127 stations. These two stations (4737, 4739) are on the fifth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms. Station 4739 is the type locality.

The surface temperatures of these two stations were 79.0° and 81.5° respectively. The frequency is less than 1%.

Amphisolenia truncata Kofoid and Michener

Plate **11**, fig. 1, 12. Figure 49:14

Amphisolenia truncata Kofoid & Michener, 1911, p. 294. Jörgensen, 1923, p. 40, 43, fig. 58.

Diagnosis: — Almost straight or with slight sigmoid curvature. Head 2.0–2.5 times wider than long. Epitheca moderately convex. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical four to five times longer than neck. Ratio between length and width of body, 28–38: 1. Antapical straight or with slight ventral concavity; approximately 6.0–6.5 times longer than neck; its posterior end not widened, straight. Antapex truncate in lateral view, without spinules. Length, 650–663 μ.

Eastern tropical Pacific, and Mediterranean.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid, with the neck somewhat deflected dorsally and the antapical straight or with a slight ventral concavity.

The head is inclined anteriorly at an angle of 30°; its axial length is 0.19–0.20 the length of the neck; and it is 2.0–2.5 times wider than long. The anterior face of the epitheca is moderately convex. The transverse furrow is 0.25 as wide as the dorsoventral diameter of the head, flat, and has, on each valve, six to seven equidistant cross-ridges. The cingular lists are 1.5–2.0 as wide as the transverse furrow; the anterior is inclined anteriorly at an angle of 20° and has, on each valve, seven or eight simple, equidistant ribs; the posterior is subhorizontal and may possibly lack ribs (Jörgensen, 1923, fig. 58b). In the type specimen no ribs were observed in the cingular lists; they probably were overlooked.

The neck is of moderate length, 0.08 the length of the body, and eight to nine times longer than wide. The sulcal lists are as in *Amphisolenia complanata.*

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is four to five times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling 0.29–0.33 the length of the body, or at a distance from the flagellar pore two to three times longer than the neck; its greatest width is 0.34–0.44 the length of the neck. The ratio between the length and the greatest width of the body is 28–38 : 1.

The antapical is unbranched, straight, or with a very slight ventral concavity; its posterior part is straight. It is approximately 6.0–6.5 times longer than the neck and 1.2–1.8 times the total length of the anterior process and the midbody. Posteriorly it grows slightly narrower; its posterior end is not widened and is 1.3–1.8 times wider than the neck. The antapex is truncate in lateral view and lacks ribs. Sometimes it is surrounded by a (protoplasmic?) sheath (see Jörgensen, 1923, fig. 58c).

The thecal wall is apparently without structure. On the posterior part of the antapical there is a row of fine pores on either side of the dorsal as well as of the ventral suture line. A row of fine pores is also found along the base of each of the sulcal lists.

The proportions of the type specimen and of the specimen drawn by Jörgensen (1923, fig. 58) were measured.

Dimensions: — Type specimen: Length of body, 650 μ. Length of head, 9 μ. Length of neck, 50 μ. Length of anterior process, midbody, and antapical, 584 μ. Approximate length of antapical, 317 μ. Width of midbody, 17 μ. Jörgensen's

(1923) specimen: "Length 663 μ, max. breadth 24 μ, or 36% of the length." According to measurements made from his figures 58a and b: Length of body, 675 μ. Length of head, 11 μ. Length of neck, 55 μ. Length of anterior process, midbody, and antapical, 600 μ. Approximate length of antapical, 380 μ. Width of body, 28 μ.

Variations: — The two specimens examined by us exhibit variations in the degree of curvature of the longitudinal axis of the body, in the ratio between the length and the width of the body, and in the relative length of the antapical.

Comparisons: — The description given above is based on the type specimen.

The specimen described and figured by Jörgensen (1923) under the name of *Amphisolenia truncata* agrees very closely with the type specimen of this species.

It is, of course, an open question as to whether or not the absence of antapical spinules in *Amphisolenia truncata* is primitive. However, the fact that antapical spinules are present in *A. inflata,* which probably is the most primitive known species of this genus, and in almost all the other known members of this genus, representing different evolutionary lines, and the fact that *A. truncata* in several respects appears to be highly differentiated rather than primitive seem to indicate that the absence of antapical spinules is secondary in this species.

Amphisolenia truncata probably is closely related to *A. schröderi*, *A. clavipes*, and *A. complanata.* It differs from these three species in not having any antapical spinules. From *A. schröderi* and *A. clavipes* it also differs in the greater width of its head.

The closest-known relative of *Amphisolenia truncata* is undoubtedly *A. complanata.* It may even be questionable whether or not the two forms are specifically distinct, and their systematic separation should be regarded as tentative. They differ mainly in the presence or absence of antapical spinules. Both the antapical spinules in *A. complanata* probably belong to one valve. Binary fission in this species might therefore be followed by a stage of short duration in which one of the daughter individuals is without antapical spinules. Is *A. truncata* based on a representative of *A. complanata* in which the antapical spinules have not yet developed following binary fission? It may be of a certain interest in this connection that in the specimen of *A. truncata* figured by Jörgensen (1923, fig. 58c) the posterior portion of the antapical appears to be surrounded by a hyaline sheath. Such a sheath may be a sign of a recent cell division.

For further discussion about the relationships of these species, see the section on the comparisons of *Amphisolenia schröderi* (p. 401).

Occurrence: — *Amphisolenia truncata* is recorded at only one of the 127 stations. This station (4733) is on the fifth line of the Expedition and in the South

Equatorial Drift. The frequency is less than 1%; only one specimen is recorded. This specimen was found in the stomach of a Salpa from surface waters, at a temperature of 80°.

The species was first recorded by Kofoid and Michener (1911) from Station 4733 of the Expedition, which thus is the type locality. Later, Jörgensen (1923) reported one specimen from the Balearic Sea, off the coast of Africa.

6. Palmata Group. All the five species that belong to this group have been found in the material of the Expedition. They have been treated in this paper in the following order indicative of relationships: — *Amphisolenia bidentata*, *A. lemmermanni*, *A. palmata*, *A. palaeotheroides*, and *A. asymmetrica*.

Amphisolenia bidentata Schröder

Figure 54: 1–4, 55, 56: 1

Amphisolenia bidentata Schröder, 1900a, p. 20, 35, pl. 1, fig. 16a–c; 1900b, p. 3; 1906a, p. 323, 324, 326, 328, 331, 332, 333, 338, 339, 371, 374; 1906b, p. 262; 1909, p. 211; 1911, p. 3, 4, 25, 38. Ostenfeld & Schmidt, 1901, p. 162. Schmidt, 1901, p. 138. Lemmermann, 1901a, p. 376. Ostenfeld, 1902, p. 21; 1915, p. 4. Entz, 1902b, p. 94; 1905, p. 112. Cleve, 1903b, *partim*, p. 339. Okamura, 1907, *partim*, p. 127, *non* pl. 3, fig. 15; 1912, p. 20. Karsten, 1907, p. 252, 256, 259, 264, 267, 269, 270, 271, 274, 280, 284, 287, 288, 292, 297, 306, 307, 308, 311, 315, 325, 334, 335, 336, 337, 339, 342, 344, 345, 346, 347, 350, 352, 353, 354, 356, 357, 359. Stüwe, 1909, p. 254, 288. Kofoid & Michener, 1911, p. 293. Schiller, 1911a, p. 52; 1912, p. 27. Pavillard, 1916, *partim*, p. 61. Forti, 1922, p. 112, 113, 192, 209, fig. 123. Jörgensen, 1923, p. 39, 40, fig. 56.
Amphisalenia sp., Chun, 1903, p. 76, fig. e.

Diagnosis: — Slightly or moderately sigmoid. Head 2.0–3.0 times wider than long. Epitheca gently convex. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical, 3.5–5.5 times longer than neck. Ratio between length and width of body, 30.3–67.7: 1. Antapical approximately 8.0–13.5 the length of neck, with gentle ventral concavity, its posteriòr part bent to the right 25°–40°, and twisted ventrally 90°; at point of bending, left valve has strong, short, pointed spinule, which makes posterior part of antapical foot-like. Seen ventrally (torsion), antapex is widened, two to three times wider than average width of antapical, truncate; with two spinules on left valve, one on each corner, but none on right valve. Length, 716–990 μ.

Of world-wide distribution, in tropical, subtropical, and warm-temperate waters.

Description: — The longitudinal axis of the body is slightly or moderately sigmoid, with the neck somewhat deflected dorsally, and the antapical having a gentle ventral concavity. The posterior part of the antapical is always bent to the right and twisted ventrally.

The head is inclined anteriorly at an angle of 30°–50°; its axial length is 0.16 (0.15–0.19) the length of the neck; and it is 2.0–3.0 times wider than long. The anterior face of the epitheca is gently convex, or in some cases rather flat. The transverse furrow is 0.20–0.30 as wide as the dorsoventral diameter of the head, gently convex flat, or slightly concave and has, on each valve, about three to five cross-ridges. The cingular lists are 1.2–2.0 as wide as the transverse furrow; both may be inclined anteriorly at an angle of 10°–25° or both may be subhorizontal; each of them has, on each valve, five to nine simple, equidistant ribs.

The neck is of moderate length and width, 0.05–0.08 the length of the body and eight to fourteen times longer than wide. The sulcal lists either end at the cytopharyngeal pore or they continue somewhat behind it; in some specimens they appear to lack ribs, in others the left one has a fission rib at the flagellar pore.

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is 3.5–5.5 times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling about one fifth to one fourth the length of the body, or at a distance from the flagellar pore 1.5–3.5 the length of the neck; its greatest width is 0.27–0.67 the length of the neck. The ratio between the length and the greatest width of the body is 46.3 (30.3–67.7): 1 (21: 1 in a parasitized specimen).

The antapical is unbranched, approximately 8.0–13.5 the length of the neck and 1.5–3.0 times longer than the total length of the anterior process and the midbody. It is gently concave ventrally, and its posterior part is bent to the right at an angle of 25°–40° and twisted ventrally 90°. Our data are insufficient to establish whether or not this torsion is a constant characteristic of this species. At the point of bending the left valve has a short, strong, pointed, heel-like spinule, which gives to the posterior part of the antapical a foot-like appearance. In lateral view (torsion) the foot-like part is not as wide as or is rather slightly wider than the average width of the antapical, about 2.5–4.5 times longer than wide and more or less rounded distally. Seen ventrally (torsion) the posterior part of the "foot" is truncate and about two to three times wider than the antapical just in front of the foot. The antapex has two fairly strong and short, pointed spinules on the left valve, one on each corner, but no spinule on the right valve. The average width of the antapical is subequal to or somewhat exceeds that of the neck. Near the antapex the antapical has what appears to be a protoplasmic sheath.

The thecal wall is apparently without structure. The posterior part of the antapical is porulate. Along the base of each of the sulcal lists there is a row of pores, and on the head a number of scattered pores are to be found.

The chromatophores are located near the center of the midbody and are light yellowish brown (Ostenfeld and Schmidt, 1901).

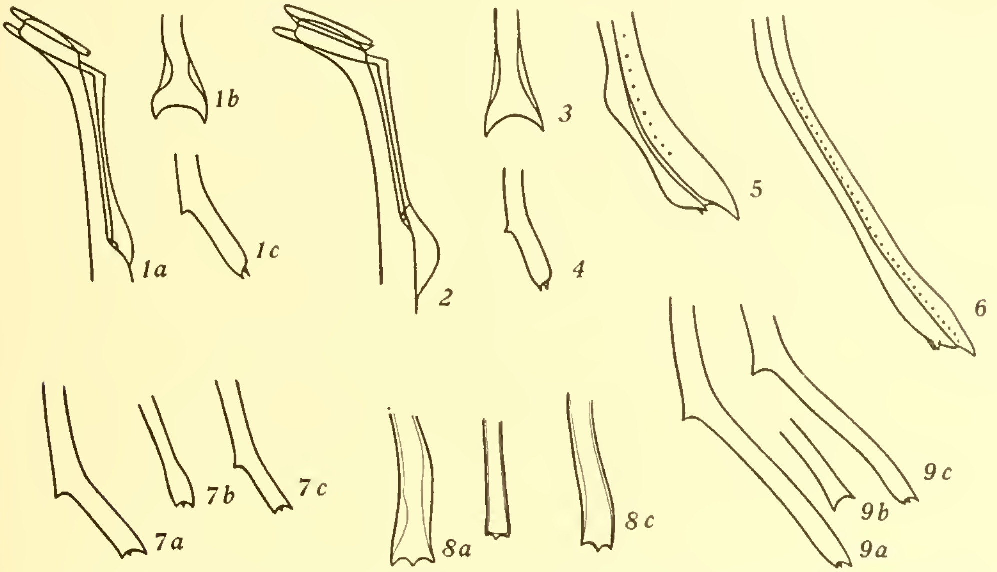

FIGURE 54.—1–4, *Amphisolenia bidentata* Schröder. × 430. 1a–c, from Station 4737 (100–0 fathoms). 1a, right lateral view of anterior portion of body; 1b and 1c, posterior portion of antapical of specimen represented by 1a; 1b is seen in right lateral view and shows ventral deflection; 1c is seen in dorsal view and shows a comparatively long "foot"; torsion disregarded. 2, right lateral view of anterior portion of body; left sulcal list has a fission rib and continues for a considerable distance beyond flagellar pore. Station 4740 (300–0 fathoms). 3, right lateral view of posterior portion of antapical; straight. Station 4730 (300–0 fathoms). 4, dorsal view of posterior portion of antapical; "foot" relatively short. Station 4713 (300–0 fathoms). 5, *A. palmata* Stein, dorsal view of posterior portion of antapical following fission; right (old) valve with its distal spinule fully developed; left (new) valve without heel spinule and with but slightly developed distal spinules. × 900. Station 4734 (300–0 fathoms). 6, *A. asymmetrica* Kofoid, dorsal view of posterior portion of antapical of type specimen of *A. dolichocephalica* Kofoid, *i.e.*, of a specimen following fission; right (old) valve has its distal spinule fully developed; left (new) valve without heel spinule and with rather slightly developed distal spinules. × 900. Station 4728 (300–0 fathoms). 7–9, *A. thrinax* Schütt. × 430. 7–8, from a specimen from Station 4594 (300–0 fathoms); 7, in right lateral view; 8, in ventral view. 7a and 8a represent posterior portion of antapical stem, with relatively short "foot," and with heel-spinule and three distal spinules; 7b and 8b represent distal portion of second antapical branch, without heel-spinule and with three distal spinules; 7c and 8c, distal portion of first antapical branch, with relatively short "foot," and with heel-spinule and three distal spinules. 9, from a specimen, in right lateral view, from Station 4737 (300–0 fathoms). 9a, posterior portion of antapical stem, with relatively long "foot," and with heel-spinule and three distal spinules; 9b, distal portion of second antapical branch, without heel-spinule and with two distal spinules on left valve; 9c, distal portion of first antapical branch, with relatively long "foot," and with heel-spinule and three distal spinules.

The length and the width of the body were measured in twenty of our specimens and the proportions of the head and of the neck in fourteen of our specimens. All the proportions were measured in only three of our specimens and in the type specimen and the specimen reproduced by Jörgensen (1923, fig. 56).

Dimensions: — Our specimens: Length of body, 716–990 μ (average, 822 μ). Length of head, 6–10 μ (average, 8 μ). Length of neck, 43–53 μ (average, 47 μ). Width of midbody, 14.0–29.6 μ (average, 18.8 μ); in a parasitized specimen it was 34.8 μ. Type specimen (Schröder, 1900a, pl. 1, fig. 16a): Length of body, 773 μ. Length of head, 8.5 μ. Length of neck, 48 μ. Length of anterior process and midbody, 178 μ. Length of antapical, 537 μ. Width of midbody, 18 μ. Jörgensen's (1923, fig. 56) specimen: Length of body, 920 μ. Length of head, 10 μ. Length of neck, 53 μ. Length of anterior process and midbody, 280 μ. Length of antapical 580 μ. Width of midbody, 20 μ.

Variations: — The length of the body and the width of the midbody are rather variable. Variability is also found in other characters, *e.g.*, in the width and relative length of the foot-like posterior part of the antapical. It may be pertinent to mention in this connection that in our narrowest specimen (ratio between the length and the width of the body, 67.7: 1) one of the two thecal valves was new; in other words, this specimen had been taken shortly after the separation of the two daughter cells in binary fission. This may indicate that the width of the midbody increases with the age of the individuals (see the section on the reproduction of this genus).

Comparisons: — The specimens found in the material of the Expedition show, as previously mentioned, some variability. However, most of them agree closely with *Amphisolenia bidentata* as figured and described by Schröder (1900a).

With regard to the specimen figured by Okamura (1907, pl. 3, fig. 15) under the name of *Amphisolenia bidentata*, see the following section. The specimen represented by Jörgensen (1923, fig. 56) under this name agrees very closely with the type specimen.

The unbranched antapical is a primitive feature of this species. The slight sigmoid curvature of the longitudinal axis of the body, the narrowness, and the gradual merging of the midbody into the antapical, as well as the differentiation of the posterior part of the antapical, are probably later acquisitions.

Amphisolenia bidentata is certainly very closely related to *A. lemmermanni*. Indeed, these two forms are so similar that their systematic separation should be regarded as tentative. They differ from each other mainly in the length of the body and in the width of the midbody. The length of *A. bidentata* is 716–990 μ (average, 822 μ); that of *A. lemmermanni*, 522–669 μ (average, 572 μ). The ratio between the length and the width of the body is 30.3–67.7 (average, 46.3): 1 in *A. bidentata;* in *A. lemmermanni* it is 13.4–33.8 (average, 23.4): 1 (see the previous section). Furthermore, the posterior part of the antapical is twisted ventrally at an angle of about 90° in *A. bidentata* and appears always to be without torsion in *A. lemmermanni*. However, our data are not sufficient to establish whether or not the last difference is constant. In order to settle the question as to whether or not these two forms are specifically distinct, it will be necessary to resort to biometric determinations on more extensive material. Our statements of the lengths and the relative widths of these forms are based on thirty-six specimens, twenty of which were referable to *A. bidentata* and sixteen to *A. lemmermanni*.

Another close relative of *Amphisolenia bidentata* is undoubtedly *A. palmata*. The former species differs from the latter mainly in its slightly larger size and in having two, instead of three, spinules on the antapex; in other words, in not having any antapical spinule on the right valve. The systematic separation of these two forms should be regarded as an open question (see Schröder, 1906a, p. 371, and Ostenfeld, 1915, p. 4). This statement is based on the following facts. The antapical mid-spinule in *A. palmata* belongs to the right valve, the two remaining spinules on the antapex to the left valve. Figure 54: 5 shows that, in this species, there is a stage following binary fission in which the antapical spinules of the new valve are very slightly or not at all developed. We have, therefore, reason to suppose that one of the two daughter individuals passes through a stage characterized by the same number and arrangement of the antapical spinules as in *A. bidentata*. It also may be mentioned that in *A. bidentata* and in *A. lemmermanni* the posterior part of the antapical is characterized by what appears to be a hyaline sheath, while such a sheath has not been found in *A. palmata*. The presence of a sheath of this kind may possibly be a sign of recent binary fission (see *A. asymmetrica*, the section on comparison. These facts seem to indicate that *A. palmata* may be an older developmental stage of *A. bidentata*. However, this assumption appears to be contradicted by the following facts: — (*1*) *A. bidentata* is more frequent than *A. palmata* in the material of the Expedition, although the differentiation of thecal structures following binary fission has been found to take place very rapidly in all the dinoflagellates that have been studied in this respect; (*2*) in *A. schröderi*, *A. clavipes*, and *A. complanata* the antapex appears to have the same number and arrangement of spinules as in *A. bidentata*.

Other close relatives of *Amphisolenia bidentata* are *A. palaeotheroides* and *A. asymmetrica*, both of which are easily distinguished from the first-mentioned species by having three, instead of two, spinules on the antapex. *A. asymmetrica* is also characterized by the extreme width of its head.

Amphisolenia bidentata, *A. lemmermanni*, *A. palmata*, *A. palaeotheroides*, and *A. asymmetrica* form a natural systematic group, the PALMATA group. Their closest relatives, outside the group, are probably to be found on the one hand in the SCHRÖDERI group, on the other in the BIFURCATA group (see the section on the subdivisions of the genus, p. 360).

Synonymy: — The species was established by Schröder (1900a) under the name of *Amphisolenia bidentata*. Of the writers who have treated this species only Jörgensen (1923) gives drawings by means of which the determinations may be checked. Forti (1922) gives a reproduction of Schröder's figure of the type specimen.

Cleve (1903b, p. 339) wrote *Amphisolenia bidentata* as a synonym of *A. globifera*. This decision was justly rejected by Schröder (1906a, p. 371) as well as by other writers who have treated these species. Cleve's (1903b) data have accordingly not been included in our section on the distribution of *A. bidentata*.

The specimen figured by Chun (1903, p. 76, fig. e) under *Amphisolenia* sp. probably belongs to *A. bidentata*, but the drawing does not permit a certain determination.

The specimen reproduced by Okamura (1907, pl. 3, fig. 15) under the name of *Amphisolenia bidentata* is referable to *A. lemmermanni*. It is only 666 μ long, the ratio between the length and the width of its body is 29: 1, and the posterior part of its antapical is not twisted ventrally. According to statements in the text, the specimens examined by Okamura were 0.1 mm. long and 0.02 mm. wide. These measurements probably are wrong; they presumably stand for 1000 μ and 20 μ. The latter figures indicate that some of the specimens examined by Okamura (1907) belonged to *A. bidentata*. However, their assignment must be regarded as uncertain.

Ostenfeld (1915, p. 4) suggested as a possibility that *Amphisolenia palmata* Cleve (1901a) from the Malay Archipelago may be identical with *A. bidentata*. Cleve (1901a) recorded only *A. palmata* from these waters, Ostenfeld (1915) only *A. bidentata*. Since no data bearing on this question have yet been published, Cleve's determination has been accepted in this paper.

Among the specimens of *Amphisolenia bidentata* found by Pavillard (1916, p. 61) there was one that agreed with *A. palmata*. "Cependant une récolte du 27 décembre 1914 m'a donné, au milieu d'une douzaine d'échantillons typiques, un individu muni d'un troisième denticule antapical, reproduisant ainsi la disposition caractéristique de l'*A. palmata*." This specimen, which was referred to *A. bidentata* by Pavillard (1916), has been referred to *A. palmata* in the present paper. Pavillard (1916) considered the independence of these two species as probable.

With regard to Jörgensen's (1923, p. 40) statement that *Amphisolenia palmata* and *A. bidentata* have been confused by previous authors, see below, the section on the distribution.

Occurrence: — The species is recorded at sixty-three of the 127 stations. There are 13, 7, 4, 10, 21, and 8 stations on the six lines of the Expedition. Of these sixty-three stations, three (4574, 4580, 4583) are in the California Current; seven (4587, 4588, 4590, 4592, 4594, 4596, 4605) are in the Mexican Current; six (4609, 4613, 4617, 4634, 4638, 4640) are in the Panamic Area; five (4646, 4648, 4659, 4667, 4676) are in the Peruvian Current; seven (4689, 4691, 4694, 4695, 4697, 4699, 4700) are in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; twenty-eight (4679, 4701, 4705, 4708, 4712, 4717, 4718, 4719, 4720, 4721, 4722, 4723, 4724, 4725, 4727, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4738, 4739, 4740, 4741) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; two (4541, 4542) are in the Equatorial Counter Current; one (4543) is in the North Equatorial Current. At twenty-four stations (4588, 4592, 4596, 4640, 4676, 4694, 4700, 4708, 4712, 4718, 4720, 4723 [Salpa stomachs], 4725, 4727, 4729, 4731, 4733 [Salpa stomach], 4738, 4741, 4743, 4540, 4541, 4542, 4543) the species was found in surface catches only. At four stations (4583, 4638, 4648, 4740) it was found in surface catches as well as in catches from 300–0 fathoms; at one station (4737) in a catch from 100–0 fathoms as well as in one from 300–0 fathoms; at one station (4713) in a catch from 150–0 fathoms as well as in one from 300–0 fathoms; at seven stations (4689, 4701, 4717, 4721, 4724, 4728, 4732) in catches from both 800–0 fathoms and 300–0 fathoms. All the remaining records refer to catches from 300–0 fathoms only.

The species is also recorded from Acapulco Harbor near the Mexican Current; this station is not included in the 127 stations mentioned above.

The temperature range of these sixty-three stations at the surface was 68°–95°; the average was 77.0°. At the twenty-eight stations in the surface catches of which the species was found, the surface temperature ranged from 69° to 84°; the average was 77.7°. At Acapulco the temperature was 83°.

For the surface samples the following frequencies are recorded: — 2% at four stations (4592, 4720, 4725, 4741); 1% at twelve stations (4583, 4596, 4638, 4640, 4648, 4676, 4712, 4718, 4731, 4738, 4743, 4543); in the remaining cases less than 1%. For the samples from 100, 150, 300, or 800 fathoms to the surface the records of frequency are as follows: 8% at one station (4648); 6% at one station (4739); 4% at three stations (4713, 4719, 4740); 3% at six stations (4587, 4590, 4689, 4697, 4728, 4737); 2% at eight stations (4583, 4659, 4701, 4717, 4721, 4724, 4734, 4736); 1% at fourteen stations (4580, 4605, 4609, 4613, 4617, 4638, 4646, 4667, 4691, 4695, 4722, 4730, 4732, 4742); in the remaining cases less than 1%.

The species was first recorded by Schröder (1900a) from the Gulf of Naples, which thus is the type locality. In the Atlantic Ocean it was found by Stüwe (1909) at lat. 3° 50′ N., long. 26° 15′ W.; by Schröder (1909) at St. Thomas in the West Indies; and by Jörgensen (1923) in the Bay of Cadiz. Jörgensen (1923, p.

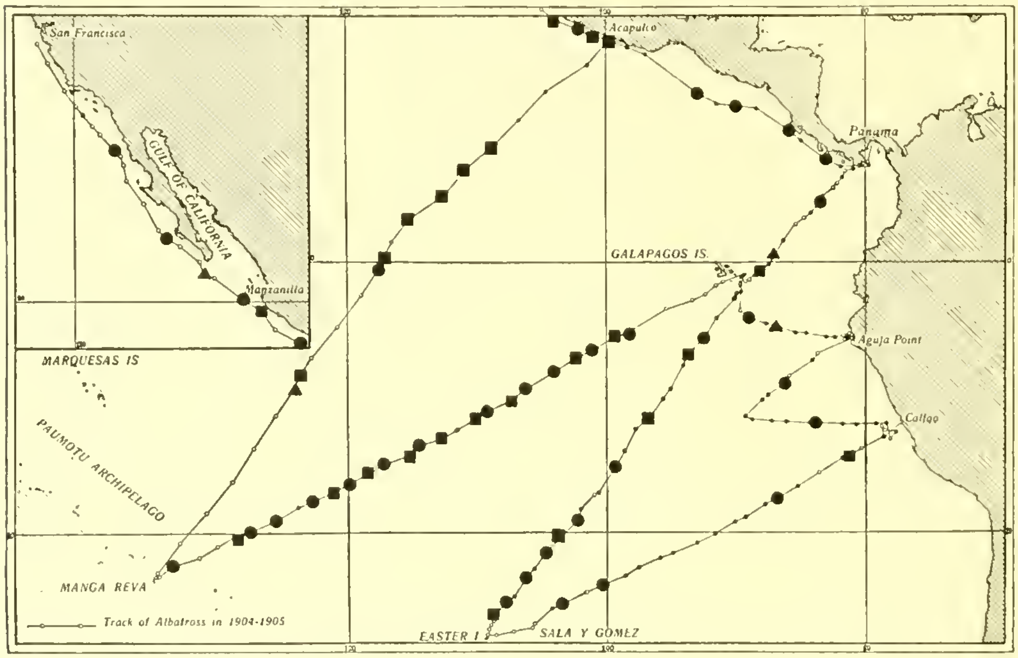

FIGURE 55.—Occurrence of *Amphisolenia bidentata* Schröder. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

40) states that *Amphisolenia bidentata* "has a wide distribution in the Atlantic, both in the northern and the southern parts," and that the Atlantic distribution of *A. palmata* is unknown, as this species "has been confused with and included under *A. bidentata*." These statements, although very plausible, are not supported by any published records (see also the section on the comparisons of *A. bidentata*, p. 412). Jörgensen (1923) found *A. bidentata* to be the most common species of this genus and distributed throughout the Mediterranean. In the Gulf of Lyons it was found by Pavillard (1916); in the Ligurian Sea by Forti (1922); in the Adriatic Sea by Entz (1902b, 1905), Schröder (1911), and Schiller (1911a, 1912). In the Red Sea it was found by Ostenfeld and Schmidt (1901), Schröder (1906a), and Karsten (1907); in the Gulf of Aden by Ostenfeld and Schmidt (1901), Schröder (1906a), and Karsten (1907); in the Arabian Sea by Ostenfeld and

Schmidt (1901) and by Schröder (1906a); in the Indian Ocean by Ostenfeld (1902), Schröder (1906a), and Karsten (1907). Karsten recorded it from twenty-six of the stations of the Valdivia Expedition in the Indian Ocean, between lat. 8° N. and lat. 10° S., and from near the west coast of Sumatra to near the east coast of Africa. From the East Indies it was recorded by Schröder (1906a) and Ostenfeld (1915); from the Gulf of Siam by Schmidt (1901); from Japanese waters by Schröder (1906a) and Okamura (1907, 1912); from the eastern part of the Pacific, at lat. 33° N., long. 135° W., and lat. 25° N., long. 140° W., by Schröder (1906a).

Most of the records referred to above were from surface catches (see the section on the distribution of the genus, p. 349). The only records of closing-net hauls published as yet are those of Karsten (1907) from Station 268 of the Valdivia Expedition, lat. 9° 6′ N., long. 53° 41′ E., viz., hauls from 17–0 m., 24–4 m., 30–0 m., 63–46 m., and 105–88 m.; all the individuals are reported as living.

The species occurs in waters of the following temperatures and salinities:— Ostenfeld and Schmidt (1901): temperature range of four stations, 79.0°–84.5°; average, 80.5°. Ostenfeld (1902): temperature, 82.4°; salinity, 33.8. Okamura (1912): temperature, 76.5°–76.8°. Stüwe (1909): temperature, 80.1°. Forti (1922): the temperature range of four stations, 55.6°–65 .6°, and the average, 61.0°.

Of the writers who have contributed to our knowledge of the distribution of this species only Schröder (1900a), Okamura (1907), and Jörgensen (1923) give any information or figures by means of which the accuracy of their determinations may be judged. The figure given by Forti (1922) is a reproduction of Schröder's (1900a) drawing of the type specimen. With regard to Okamura's (1907) determinations, see above.

For a discussion of Ostenfeld's (1915) suggestion that the specimens recorded by Cleve (1901a) from the Malay Archipelago under the name of *Amphisolenia palmata* would belong to *A. bidentata*, see above.

Amphisolenia bidentata evidently is one of the most common species of its genus, of world-wide distribution in tropical, subtropical, and warm-temperate seas and sometimes fairly rich in individuals (*e. g.*, it was found to be "common" in the Arabian Sea by Schröder, 1906a). In the material of the Expedition it is by far the most common representative of this genus. The most outstanding peculiarities of its distribution in the Eastern Pacific, according to the records of the Expedition, are its eupelagic habitat and its frequent occurrence in all regions except in the Peruvian Current and in the part of the South Equatorial Drift which is nearest to this current. Among all the species of this genus it is the most frequent in surface waters.

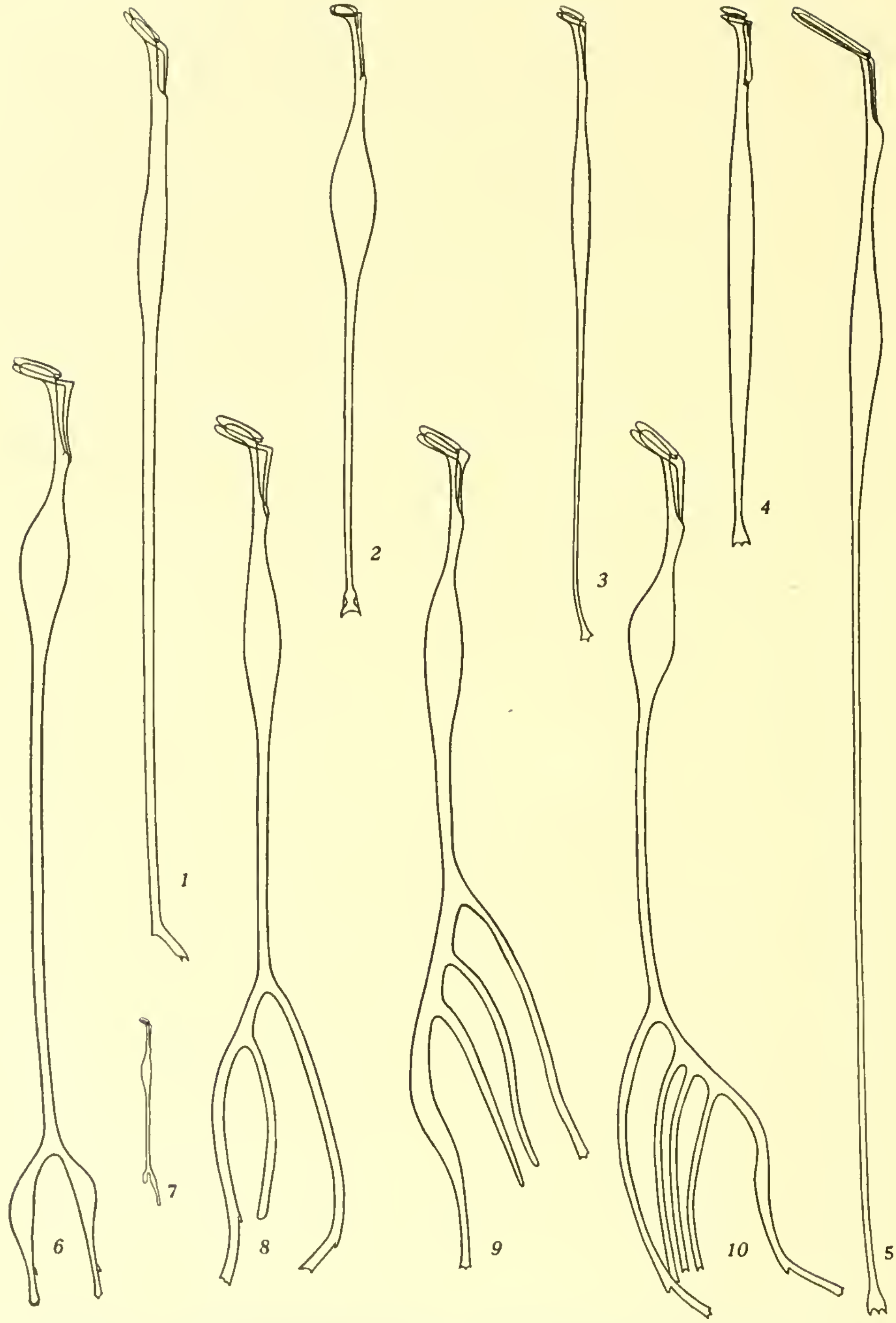

FIGURE 56.— 1, *Amphisolenia bidentata* Schröder. Station 4730 (300–0 fathoms). 2, *A. lemmermanni* Kofoid. Station 4730 (300–0 fathoms). 3, *A. palmata* Stein. Station 4734 (300–0 fathoms). 4, *A. palaeotheroides* Kofoid. Station 4732 (300–0 fathoms). 5, *A. asymmetrica* Kofoid. Station 4732 (300–0 fathoms). 6, *A. bifurcata* Murray and Whitting. Station 4699 (300–0 fathoms). 7, *A. projecta* Kofoid. Station 4701 (300–0 fathoms). 8, *A. thrinax* Schütt. Station 4737 (300–0 fathoms). 9, *A. quadricauda* Kofoid. Station 4695 (300–0 fathoms). 10, *A. quinquecauda* Kofoid. Station 4739 (300–0 fathoms). Figure 2, 4, 5, 7, 9, and 10 from type specimens. Right lateral view. × 150.

Amphisolenia lemmermanni Kofoid

Plate 9, fig. 11, 12. Figure 50: 8, 56: 2, 57

Amphisolenia lemmermanni Kofoid, 1907a, p. 199, pl. 14, fig. 88, 89.
Amphisolenia bidentata Okamura, 1907, *partim*, p. 137, pl. 3, fig. 15a–d.

Diagnosis: — Almost straight or with gentle sigmoid curvature. Head 2.0–2.5 times wider than long. Epitheca gently convex. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical, 3.5–4.5 times longer than neck. Ratio between length and width of body, 13.4–33.8: 1. Antapical approximately six to nine times longer than neck, straight or with gentle ventral concavity; its posterior part of the same shape and structure as in *Amphisolenia bidentata* but generally not twisted ventrally. Length, 522–669 μ.

Tropical and subtropical regions of the Pacific.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid, with the neck somewhat deflected dorsally, and the antapical having a slight ventral concavity. The posterior part of the antapical is bent to the right.

The axial length of the head is 0.17 (0.15–0.20) the length of the neck; and the head is 2.0–2.5 times wider than long.

The neck is of moderate length and width, 0.07–0.10 the length of the body and seven to eleven times longer than wide.

The approximate distance between the flagellar pore and the anterior end of the antapical is 3.5–4.5 times longer than the neck. The midbody is slender or of moderate width, widest at a distance from the flagellar pore equaling about one third to one fourth the length of the body, or at a distance from the flagellar pore 2.0–2.5 the length of the neck; its greatest width is 0.40–0.72 the length of the neck. The ratio between the length and the greatest width of the body is 23.4 (13.4–33.8): 1. It should be mentioned that the type specimen is by far the widest specimen of this species recorded as yet; the ratio between its length and its greatest width is 13.4: 1, while in the next-widest specimen it is only 19.2: 1.

The antapical is six to nine times longer than the neck and 1.5–2.0 times longer than the total length of the anterior process and the midbody. It is almost straight or slightly concave ventrally. Its posterior part seems always to lack the ventral torsion. However, our data are not sufficient to establish whether this lack of torsion is a constant characteristic of this species.

The nucleus is large and ovoidal. There are a great number of small spheroidal chromatophores scattered throughout the whole body.

In the characters not mentioned above the species agrees with *Amphisolenia bidentata.*

The length and the width of the body were measured in sixteen of our specimens and the proportions of the head and of the neck in seven of our specimens. All the proportions were measured in only two of our specimens and in the specimen reproduced by Okamura (1907, pl. 3, fig. 15a).

Dimensions: — Our specimens: Length of body, 522–669 μ (average, 572 μ; type, 567 μ). Length of head, 7–10 μ (average, 8.4 μ; type, 9.5 μ). Length of neck, 45–53 μ (average, 49 μ; type, 53 μ). Length of anterior process and midbody 169–197 μ (type, 197 μ). Length of antapical, 308–400 μ (type, 308 μ). Width of midbody, 20–42 μ (average, 25.5 μ; type, 42 μ). Okamura's (1907, pl. 3, fig. 15) specimen: Length of body, 666 μ. Length of head, 8.5 μ. Length of neck, 50 μ. Length of anterior process and midbody, 199 μ. Length of antapical, 405 μ. Width of midbody, 23 μ.

Variations: — The length of the body, the width of the midbody, and the relative length and width of the posterior, foot-like portion of the antapical are rather variable.

Comparisons: — The description given above is based on the type material.

The specimen figured by Okamura (1907, pl. 3, fig. 15) under the name of *Amphisolenia bidentata* and in the present paper referred to *A. lemmermanni* differs from the type specimen of the last species as drawn by Kofoid (1907a) in the narrowness of its midbody but agrees closely with a number of specimens of this species found in the material of the Expedition.

The closest relative of *Amphisolenia lemmermanni* undoubtedly is *A. bidentata.* For a discussion of the relationship of these two forms, see *A. bidentata,* the section on comparisons (p. 412).

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia lemmermanni.* Okamura (1907) figured one specimen under the name of *A. bidentata* (see the last species, the section on synonymy, p. 414).

Occurrence: — *Amphisolenia lemmermanni* is recorded at twenty-six of the 127 stations. There are 5, 1, 1, 5, 11, and 3 stations on the six lines of the Expedition. Of these twenty-six stations, four (4587, 4590, 4594, 4605) are in the Mexican Current; one (4623) is in the Panamic Area; one (4667) is in the Peruvian Current; three (4691, 4697, 4699) are in the Easter Island Eddy; sixteen (4701, 4705, 4709, 4717, 4719, 4720, 4722, 4723, 4724, 4728, 4730, 4732, 4734, 4737, 4740, 4741) are in the South Equatorial Drift; one (4742) is in the South Equatorial

Current. At four of these stations (4623, 4720, 4723 [Salpa stomach], 4741) the species was found in surface catches only; at three stations (4717, 4724, 4728) in catches from both 800–0 fathoms and 300–0 fathoms. All the remaining records refer to catches from 300–0 fathoms only.

The temperature range of these twenty-six stations at the surface was 68°–85°; the average was 77.4°. At the four stations in the surface catches of which

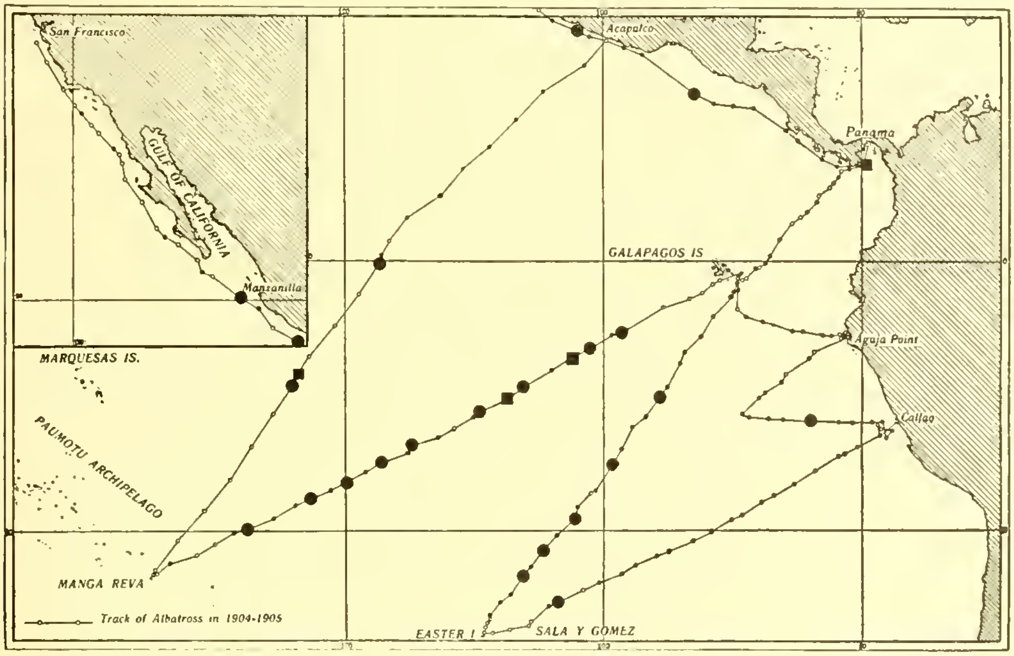

FIGURE 57.— Occurrence of *Amphisolenia lemmermanni* Kofoid. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

the species was found, the surface temperature ranged from 76° to 80°; the average was 77.7°.

The frequency is 2% at one station (4590), 1% at three stations (4691, 4717, 4719), and less than 1% at the remaining stations.

The species was first recorded by Kofoid (1907a) from Station 4730 of the Expedition, which thus is the type locality. It was found by Okamura (1907) in Japanese waters.

According to the records of the Expedition, the eupelagic habitat, the absence from the California Current, the rare occurrence in the Peruvian Current and in the part of the South Equatorial Drift that is directly influenced by this current, and the relatively frequent occurrence in the Easter Island Eddy and in the South

Equatorial Drift are the most outstanding characteristics of the distribution of this species in the Eastern Pacific. Contrary to its close relative *Amphisolenia bidentata*, it was very rare in the surface catches of the Expedition.

AMPHISOLENIA PALMATA Stein

Plate 12, fig. 4, 7. Figure 54: 5, 56: 3

Amphisolenia palmata STEIN, 1883, p. 24, pl. 21, fig. 11–15. BÜTSCHLI, 1885, pl. 55, fig. 4b. SCHÜTT, 1893, p. 299. DELAGE & HÉROUARD, 1896, fig. 672. CLEVE, 1897a, p. 25, tab. 1; 1900b, p. 1030; 1901a, p. 13; 1901c, p. 205; 1902b, p. 24; 1903b, p. 339. LEMMERMANN, 1899a, p. 316, 317, 319, 320, 331, 332, 373; 1901a, p. 376; 1904, p. 611, 643; 1905a, p. 37; 1908b, p. 127, 129. MURRAY & WHITTING, 1899, p. 331, tab. 6, 8, 9. SCHRÖDER, 1900a, p. 20; 1906a, p. 326, 371; 1911, p. 3, 4, 25, 38. KARSTEN, 1906, p. 183, 184, 187, 188, 189, 190, 195, 200, 201, 206; 1907, p. 244, 248, 254, 257, 258, 260, 262, 272, 273, 275, 278, 279, 281, 282, 286, 296, 298, 305, 317, 318, 320, 324, 331, 332, 335, 336, 337, 339, 341, 342, 343, 350, 352, 353, 356, 357, 358, 471. KOFOID, 1907b, p. 315. STÜWE, 1909, p. 235, 238, 240, 254, 288. SCHILLER, 1911a, p. 52; 1912, p. 27. HENSEN, 1895, p. 190; 1911, p. 159, 160, 161, tab. 13. OSTENFELD, 1915, p. 4. PAVILLARD, 1916, p. 61. FORTI, 1922, p. 113. JÖRGENSEN, 1923, p. 40, 41, fig. 57.

Amphisolenia bidentata PAVILLARD, 1916, *partim*, p. 61.

Diagnosis: — Slightly or moderately sigmoid. Head 1.7–2.5 times wider than long. Epitheca gently convex or flat. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical, 3.3–5.0 times longer than neck. Ratio between length and width of body, 27–42: 1. Antapical approximately 6.5–9.8 the length of neck; almost straight or with gentle ventral concavity; its posterior part bent to the right 20°–40° with or without ventral torsion of 90°. Posterior part of antapical as in *Amphisolenia bidentata* but right valve has strong, short, pointed spinule on antapex. Length, 565–810 μ.

Of world-wide distribution in tropical, subtropical, and warm-temperate regions.

Description: — The longitudinal axis of the body is slightly or moderately sigmoid, with the neck somewhat deflected dorsally, and the antapical having a slight or moderate ventral concavity. The posterior part of the antapical is always bent to the right and sometimes twisted ventrally.

The head is inclined anteriorly at an angle of 30°–45°; its axial length is 0.17 (0.11–0.26) the length of the neck; and it is 1.7–2.5 times wider than long. The anterior face of the epitheca is gently convex or more or less flattened. The transverse furrow is 0.25–0.30 as wide as the dorsoventral diameter of the head, gently convex, flat, or slightly concave and has, on each valve, about three to five cross-ridges. The cingular lists are 1.3–2.0 as wide as the transverse furrow; the anterior is generally inclined anteriorly at an angle of 10°–25°, but in the type specimen it flares at an angle of about 40°; the posterior is generally somewhat less inclined than the anterior, sometimes even subhorizontal; each list has, on each valve, five to ten simple, equidistant ribs.

The neck is of moderate length and width, 0.06–0.09 the length of the body and eight to fourteen times longer than wide. The sulcal lists end at or somewhat behind the flagellar pore and lack ribs; the fission rib has not been observed.

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is 3.3–5.0 times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling one third to one fourth of the length of the body, or at a distance from the flagellar pore 1.5–2.5 times longer than the neck; its greatest width is 0.38 (0.25–0.56) the length of the neck. The ratio between the length and the greatest width of the body is 35 (27–42): 1.

The antapical is unbranched, approximately 6.5–9.8 the length of the neck and 1.5–2.3 times the total length of the anterior process and the midbody. It is slightly or moderately concave ventrally, and its posterior part is bent to the right at an angle of 20°–40° and sometimes twisted ventrally 90°, sometimes without torsion. Sometimes, when the antapical is characterized by a moderate ventral concavity and the posterior part of the antapical by torsion, the bending of the posterior part and the ventral concavity are confluent (Figure 56: 3). At the point of bending the left valve has a short, strong, pointed, heel-like spinule, which gives to the posterior part of the antapical a foot-like appearance. In lateral view (torsion) the foot-like part is not as wide as or is rather slightly wider than the average width of the antapical, about 2.5–4.0 times longer than wide and, if the spinules are disregarded, more or less rounded distally. Seen ventrally (torsion) the posterior part of the "foot" is truncate and about two to three times wider than the antapical just in front of the foot. The antapex has three short, strong, and pointed spinules, one on each corner and one in the middle; of these spinules the former belong to the left valve (as in *Amphisolenia bidentata*), the latter belongs to the right valve. The average width of the antapical is subequal to or somewhat exceeds that of the neck. No protoplasmic sheath of the kind found in *A. bidentata* and *A. lemmermanni* has been seen in this species.

Figure 54: 5 represents the posterior part of the antapical following binary fission; the left valve is new. It shows that the antapical spinules are not subject to resorption in fission. The spinule of the right valve is of normal size and shape, while of the three spinules of the left valve one, the heel-spinule, is not at all developed, and the others are very small.

The thecal wall has the same structure as in *Amphisolenia bidentata*.

The chromatophores are rod-shaped.

The proportions of two of our specimens and of the type specimen (Stein, 1883, pl. 21, fig. 11) and of the specimen drawn by Jörgensen (1923, fig. 57) were measured.

Dimensions: — Our specimens: Length of body, 565–661 μ. Length of head, 7–9 μ. Length of neck, 46–49 μ. Length of anterior process and midbody, 192–207 μ. Length of antapical, 301–403 μ. Width of midbody, 16–19 μ. Type specimen (Stein, 1883, pl. 21, fig. 11): Length of body, 810 μ. Length of head, 9 μ. Length of neck, 74 μ. Length of anterior process and midbody, 244 μ. Length of antapical, 486 μ. Width of midbody, 19 μ. Jörgensen's (1923, fig. 57) specimen: Length of body, 750 μ. Length of head, 11 μ. Length of neck, 47 μ. Length of anterior process and midbody, 230 μ. Length of antapical, 455 μ. Width of midbody, 28 μ.

Variations: — Judging by the few specimens that have been examined, the species appears to be rather constant. Variations occur in the length and the width of the body, the shape of the longitudinal axis of the body, and the amount of torsion in the posterior part of the antapical.

Comparisons: — The specimens found in the material of the Expedition and assigned to *Amphisolenia palmata* are comparatively small and their anterior cingular list has a rather slight anterior inclination, but in other respects they agree closely with the type specimen of this species as drawn by Stein (1883).

The specimen figured by Jörgensen (1923, fig. 57) under the name of *Amphisolenia palmata* also agrees closely with the type specimen.

Amphisolenia palmata is undoubtedly very closely related to *A. bidentata* and *A. lemmermanni*, from which it differs in having three, instead of two, spinules on the antapex, in other words, in having an antapical spinule on the right valve. Other close relatives of *A. palmata* are *A. palaeotheroides*, characterized by its very short and thick antapical, and *A. asymmetrica*, characterized by its excessively wide head. With regard to Kofoid's (1907b, p. 315) suggestion that *A. palmata* and *A. spinulosa* are closely related, see the section on the subdivision of the genus (p. 360). For further discussion of the relationships between the species of the Palmata group, see the section on the comparisons of *Amphisolenia bidentata* (p. 412).

Synonymy: — The species was established by Stein (1883) under the name of *Amphisolenia palmata*. Of later investigators only Jörgensen (1923) gives drawings by means of which the determinations may be checked. Bütschli (1885) and

Delage and Hérouard (1896) give reproductions of Stein's (1883) figures of the type specimen.

With regard to Cleve's determinations of this species, see Schröder (1906a, p. 371) and Ostenfeld (1915, p. 4). Since no data bearing upon this question have been published as yet, Cleve's determinations have been accepted in this paper.

Concerning one specimen recorded by Pavillard (1916) from the Gulf of Lyons under the name of *Amphisolenia bidentata* and referred to *A. palmata* in the present paper, see the section on the synonymy of *A. bidentata* (p. 414).

Jörgensen (1923, p. 40) writes that *Amphisolenia palmata* "has been confused with and included under *A. bidentata*"; however, no data are given in support of this statement.

Occurrence: — *Amphisolenia palmata* is recorded at six of the 127 stations. There are 1, 0, 1, 2, 2, and 0 stations on the six lines of the Expedition. Of these six stations, one (4587) is in the Mexican Current; two (4697, 4700) are in the Easter Island Eddy; three (4688, 4734, 4737) are in the South Equatorial Drift. At two of these six stations (4688, 4700) the species was found in surface catches only; at the remaining stations in catches from 300–0 fathoms only.

The temperature range of these six stations at the surface was 72°–82°; the average was 77.6°. At the two surface Stations 4689, 4700, the temperatures at the surface were 72° and 74°, respectively.

The frequency is less than 1% except at Station 4688, where it is 1%.

The species was first recorded by Stein (1883) "aus der Südsee"; the type locality is unknown. In the Atlantic Ocean it was found by Schütt (1893), who mentioned it as characteristic of the Florida Current and of the Sargasso Sea; by Cleve (1897a) at lat. 37° 47′ N., long. 47° 31′ W., and at lat. 35° 57′ N. and long. 58° 3′ W., *i.e.*, in the Sargasso Sea; by Lemmermann (1899a) at three stations, viz., lat. 3° N., long. 27° W., lat. 14° S., long. 27° W., and lat. 21° S., long. 26° W.; by Murray and Whitting (1899) at twenty-one stations, from near the east coast of America, including the Caribbean Sea, to near the west coast of Europe and of Africa, and from lat. 38° N. to lat. 14° N.; by Cleve (1901c) at a fairly great number of stations, from near the east coast of America, including the Caribbean Sea, to near the west coast of Europe and of Africa, and from lat. 42° N. to lat. 19° S.; by Cleve (1902b) at five stations, four of which are in the region of distribution established by Cleve (1901c) and one as far south as lat. 21° S., long. 1° E.; by Stüwe (1909) at fifteen stations in the eastern part of the Atlantic, between lat. 34° N. and lat. 3° N.; and by Karsten (1906) at ten stations along the west coast of Africa, between lat. 12° N. and lat 5° S.; by Hensen (1911) at a very great number of stations in different parts of the tropical, subtropical and warm-temperate regions of the Atlantic. Jörgensen (1923, p. 40) states that the Atlantic distribution of *Amphisolenia palmata* is unknown, as this species "has been confused with and included under *A. bidentata*." This statement is very plausible but not supported by any published records. In this absence, the data given above are treated as valid. Jörgensen (1923) found *A. palmata* at seven stations in different parts of the Mediterranean; Cleve (1903b) at lat. 37° N., long. 0°–12° E.; Pavillard (1916) in the Gulf of Lyons; Schröder (1911) and Schiller (1911a, 1912) in the Adriatic Sea. In the Red Sea it was found by Cleve (1900b, 1903b) and by Karsten (1907); in the Gulf of Aden by Cleve (1903b) and by Karsten (1907); in the Arabian Sea by Cleve (1901a, 1903b) and Schröder (1906a); in the Indian Ocean by Cleve (1901a) and by Karsten (1907). Karsten (1907) recorded the species from thirty-one of the stations of the VALDIVIA Expedition; of these stations twenty-seven are in the Indian Ocean, from near the west coast of Sumatra to near the east coast of Africa, and between lat. 8° N. and lat. 12° S. In the Malay Archipelago it was found by Cleve (1901a); in the mouth of the river Menam by Lemmermann (1908b), probably dead, the cytoplasm disintegrating, certainly carried in by the tidal water. Lemmermann (1899a, 1904) recorded it from four localities in the Pacific, viz., at lat. 6° N., long. 111° W., lat. 12° N., long. 117° W., Pearl Harbor in the Island of Oahu, and between Laysan and Hawaii.

Most of the records referred to above were from surface catches. No certain closing-net records are available (see Karsten, 1907, p. 258).

The species occurs in waters of the following temperatures and salinities:—Murray and Whitting (1899): temperature range, 60°–81°. Cleve (1901a): temperature range, 80.2°–82.9°; salinity range, 33.06–33.71. Cleve (1901c): temperature range, 61.5°–82.7°; mean of sixty-five observations, 76.0°. Salinity: range, 33.20–37.37; mean of thirty-four observations, 36.22. Cleve (1902b): temperature, mean of ten observations, 72.3°; salinity, mean of ten observations, 36.61. Cleve (1903b): temperature range, 57.0°–88.4°; mean of twelve observations, 78.4°. Salinity: range, 36.02–39.92; mean of twelve observations, 37.38. Stüwe (1909): temperature range, 65.0°–82.8°.

Of the writers who have contributed to our knowledge of the distribution of this species only Stein (1883) and Jörgensen (1923) give drawings by means of which the accuracy of their determinations may be judged (see the section on the synonymy of this species, p. 424).

The species is eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. While it has been recorded a rather great number of times from other seas (Hensen, 1911, found it to be by far the most frequent species of this genus), it appears to be rare in the region investigated by the Expedition. In the Eastern Pacific it occurs in waters of high average temperature (77.6°). Its absence from the relatively cool Peruvian Current and its relatively frequent occurrence in the Easter Island Eddy, according to our records, are noteworthy.

Amphisolenia palaeotheroides Kofoid

Plate 11, fig. 2, 3, 4. Figure 56: 4

Amphisolenia palaeotheroides Kofoid, 1907a, p. 199, pl. 14, fig. 84.

Diagnosis:—Almost straight. Head 1.5–2.0 times wider than long. Epitheca gently convex. Midbody fusiform and passes imperceptibly into anterior process and antapical. Approximate distance from flagellar pore to antapical about seven times longer than neck. Ratio between length and width of body, 21–51: 1. Antapical approximately about twice the length of neck, straight; its posterior part bent to the right 20°–40°, without ventral torsion and of the same structure as in *Amphisolenia palmata;* its spinules very strong. Length, 426–615 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight; the neck is gently curved dorsally, and the posterior part of the antapical is bent to the right.

The head is inclined anteriorly at an angle of 20°–25°; its axial length is about 0.23 the length of the neck; and it is 1.5–2.0 times wider than long. The anterior face of the epitheca is gently convex. The transverse furrow is about 0.28 as wide as the dorsoventral diameter of the head, flat or slightly concave and has, on each valve, four to six cross-ridges. The cingular lists are 1.3–2.0 times wider than the transverse furrow; the anterior is inclined anteriorly at an angle of 15°–25°, the posterior has the same inclination or is subhorizontal; each list has, on each valve, six to eight simple, equidistant ribs.

The neck is of moderate length and width, about 0.10 the length of the body and seven to ten times longer than wide. The two sulcal lists end at the flagellar pore, or the left list continues a short distance behind the pore; they either lack ribs, or the left has a fission rib at the flagellar pore.

The midbody is fusiform and passes imperceptibly into the anterior process and into the antapical; its relative length is almost impossible to determine even approximately. The approximate distance between the flagellar pore and the anterior end of the antapical appears to be about seven times longer than the neck. The midbody is very slender, widest near the middle of the body; its greatest width is 0.36–0.50 the length of the neck. The ratio between the length and the greatest width of the body is 31 (21–51): 1; the type specimen is the stoutest of all specimens seen, with a ratio of 21: 1.

The antapical is unbranched; its approximate length (see the previous paragraph) is about twice the length of the neck and 0.28 the total length of the anterior process and the midbody. Its anterior part is straight. Its posterior part is bent to the right at an angle of 20°–40° but never, as far as our experience goes, twisted ventrally; its structure is the same as in *Amphisolenia palmata;* the antapical spinules are very strong. In one specimen, characterized by a rather weak antapical spinule on the right valve, the posterior part of the antapical was characterized by what appeared to be a protoplasmic sheath.

The thecal wall has the same structure as in *Amphisolenia bidentata.*

The nucleus is large, oblong, and somewhat irregular. The chromatophores are subspheroidal, subellipsoidal, or rod-like.

The length and the width of the body were measured in five specimens, and the proportions of the head and of the neck in two specimens. All the proportions were measured in one specimen only, the type.

Dimensions: — Length of body, 426–615 μ (average, 513 μ; type, 475 μ). Length of head, 10–11 μ. Length of neck, 43–48 μ (type, 48 μ). Length of anterior process, midbody, and antapical of type, 415 μ. Width of midbody, 12.0–22.3 μ (average, 17.5 μ; type, 22.3 μ).

Variations: — Judging by the specimens that have been carefully examined, the species appears to be rather constant. The length and the width of the body are the most variable characters.

Comparisons: — The description given above is based on the type material. *Amphisolenia palaeotheroides* is undoubtedly very closely related to *A. palmata*, as is shown by the similar differentiation of the posterior portion of the antapical in these two species. It is easily distinguished from the last species by its comparatively very short and thick antapical. Other close relatives of *A. palaeotheroides* are *A. asymmetrica*, characterized by its excessively wide head, and *A. bidentata* and *A. lemmermanni*, characterized by having only two spinules on the antapex, in other words, by lacking an antapical spinule on the right valve. For further discussion of the relationships of these species, see the section on the comparisons of *Amphisolenia bidentata* (p. 412).

Occurrence: — *Amphisolenia palaeotheroides* is recorded at twelve of the 127 stations. There are 0, 1, 2, 4, 4, and 1 stations on the six lines of the Expedition. Of these twelve stations, one (4668) is in the Peruvian Current; three (4689, 4691, 4699) are in the Easter Island Eddy; eight (4701, 4707, 4709, 4728, 4732, 4734, 4737, 4740) are in the South Equatorial Drift. At one station (4732) the species is recorded from 800–0 fathoms; at one station (4701) from 800–0 fathoms as well as from 300–0 fathoms. All the remaining records refer to catches from 300–0 fathoms only.

The temperature range of these twelve stations at the surface was 67.0°–81.5°; the average was 75.2°.

The frequency is less than 1% except at three stations (4689, 4699, 4737) where it is 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4732 of the Expedition, which thus is the type locality.

Although the species was found at as many as twelve of the stations of the Expedition, it has been recorded only once outside the Easter Island Eddy and the South Equatorial Drift.

Amphisolenia asymmetrica Kofoid

Plate 11, fig. 5, 6, 7, 13. Figure 54: 6, 56: 5

Amphisolenia asymmetrica Kofoid, 1907a, p. 196, pl. 13, fig. 76.
Amphisolenia dolichocephalica Kofoid, 1907a, p. 196, pl. 13, fig. 82. Doflein, 1909, p. 464, fig. 403c; 1911, p. 531, fig. 462c; 1916, p. 437, fig. 374c.

Diagnosis: — Gently sigmoid. Head nine to ten times wider than long. Epitheca flat. Midbody fusiform, merging almost gradually into anterior process and midbody. Distance from flagellar pore to antapical, 4.0–6.5 times longer than neck. Ratio between length and width of body, 44–55: 1. Antapical 11.5–14.5 the length of neck, with gentle ventral concavity; its posterior, foot-like part of about the same structure as in *Amphisolenia palmata* but seven to eight times longer than wide. Length, 1080–1207 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is gently sigmoid, with the neck slightly deflected dorsally and the antapical having a gentle ventral concavity. The posterior part of the antapical is bent to the right and sometimes twisted ventrally.

The head is inclined anteriorly at an angle of 20°–30°; its axial length is 0.13–0.14 the length of the neck; and it is nine to ten times wider than long; its width even somewhat exceeds the length of the neck. The anterior face of the epitheca is flat. The transverse furrow is 0.06 as wide as the dorsoventral diameter of the head, gently convex or flat, and without cross-ridges. The cingular lists are about 1.3–1.8 as wide as the transverse furrow, subhorizontal, and furnished with a great number, about 25–30 on each valve, of simple, equidistant ribs.

The neck is rather short, 0.05–0.06 the length of the body, and 11 times longer than wide. The sulcal lists end at the flagellar pore and have no ribs.

The midbody is fusiform and merges almost gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 5.0 (4.0–6.5) times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling about one fourth of the length of the body, or at a distance from the flagellar pore 2.5–3.5 times longer than the neck; its greatest width is 0.30–0.50 the length of the neck. The ratio between the length and the greatest width of the body is 50 (44–55): 1.

The antapical is unbranched, 12.8 (11.5–14.5) the length of the neck and two to three times the total length of the anterior process and the midbody. It is gently concave ventrally, and its posterior part is bent to the right at an angle of 20°–40° and sometimes twisted ventrally 90°, sometimes without torsion. Sometimes, when the antapical is characterized by torsion, the bending of the posterior part and the ventral concavity are confluent. The posterior foot-like part of the antapical has about the same structure as in *Amphisolenia palmata*, but is seven to eight times longer than wide. The antapical spinules are of moderate strength. The average width of the antapical is subequal to or somewhat exceeds that of the neck. In one specimen the posterior part of the antapical was characterized by what appeared to be a protoplasmic sheath (see below, the section on the synonymy).

The thecal wall is apparently without structure. Near the antapex there is, on each valve, a longitudinal row of fine pores and a few scattered pores. On the neck no pores were observed but these may have been overlooked.

The proportions of three specimens were measured; among these specimens were the types of this species and of *Amphisolenia dolichocephalica*.

Dimensions: — Length of body, 1080–1207 μ (type, 1207 μ). Length of head, 8 μ. Length of neck, 58–62 μ (type, 58 μ). Length of anterior process and midbody, 274–348 μ (type, 348 μ). Length of antapical, 722–765 μ (type, 765 μ). Width of midbody, 20–28 μ (type, 28 μ).

Variations: — The species appears to be rather constant. Variations occur in the length and the width of the body and in the relative length of the midbody.

Comparisons: — The description given above is based on the type material. It should be mentioned in this connection that, unfortunately, an error has crept into the preliminary description of this species given by Kofoid (1907a, p. 196). We read as follows: — "Walls thickened distally along sutures which do not follow the median plane of symmetry through the apparently twisted antapex but divide it into two asymmetrical valves, the right with two terminal spinules and the left with one terminal and the lateral." As we have seen from the description given above, the right valve has only one antapical spinule, the middle one of the three spinules on the antapex; and the left valve has three spinules, the two outer ones of the three spinules on the antapex and the heel-spinule (the "lateral" spinule).

Amphisolenia asymmetrica undoubtedly is rather closely related to *A. palmata*, *A. palaeotheroides*, *A. bidentata*, and *A. lemmermanni*. It is easily distinguished from these species by the great length of its body, the excessive width of its head, and the great relative length of the posterior foot-like part of its antapical. For further discussion of the relationships of these species, see the section on the comparisons of *Amphisolenia bidentata* (p. 412).

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia asymmetrica*.

In the same paper Kofoid (1907a, p. 198) described another species of this genus, *Amphisolenia dolichocephalica*, which, according to the original description and drawing, differs from *A. asymmetrica* mainly in the following respects: — (*1*) the posterior, foot-like part of its antapical has no "heel-spinule," only two spinules on the antapex, and "decurrent hyaline ridges which pass quickly from the knob-like end to the slender cylindrical stem"; (*2*) its midbody is somewhat narrower; (*3*) its size is somewhat smaller. These two species probably are identical for the following reasons: — (*1*) The specimen on which *A. dolichocephalica* was founded had been taken just following binary fission; its left (new) valve was but slightly differentiated (see Plate 11, fig. 6, showing the slight development of the cingular lists of the left valve). The posterior, foot-like part of the antapical had the same number and arrangement of spinules as in Figure 54:5 of *A. palmata* (Figure 54:6). The absence of a "heel-spinule" and the slight development of the two spinules on the antapex of the left valve should be interpreted as an early stage following binary fission and not as being due to genetic causes. The "hyaline ridges" of *A. dolichocephalica* certainly correspond to what we have interpreted as a "hyaline sheath" in *A. bidentata*, *A. lemmermanni*, and *A. globifera*. The material of this sheath is possibly utilized in thickening the thecal walls of "the foot." The absence of a sheath would be a sign of more advanced age. The thickness of the thecal wall near the antapex in *A. asymmetrica* may be noteworthy in this connection (Plate **11**, fig. 5). However, it must be emphasized that we have no conclusive proofs in support of this interpretation. (*2*) The narrowness of the midbody in *A. dolichocephalica* is probably also a sign of recent binary fission. (*3*) The difference in size is not greater than in related species.

Doflein (1909, 1911, 1916) used the name *Amphisolenia dolichocephalica* for this species and gives a reproduction of Kofoid's (1907a) Plate 13, figure 82.

Occurrence:—*Amphisolenia asymmetrica* is recorded at three of the 127 stations of the Expedition. These three stations (4728, 4732, 4739) are on the fifth line of the Expedition and in the South Equatorial Drift. At one station (4732) the species was found in a catch from 800–0 fathoms as well as in a catch from 300–0 fathoms; at the two other stations in catches from 300–0 fathoms only.

The temperature range of these three stations at the surface was 77°–79°; the average was 78.3°.

The frequency is less than 1% except at Station 4732, where it is 1%.

The species has been found only in the material of the Expedition. It previously has been recorded from Stations 4728 and 4732 of the Expedition. Station 4732 is the type locality. The restriction of the records of this species to the South Equatorial Drift is noteworthy.

7. Bifurcata Group. All the five species that belong to this group have been found in the material of the Expedition. They have been treated in this paper in the following order indicative of relationships: — *Amphisolenia bifurcata*, *A. projecta*, *A. thrinax*, *A. quadricauda*, and *A. quinquecauda*.

Amphisolenia bifurcata Murray and Whitting

Plate **12**, fig. 1, 3, 5. Figure 56: 6

Amphisolenia bifurcata Murray & Whitting, 1899, p. 331, tab. 7, 8, 9, pl. 31, fig. 1a–e. Lemmermann, 1899a, p. 373; 1901a, p. 376. Schröder, 1900a, p. 20. Cleve, 1902b, p. 24. Kofoid, 1906c, p. 94, 95; 1907a, p. 199. Karsten, 1907, p. 243, 425, 472. Stüwe, 1909, p. 236, 242, 254, 288.
Amphisolenia thrinax Zacharias, 1906, p. 561, 563, 564.

Diagnosis: — Almost straight or gently sigmoid in front of bifurcation. Head three to four times wider than long. Epitheca flat or gently convex. Midbody fusiform merging gradually into anterior process and antapical. Distance from flagellar pore to antapical, 3.7–4.3 times longer than neck. Ratio between length and width of body, 19–26:1. Antapical bifurcate; stem in front of bifurcation straight or slightly concave ventrally and 6.0–9.7 the length of neck. Antapical limbs subequal or somewhat different in length, the dorsal 2.6–5.3, the ventral 2.6–4.5 times longer than neck; their proximal or middle portions somewhat inflated, fusiform, 1.5–2.5 the average width of the antapical stem in front of bifurcation; their distal portions with spinules of the *palmata* type. Length 794–1050 μ.

Of world-wide distribution in tropical and subtropical waters.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid in front of the bifurcation; in some specimens the neck is somewhat deflected dorsally; and the undivided antapical stem is straight or gently concave ventrally. The antapical limbs have a spread of 15°–25°.

The head is inclined anteriorly at an angle of 20°–30°; its axial length is 0.18–0.25 the length of the neck; and it is three to four times wider than long. The anterior face of the epitheca is flat or gently convex. The transverse furrow is about 0.18 as wide as the dorsoventral diameter of the head, flat or gently convex and has, on each valve, about six to nine cross-ridges. The cingular lists are 1.5–2.0 times as wide as the transverse furrow; the anterior flares anteriorly at an angle of 15°–20° and has, on each valve, about nine to eleven simple, equidistant ribs; the posterior is subhorizontal and has, as a rule, a somewhat smaller number of ribs.

The neck is rather short, 0.05–0.06 the length of the body, and five to seven times longer than wide. The sulcal lists end at the flagellar pore and have no ribs.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 4.0 (3.7–4.3) times longer than the neck. The midbody is of moderate width or more or less slender, widest at a distance from the apex equaling about one fourth to one fifth of the length of the body, or at a distance from the flagellar pore 2.0–2.5 the length of the neck; its greatest width is 0.6–1.0 the length of the neck. The ratio between the length and the greatest width of the body is 22 (19–26): 1.

The antapical is bifurcate. The antapical stem in front of the bifurcation is straight or slightly concave ventrally, 6.0–9.7 the length of the neck and 1.6–2.3 times the total length of the anterior process and the midbody; it is of about the same width throughout its whole length, and its width is subequal to or somewhat exceeds that of the neck. The two antapical limbs, one of which is the originally posterior part of the antapical, are either subequal or of somewhat different lengths; when they are of different lengths, the dorsal appears always to be the longer; the dorsal is 2.6–5.3, the ventral 2.6–4.5 the length of the neck. In the type specimen (Murray and Whitting, 1899, pl. 31, fig. 1a) the ratio between the length of the dorsal limb and the length of the ventral limb was about 5: 4; in our specimens the difference in length always was less; in the type specimen the dorsal limb was but slightly shorter than the antapical stem in front of the bifurcation; in our specimens the corresponding ratio is 0.36–0.37: 1. The proximal or the middle portion of each limb is somewhat inflated, fusiform, 1.5–2.5 the average width of the antapical stem in front of the bifurcation. The posterior end of each limb is rather narrow and has fairly weak or moderately strong spinules of the *palmata* type.

The thecal wall has rather widely spaced minute pores, partly arranged in more or less regular, longitudinal rows.

The nucleus is fairly large, ellipsoidal. The chromatophores are spheroidal or ellipsoidal and of various sizes.

The proportions of three of our specimens and of the type specimen were measured.

Dimensions: — Our specimens: Length of body, 865–896 μ (average, 871 μ). Length of head, 9–10 μ. Length of neck, 45–55 μ (average, 51 μ). Length of anterior process and midbody, 181–210 μ (average, 201 μ). Width of midbody 39–46 μ (average, 43 μ). Length of antapical stem in front of bifurcation, 444–461 μ (average, 450 μ). Length of inside of ventral limb, 122–136 μ (average, 131 μ). Length of inside of dorsal limb, 136–145 μ (average, 138 μ). Type specimen (Murray and Whitting, 1899, pl. 31, fig. 1a): Length of body, 794 μ. Length of head, 9 μ. Length of neck, 50 μ. Length of anterior process and midbody, 181 μ. Width of midbody, 30 μ. Length of antapical stem in front of bifurcation, 297 μ. Length of inside of ventral limb, 204 μ. Length of inside of dorsal limb, 250 μ. Zacharias's (1906, p. 563, 564) specimen: Length of body, 1050 μ. Length of "Proabdomen" (= neck and anterior process), 112 μ. Length of "abdominal Spindel" (= midbody), 160 μ. Length of "Postabdomen" (= antapical stem), 458 μ. Length of "zinkenähnliche Fortsätze" (= antapical limbs), 320 μ.

Variations: — The specimens examined by us were very constant. The most variable characters in this species, as conceived in the present paper, are the width of the midbody, the relative length of the antapical stem in front of the bifurcation, and the relative length and width of the antapical limbs.

Comparisons: — The specimens found in the material of the Expedition and referred to *Amphisolenia bifurcata* differ from the type specimen of this species as described and figured by Murray and Whitting (1899) in having the antapical stem in front of the bifurcation comparatively longer and the antapical limbs comparatively shorter. In spite of these differences the assignment of our specimens may be regarded as fairly certain.

The species undoubtedly is closely related to *Amphisolenia thrinax*, *A. quadricauda*, and *A. quinquecauda*. The great structural resemblance between the antapical limbs in these four species can hardly be explained except by the assumption of close relationship. The main differentiating character is the number of the antapical limbs.

With regard to the relationship between *Amphisolenia bifurcata* and *A. projecta*, see *A. projecta* (p. 438).

Amphisolenia bifurcata, *A. projecta*, *A. thrinax*, *A. quadricauda*, and *A. quinquecauda* form a natural systematic unit, the BIFURCATA group, which in many respects is the most highly differentiated group in the genus. Their closest relatives, outside the group, are probably to be found in the PALMATA group.

Synonymy: — The species was established by Murray and Whitting (1899) under the name of *Amphisolenia bifurcata*. This name has been used by later writers, but none of them has given any drawings by means of which the determinations may be checked.

Amphisolenia thrinax Zacharias (1906) is probably a synonym of *A. bifurcata*. All the statements made by Zacharias (1906, p. 563, 564) about the specimen that he referred to *A. thrinax* agree with our conception of *A. bifurcata*. The author accounted for the fact that his specimen had only two antapical limbs by assuming that these limbs varied in number in *A. thrinax*.

Occurrence: — *Amphisolenia bifurcata* is recorded at six of the 127 stations. There are 1, 0, 1, 3, 1, and 0 stations on the six lines of the Expedition. Of these six stations, one (4583) is in the California Current; three (4691, 4695, 4699) are in the Easter Island Eddy; two (4701, 4724) are in the South Equatorial Drift. All the records refer to catches from 300–0 fathoms.

The temperature range of these six stations at the surface was 72°–83°; the average was 76.0°. The frequency is less than 1%.

The species was first recorded by Murray and Whitting (1899) from four localities in the tropical and subtropical regions of the Atlantic Ocean and in the Caribbean Sea, viz., lat. 29°–31° N., long. 44°–42° W., lat. 16°–17° N., long. 69°–72° W., lat. 14°–15° N., long. 63°–67° W., and lat. 4°–6° S., long. 32°–33° W. No information is given as to which of these four stations is the type locality. Zacharias (1906) recorded it, under the name of *Amphisolenia thrinax*, from lat. 14° N., long. 41° W.; Stüwe (1909) from lat. 3° N., long. 26° W. Cleve (1902b) found it somewhat farther south in the Atlantic than previous authors, viz., at lat. 24° S., long. 41° W. Karsten (1907) reported it as taken in the Indian Ocean, at one of the stations of the VALDIVIA Expedition, lat. 18° S., long. 96° E. Most of the records referred to above were from catches made at or near the surface; Stüwe's (1909) were from 150 (100)–0 m.

The species occurs in waters of the following temperatures and salinities: — Murray and Whitting (1899): temperature range, 67°–81°; average of four observations, 76.5°. Cleve (1902b): temperature, 73°; salinity, 37.07. Stüwe (1909): temperature, 80.2°.

Of the writers who have contributed to our knowledge of the distribution of this species only Murray and Whitting (1899) give drawings by means of which their determinations may be verified.

The species probably is eupelagic and has a world-wide distribution in tropical and subtropical seas, but it is very rare. With regard to its occurrence in the Eastern Pacific, according to our records, its absence from the relatively cool Peruvian Current is most noteworthy.

AMPHISOLENIA PROJECTA Kofoid

Figure 56: 7, 58

Amphisolenia projecta KOFOID, 1907a, p. 199, pl. 13, fig. 77.

Diagnosis: — Almost straight in front of bifurcation. Midbody fusiform, merging gradually into anterior process and antapical. Distance from flagellar pore to antapical, 2.4 times longer than neck. Ratio between length and width of body, 18–19: 1. Antapical bifurcate; stem in front of bifurcation straight and 3.7 the length of neck. Antapical limbs very unequal; the ventral 1.8 the length of neck, its proximal half inflated, fusiform, about twice as wide as antapical stem in front of bifurcation, its distal portion with spinules of the *palmata* type; the dorsal limb about 0.33 the length of ventral, of about the same shape as proximal portion of ventral, obliquely truncate posteriorly, without spinules. Length, 185 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight in front of the bifurcation. The antapical limbs have a spread of 30°.

The shape and the inclination of the head are not known with certainty. Probably the head is inclined anteriorly at an angle of about 20°; its axial length is probably 0.17–0.25 the length of the neck; and it is probably about three times wider than long. The anterior face of the epitheca is probably flat or gently convex. The cingular lists are probably about 1.5–2.0 times as wide as the transverse furrow; the anterior flares anteriorly at an angle of about 20°, the posterior is subhorizontal.

The neck is of moderate length, 0.11 the length of the body, and seven to nine times longer than wide.

The midbody is fusiform and merges gradually into the anterior process and into the antapical; its ventral margin is less convex than the dorsal. The distance between the flagellar pore and the anterior end of the antapical is about 2.4 times longer than the neck. The midbody is of moderate width, widest at a distance from the apex equaling about one third to one fourth the length of the body, or at a distance from the flagellar pore about 1.5 the length of the neck; its greatest width is 0.55 the length of the neck. The ratio between the length and the greatest width of the body is 18–19:1.

The antapical is bifurcate. The antapical stem in front of the bifurcation is straight, 3.7 the length of the neck and 1.4–1.6 times the total length of the anterior process and the midbody; it is of about the same width throughout its whole length, and its width is subequal to or somewhat exceeds that of the neck. The antapical limbs are very unequal. The ventral is 1.8 the length of the neck; its proximal half is inflated and fusiform and about twice as wide as the antapical stem in front of the bifurcation; its posterior portion is slender and has moderately strong spinules of the *palmata* type. The dorsal limb is about 0.33 the length of the ventral, of about the same shape as the proximal portion of the ventral, obliquely and broadly truncate posteriorly, and lacks spinules.

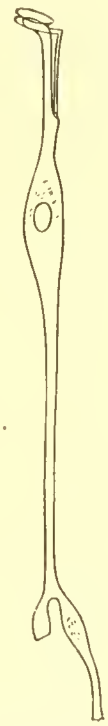

FIGURE 58.—*Amphisolenia projecta* Kofoid, right lateral view of type specimen, after free-hand sketch from life, and attached measurements and notes. × 510. Station 4701 (300–0 fathoms).

The nucleus is of moderate size, ellipsoidal, and longitudinal. The chromatophores are numerous, small, and greenish yellow; most of them are to be found in the anterior portion of the midbody and in the inflated portion of the ventral antapical limb.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 185 μ. Length of head, about 3.5 μ. Length of neck, 20 μ. Length of anterior process and midbody, 49 μ. Width of midbody, 10 μ. Length of antapical stem in front of bifurcation, 75 μ. Length of ventral antapical limb, 36 μ.

Comparisons: — Only one specimen of this species has been seen. This specimen was found by the senior author in his preliminary examination of the material of the Expedition when still on board the ALBATROSS. A freehand drawing made on board ship and the attached measurements were used in making Figure 58 of the present paper. This figure and not Plate 13, figure 77, of the original description (Kofoid, 1907a) is the basis of the description given above. It should be noted that the shape and inclination of the head are uncertain; in the original sketch the head is not drawn but only the cingular lists.

The question as to whether or not this is a valid species cannot be settled as yet. The type specimen possibly may be a representative of *Amphisolenia bifurcata* in which the dorsal antapical limb is broken. This supposition, which necessitates the assumption that the length of the body (185 μ) given in the original description is wrong, is supported by the close similarity between the neck, the anterior process, the midbody, the antapical stem in front of the bifurcation, and the ventral antapical limb in *A. projecta* and the corresponding parts in *A. bifurcata*. Furthermore, the dorsal antapical limb in *A. projecta* has the same shape as the proximal part of the ventral limb; and its obliquely and broadly truncate tip, lacking spinules, suggests the possibility of a broken process. On the other hand, the fact that there is no indication of mistake in the original measurements, and the fact that closely related dwarfs and giants rather frequently have been found in this tribe make it necessary to treat *A. projecta*, tentatively, as a valid species. The type specimen of this species has been searched for in the type material but without success.

Amphisolenia projecta is undoubtedly most closely related to *A. bifurcata*. It differs from this species mainly in size (185 μ as compared to 794–1050 μ) and in the relative length and shape of the dorsal, non-spinulate, antapical limb (see *A. bifurcata*, the section on comparisons, p. 434).

Occurrence: — This species is recorded at only one of the 127 stations. This station (4701) is on the fourth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 72°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4701 of the Expedition, which thus is the type locality.

AMPHISOLENIA THRINAX Schütt

Plate 12, fig. 2, 6. Figure 54: 7–9, 56: 8, 59

Amphisolenia thrinax SCHÜTT, 1893, p. 271, 299, 301, fig. 81. LEMMERMANN, 1899a, p. 319, 331, 373; 1901a, p. 376. MURRAY & WHITTING, 1899, p. 331, tab. 6, 8. SCHRÖDER, 1900a, p. 20; 1906a, p. 326, 328. OSTENFELD & SCHMIDT, 1901, p. 163. CLEVE, 1901a, p. 13; 1901c, p. 206. KOFOID, 1906c, p. 94,

95; 1907a, p. 199, 200. KARSTEN, 1907, p. 244, 249, 263, 272, 273, 280, 282, 283, 284, 286, 287, 288, 291, 295, 296, 301, 307, 308, 312, 314, 322, 345, 346, 349, 350, 425, 427, 440, 442, 472, 473. STEUER, 1910, fig. 105; 1911, fig. 81. KOFOID & MICHENER, 1911, p. 293. HENSEN, 1911, p. 159, 160, tab. 13. OKAMURA, 1912, p. 20, fig. 51a–c. OLTMANNS, 1923, p. 327, fig. 718: 2.
non *Amphisolenia thrinax* ZACHARIAS, 1906, p. 561, 563, 564.

Diagnosis: — Resembling *Amphisolenia bifurcata* but with two antapical branches. Length of antapical stem in front of the first branch variable, 2.0–7.0 the length of neck. Length, 720–1049 μ.

Of world-wide distribution in tropical, subtropical, and warm-temperate waters.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid in front of the first antapical branch; the neck is, in some specimens, somewhat deflected dorsally, and the anterior portion of the antapical stem, which generally is straight, is sometimes gently concave ventrally. The portion of the antapical stem behind the first branch has a more or less pronounced and somewhat variable sigmoid curvature. The first antapical branch has a spread of 35°–50°; the spread of the second antapical branch is 25°–45°.

The head is inclined anteriorly at an angle of 20°–40°; its axial length is 0.14–0.25 the length of the neck; and it is 3.0–4.5 times wider than long. The anterior face of the epitheca is flat or gently convex. The transverse furrow is 0.16–0.20 as wide as the dorsoventral diameter of the head, somewhat convex, flat, or slightly concave and has, on each valve, six to ten cross-ridges. The cingular lists are 1.5–2.0 times as wide as the transverse furrow; the anterior flares anteriorly at an angle of 10°–20° and has, on each valve, about eight to twelve simple, equidistant ribs; the posterior is subhorizontal and has, as a rule, a somewhat smaller number of ribs.

The neck is rather short, 0.06–0.08 the length of the body, and six to eight times longer than wide. The sulcal lists extend to or somewhat behind the flagellar pore; ribs have not been seen but probably are as in *Amphisolenia quadricauda*.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 3.0–4.5 times longer than the neck. The midbody is of moderate width or more or less slender, widest at a distance from the apex equaling about one fourth of the length of the body, or at a distance from the flagellar pore 1.5–2.5 the length of the neck; its greatest width is 0.6–0.9 the length of the neck. The ratio between the length and the greatest width of the body is 22 (18–26): 1.

The antapical has two branches. The antapical stem in front of the first branch is generally straight, seldom slightly concave ventrally; in the specimens figured by Schütt (1893) and Okamura (1912) it is rather long, 5.5–7.0 times longer than the neck and 1.7–2.0 the total length of the anterior process and the midbody; in some of our specimens (Plate 12, fig. 6) it is short, about twice as long as the neck and 0.6–0.7 the total length of the anterior process and the midbody; it is of about the same width throughout its whole length, and its width is subequal to or somewhat exceeds that of the neck. Of the two antapical branches the first is generally slightly longer and the second somewhat shorter than the portion of the antapical stem that is behind the second branch; however, the relative lengths of the branches and of the portion of the antapical stem that is behind the second branch are somewhat variable; the first branch is 1.8–4.8, the second branch 1.5–3.3, and the posterior part of the antapical stem behind the second branch 1.5–4.1 the length of the neck. Sometimes the branches and the posterior portion of the antapical stem are almost straight, sometimes gently curved or of a sigmoid shape; these differences may, however, to some extent be apparent, due to differences in the positions of the organism. The two branches are frequently of an almost uniform thickness, about as wide as the anterior portion of the antapical stem; the proximal and the middle parts of the portion of the antapical stem behind the second branch, on the other hand, are generally more or less swollen, sometimes even about three times wider than the anterior portion of the antapical stem. In one of the specimens figured by Okamura (1912, fig. 51c) the antapical stem is strikingly widened at the base of the second branch, about three times wider than the anterior portion of the antapical stem. The distal part of both the first branch and the main antapical stem is foot-shaped and has the same number and arrangement of spinules as the "foot" of *Amphisolenia palmata; i.e.*, a "heel-spinule" at some distance from the tip and three spinules at the tip; the spinules are of moderate strength or rather weak. The foot-shaped parts are generally somewhat narrower than the anterior portion of the antapical stem and 3–11 times longer than wide; in most specimens the "foot" of the main antapical stem is somewhat longer than that of the first branch. In our specimens the second branch has two to three, in most cases, rather weak spinules at the tip but no "heel-spinule." In the type specimen, as drawn by Schütt (1893, fig. 81), this branch has a "heel-spinule," but this is probably due to a mistake (compare the structure of the corresponding parts in *A. quadricauda* and *A. quinquecauda*).

The chromatophores are fairly numerous and large, ovoidal or spheroidal. In the midbody and in the antapical there are numerous groups of three to five very small, spheroidal bodies.

The length and the width of the body were measured in seven of our specimens; the proportions of the head and the neck in four of our specimens. All the proportions were measured in two of our specimens and in the type specimen (Schütt, 1893, fig. 81) and in the specimen drawn by Okamura (1912, fig. 51a).

Dimensions: — Our specimens: Length of body, 739–1049 μ (average, 874 μ). Length of head, 10–11 μ. Length of neck, 53–60 μ (average, 57 μ). Length of anterior process and midbody, 203–216 μ. Width of midbody, 26–38 μ. Length of antapical stem in front of the first branch, 116–232 μ. Length of first branch, 271–290 μ. Length of second branch, 177–232 μ. Length of antapical stem behind second branch, 238–280 μ. Type specimen (Schütt, 1893, fig. 81): Length of body, 920 μ. Length of head, 10 μ. Length of neck, 57 μ. Length of anterior process and midbody, 232 μ. Width of midbody, 44 μ. Length of antapical stem in front of first branch, 387 μ. Length of first branch, 190 μ. Length of second branch, 148 μ. Length of antapical stem behind second branch, 175 μ. Okamura's (1912, fig. 51a) specimen: Length of body, 720 μ. Length of neck, 58 μ. Length of anterior process and midbody, 168 μ. Width of midbody, 41 μ. Length of antapical stem in front of first branch, 320 μ. Length of first branch, 100 μ. Length of second branch, 83 μ. Length of antapical stem behind second branch, 85 μ.

Variations: — As conceived in the present paper, *Amphisolenia thrinax* exhibits a rather remarkable variability. The following characters are the most variable: — the length of the body, the curvature of the longitudinal axis of the body, the width of the midbody, the relative length of the antapical stem in front of the first branch, the shape and the relative width of the antapical branches and the antapical stem behind the second branch, and the structure of the distal ends of the antapical stem and branches. Our specimens are rather strikingly variable in all these characters. Plate **12**, figure 6, shows an atypic representative of the species. Future investigations may prove it necessary and feasible to divide the species into two or more systematic units.

Comparisons: — Most of the specimens found in the material of the Expedition and referred to *Amphisolenia thrinax* agree fairly closely with the type specimen of this species as figured by Schütt (1893). On the other hand, some of our specimens differ rather strikingly from the type specimen, especially in having the part of the antapical in front of the first branch very short and relatively long antapical branches. Their assignment must be regarded as questionable (Plate **12**, fig. 6).

The specimen figured by Okamura (1912) under the name of *Amphisolenia thrinax* agrees very closely with the type specimen, and its assignment is undoubtedly correct. The tips of the antapical branches of his specimen are, however, probably misrepresented.

With regard to the relationships of this species, see the section on the comparisons of *Amphisolenia bifurcata* (p. 434).

Synonymy: — The species was established by Schütt (1893) under the name of *Amphisolenia thrinax*. This name was later used by several authors. Of these only Zacharias (1906) and Okamura (1912) give descriptions or drawings by means of which their determinations may be checked. Steuer (1910, 1911) and Oltmanns (1923) give reproductions of Schütt's (1893) figure of the type specimen.

Amphisolenia thrinax Zacharias (1906) is a synonym of *A. bifurcata* (see *A. bifurcata*, the section on synonymy, p. 435). *A. thrinax* Okamura (1912), on the other hand, is certainly correctly determined.

With regard to *Amphisolenia tripos* Schütt, see the historical discussion of the genus (p. 353).

Occurrence: — *Amphisolenia thrinax* is recorded at seventeen of the 127 stations. There are 3, 0, 1, 2, 6, and 5 stations on the six lines of the Expedition. Of these seventeen stations, four (4587, 4590, 4594, 4545) are in the Mexican Current; two (4691, 4697) are in the Easter Island Eddy; nine (4701, 4728, 4732, 4734, 4736, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; two (4742, 4743) are in the South Equatorial Current. At three stations (4741, 4743, 4545) the species was found in surface catches only; at one station (4732) in a catch from 800–0 fathoms only; at two stations (4701, 4728) in catches from 800–0 fathoms as well as in catches from 300–0 fathoms; and at one station (4737) both in a catch from 100–0 fathoms and in one from 300–0 fathoms. The remaining records refer to catches from 300–0 fathoms only.

The temperature range of these seventeen stations at the surface was 72°–84°; the average was 79.0°. At Stations 4741, 4743, and 4545, where the species was found in surface catches, the surface temperatures ranged from 78°–80°; the average was 79.0°.

The frequency is less than 1%, except at four stations (4590, 4594, 4701, 4739), where it is 1%.

The type specimen of this species (Schütt, 1893) was probably taken in the tropical or the subtropical region of the Atlantic Ocean. Murray and Whitting (1899) found the species at three stations in the Sargasso Sea; Cleve (1901c) at one station in the Caribbean Sea and at seven stations in the region from near the east coast of America to near the west coast of Africa and between lat. 40° N. and lat. 21° S.; Hensen (1911) at several stations in the Sargasso Sea and the Canary Current. From the Gulf of Aden it is reported by Ostenfeld and Schmidt (1901); from the Arabian Sea by Cleve (1901a) and Schröder (1906a); from the Indian

Ocean by Schröder (1906a) and Karsten (1907). Karsten (1907) recorded it from not less than eighteen of the stations of the VALDIVIA Expedition, all located in the Indian Ocean, from near the west coast of Sumatra to near the east coast of Africa, and between lat. 8° N. and lat. 15° S. Okamura (1912) found the species in Japanese waters and Lemmermann (1899a) at lat. 6° 24′ N., long. 111° 4′ W., in the Pacific Equatorial Counter Current.

Most of the records referred to above are from catches made at or near the surface. Karsten (1907) found the species more frequent in deep waters than near the surface. He recorded the species as taken with closing net at the following

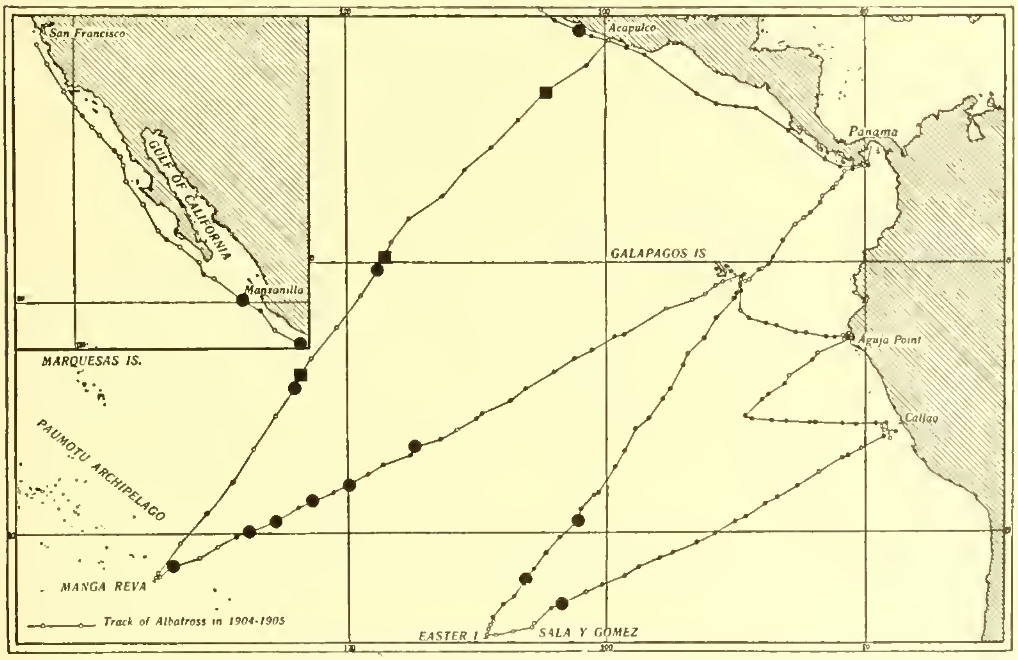

FIGURE 59.— Occurrence of *Amphisolenia thrinax* Schütt. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

stations: — Station 218, lat. 2° 29′ N., long. 76° 47′ E., 80–40 m., dead; 80–60 m., living; Station 221, lat. 40° 5′ S., long. 73° 24′ E., 185–145 m., dead, but with cytoplasmic contents; Station 236, lat. 40° 38′ S., long. 51° 16′ E., 100–65 m., living; Station 239, lat. 5° 42′ S., long. 43° 36′ E., 60–45 m., living; Station 268, lat. 9° 6′ N., long. 53° 41′ E., 21–4 m., living.

The species occurs in waters of the following temperatures and salinities: — Murray and Whitting (1899): Temperature range, 67°–74°; average of three observations 70.3°. Cleve (1901c): Temperature range, 67.0°–80.5°; mean of eight observations, 72.5°. Salinity range, 35.51–37.21; mean of four observations, 36.41.

Of the writers who have contributed to our knowledge of the distribution of this species only Schütt (1893) and Okamura (1912) give figures by means of which their determinations might be checked.

The species is eupelagic and widely distributed in tropical and subtropical seas. Its distribution in the region investigated by the Expedition is remarkable. Although it was found at not less than seventeen stations, it was not taken except in the Mexican Current, the Easter Island Eddy, the western part of the South Equatorial Drift, and in the South Equatorial Current. In other words, there are no records of this species from the California Current, the Panamic Area, the Galapagos Eddy, the Peruvian Current, and the eastern part of the South Equatorial Drift, which is under the influence of the last-mentioned current. It may be worth mentioning in this connection that the distributions of *Amphisolenia thrinax* and *Triposolenia longicornis*, both species with highly developed structural adaptations for flotation, are almost mutually exclusive according to our records.

AMPHISOLENIA QUADRICAUDA Kofoid and Michener

Plate 13, fig. 1–6, 8. Figure 48, 56: 9

Amphisolenia quadricauda KOFOID & MICHENER, 1911, p. 293.

Diagnosis: — Resembling *Amphisolenia bifurcata*, but with three antapical branches. Length, 780 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body, the spread of the antapical branches, the head, the neck, the anterior process, and the midbody are as in *Amphisolenia thrinax*. The sulcal lists end at the flagellar pore; both of them have anteriorly a few, partly anastomosing cross-ribs, and the left list has a fission rib at the flagellar pore.

The antapical has three branches. The antapical stem in front of the first branch is straight, 2.7 times longer than the neck, and 0.6 the total length of the anterior process and the midbody; it is of about the same width throughout its whole length and somewhat wider than the neck. Of the three antapical branches the first is somewhat longer, the second and the third somewhat shorter than the antapical stem behind the third branch; the first branch is 5.8, the second 4.5, the third 4.0, and the antapical stem behind the third branch 5.0 the length of the neck. The first branch is gently sigmoid, the second and third gently sigmoid or gently concave posteriorly, and the antapical stem behind the third branch rather strikingly sigmoid. In the type specimen the three branches are of an almost uniform thickness and about as wide as the antapical stem in front of the first branch; the antapical stem behind the third branch tapers posteriorly; its proximal half is about twice as wide as its distal half. The distal part of both the first branch and the antapical stem has the same shape and structure as in *Amphisolenia thrinax; i.e.*, it is foot-shaped and has a "heel-spinule" at some distance from the tip and three spinules at the tip. Each one of the second and third branches has two rather small spinules at the tip but no "heel-spinule."

The thecal wall has no structure. The distal parts of the anterior and the posterior antapical limbs are finely porulate; the two middle antapical limbs have no porulation. Along the base of each of the sulcal lists and on either side of the dorsal suture line of the neck there is a row of closely set pores. Fine porulation is also found on the head.

The proportions of one specimen, the type, were measured.

Dimensions: — Type specimen: Length of body, 780 μ. Length of head, 9 μ. Length of neck, 51 μ. Length of anterior process and midbody, 226 μ. Width of midbody, 38 μ. Length of antapical stem in front of first branch, 128 μ. Length of first branch, 284 μ. Length of second branch, 219 μ. Length of third branch, 194 μ. Length of antapical stem behind third branch, 245 μ.

Comparisons: — The description given above is based on the type specimen. With regard to the relationships of the species, see the section on the comparisons of *Amphisolenia bifurcata* (p. 434).

Occurrence: — *Amphisolenia quadricauda* is recorded at only one of the 127 stations. This station (4695) is on the fourth line of the Expedition and in the Easter Island Eddy. The depth is 300–0 fathoms, the surface temperature 74°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4695 of the Expedition, which thus is the type locality. The single record station of this species is within the area of distribution established for *Amphisolenia thrinax*.

Amphisolenia quinquecauda Kofoid

Plate 13, fig. 7, 9–14. Figure 56: 10

Amphisolenia quinquecauda Kofoid, 1907a, p. 200, pl. 13, fig. 75; 1906c, p. 95. Kofoid & Michener, 1911, p. 293.

Diagnosis: — Resembling *Amphisolenia bifurcata*, but with four antapical branches. Length, 840 μ.

Eastern tropical Pacific.

Description: — The species differs from *Amphisolenia quadricauda* only in the following respects: — the antapical stem in front of the first branch is 5.8 times longer than the neck and 1.6 the total length of the anterior process and the midbody; however, this character is probably variable just as in *A. thrinax.* The most striking difference is that the antapical has four instead of three branches. Of these the second, third, and fourth are subequal and of about the same relative length and of the same shape and structure as the corresponding branches in *A. quadricauda.* The chromatophores are small, oblong, ellipsoidal, and numerous.

The proportions of one specimen, the type, were measured.

Dimensions: — Type specimen: Length of body, 840 μ. Length of head, 10 μ. Length of neck, 52 μ. Length of anterior process and midbody, 176 μ. Width of midbody, 44 μ. Length of antapical stem in front of first branch, 280 μ. Length of first branch, 316 μ. Length of second branch, 215 μ. Length of third branch, 187 μ. Length of fourth branch, 175 μ. Length of antapical stem behind fourth branch, 245 μ.

Comparisons: — The description given above is based on the type specimen. With regard to the relationships of the species, see the section on the comparisons of *Amphisolenia bifurcata* (p. 434).

Occurrence: — *Amphisolenia quinquecauda* is recorded at two of the 127 stations. These stations (4737, 4739) are on the fifth line of the Expedition and in the South Equatorial Drift. The samples are from 300–0 fathoms.

The surface temperatures of these stations were 81.5° and 70.0° respectively.

The frequency is less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4739 of the Expedition which thus is the type locality. The two record stations of this species are located in the area of distribution established for *Amphisolenia thrinax.*

Triposolenia Kofoid

Plate 14, 15, 27. Figure 60–74

Triposolenia Kofoid, 1906c, p. 93, 101; 1906d, p. 117; 1906e, p. 127; 1907a, p. 201.

Diagnosis: — Body seemingly tripartite, with three long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process, and two posterior, the antapicals, one of which is dorsal, the other ventral in origin. The three extensions are generally subequal and approximately balanced; their length is 1.0–3.4 the dorsoventral diameter of midbody measured between bases of antapicals.