

DEPARTMENT OF TERRESTRIAL MAGNETISM  
J. A. Fleming, Director

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Scientific Results of Cruise VII of the CARNEGIE during 1928-1929  
under Command of Captain J. P. Ault

BIOLOGY—II

The Oceanic Tintinnoina of the Plankton  
Gathered during the Last Cruise  
of the CARNEGIE

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## PREFACE

Of the 110,000 nautical miles planned for the seventh cruise of the nonmagnetic ship *Carnegie* of the Carnegie Institution of Washington, nearly one-half had been completed upon her arrival at Apia, November 28, 1929. The extensive program of observation in terrestrial magnetism, terrestrial electricity, chemical oceanography, physical oceanography, marine biology, and marine meteorology was being carried out in virtually every detail. Practical techniques and instrumental appliances for oceanographic work on a sailing vessel had been most successfully developed by Captain J. P. Ault, master and chief of the scientific personnel, and his colleagues. The high standards established under the energetic and resourceful leadership of Dr. Louis A. Bauer and his co-workers were maintained, and the achievements which had marked the previous work of the *Carnegie* extended.

But this cruise was tragically the last of the seven great adventures represented by the world cruises of the vessel. Early in the afternoon of November 29, 1929, while she was in the harbor at Apia completing the storage of 2000 gallons of gasoline, there was an explosion as a result of which Captain Ault and cabin boy Anthony Kolar lost their lives, five officers and seamen were injured, and the vessel with all her equipment was destroyed.

In 376 days at sea nearly 45,000 nautical miles had been covered. In addition to the extensive magnetic and atmospheric-electric observations, a great number of data and marine collections had been obtained in the fields of chemistry, physics, and biology, including bottom samples and depth determinations. These observations were made at 162 stations, at an average distance apart of 300 nautical miles. The distribution of these stations is shown in map 1, which delineates also the course followed by the vessel from Washington, May 1, 1928, to Apia, November 28, 1929. At each station, salinities and temperatures were obtained at depths of 0, 5, 25, 50, 75, 100, 200, 300, 400, 500, 700, 1000, 1500, etc., meters, down to the bottom or to a maximum of 6000 meters, and complete physical and chemical determinations were made. Biological samples to the number of 1014 were obtained both by net and by pump, usually at 0, 50, and 100 meters. Numerous physical and chemical data were obtained at the surface. Sonic depths were determined at 1500 points and bottom samples were obtained at 87 points. Since, in accordance with the established policy of the Department of Terrestrial Magnetism, all observational data and materials were forwarded regularly to Washington from each port of call, the records of only one observation were lost with the ship, namely, a depth determination on the short leg between Pago Pago and Apia.

The compilations of, and reports on, the scientific results obtained during this last cruise of the *Carnegie* are being published under the classifications Physical Oceanography, Chemical Oceanography, Meteorology, and Biology, in a series numbered, under each subject, I, II, III, etc.

A general account of the expedition has been prepared and published by J. Harland Paul, ship's surgeon and observer, under the title *The last cruise of the Carnegie*, and contains a brief chapter on the previous cruises of the *Carnegie*, a description of the vessel and her equipment, and a full narrative of the cruise (Baltimore, Williams and Wilkins Company, 1932; xiii + 331 pages with 198 illustrations).

The preparations for, and the realization of, the program would have been impossible without the generous cooperation, expert advice, and contributions of special equipment and books received on all sides from interested organizations and investigators both in America and in Europe. Among these, the Carnegie Institution of Washington is indebted to the following: the United States Navy Department, including particularly its Hydrographic Office and Naval Research Laboratory; the Signal Corps and the Air Corps of the War Department; the National Museum, the Bureau of Fisheries, the Weather Bureau, the Coast Guard, and the Coast and Geodetic Survey; the Scripps Institution of Oceanography of the University of California; the Museum of Comparative Zoölogy of Harvard University; the School of Geography of Clark University; the American Radio Relay League; the Geophysical Institute, Bergen, Norway; the Marine Biological Association of the United Kingdom, Plymouth, England; the German Atlantic Expedition of the *Meteor*, Institut für Meereskunde, Berlin, Germany; the British Admiralty, London, England; the Carlsberg Laboratorium, Bureau International pour l'Exploration de la Mer, and Laboratoire Hydrographique, Copenhagen, Denmark; and many others. Dr. H. U. Sverdrup, now Director of the Scripps Institution of Oceanography of the University of California, at La Jolla, California, who was then a Research Associate of the Carnegie Institution of Washington at the Geophysical Institute at Bergen, Norway, was consulting oceanographer and physicist.

In summarizing an enterprise such as the magnetic, electric, and oceanographic surveys of the *Carnegie* and of her predecessor the *Galilee*, which covered a quarter of a century, and which required cooperative effort and unselfish interest on the part of many skilled scientists, it is impossible to allocate full and appropriate credit.

Captain W. J. Peters laid the broad foundation of the work during the early cruises of both vessels, and Captain J. P. Ault, who had had the good fortune to serve under him, continued and developed what Captain Peters had so well begun. The original plan of the work was envisioned by L. A. Bauer, the first Director of the Department of Terrestrial Magnetism, Carnegie Institution of Washington; the development of suitable methods and apparatus was the result of the painstaking efforts of his co-workers at Washington. Truly, as was stated by Captain Ault in an address during the commemorative exercises held on board the *Carnegie* in San Francisco,

August 26, 1929, "The story of individual endeavor and enterprise, of invention and accomplishment, cannot be told."

The following memoir by Dr. Arthur S. Campbell is the second in the series of reports on studies of the plankton gathered during the last cruise of the *Carnegie*. Of value in this study of the oceanic Tintinnoida has been the mass of material accumulated by other vessels, especially the *Albatross* and the *National*, detailed accounts of which are given elsewhere.

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## METHODS

The samples were examined in the original sea water and formalin without other treatment than the occasional replacement of loss by evaporation with distilled water. It is thus possible carefully to orient the organism under the cover slip and to secure diverse views of the same individual. There does not seem to be any satisfactory method of sealing off mounts in formalin. A few smears of plankton were made, however, and mounted either in Venice turpentine or in balsam. These were used to supplement the routine examinations. Adequate microscopes and maximum equipment were used at all times in the examination of the material.

After a sufficient knowledge of the species of *Tintinnina* had been obtained, each sample was systematically searched by the use of the mechanical stage until all the species had been detected. Each sample, after being thoroughly shaken, was examined on a standard slide under a long cover slip, and several slides were made of it. When the whole sample had been investigated, the material was washed back into the original phial. Care was taken that slides, slips, pipettes, and other instruments were cleaned before another sample was opened. The camera lucida was always attached to the microscope so that drawings could be made at once when a desired individual was discovered. In order to have some semblance of quantitative record of frequency in individuals of the component species of each net sample, records were made during the search of the sample up to the first hundred individuals examined. Thereafter each additional species was recorded as merely present. The number of individuals recorded is thus the percentage in that sample. These records refer solely to the relative numbers of different species in the one sample, and do not indicate the relative numbers of the same species in other samples. In the examination of the pump samples, the whole number of individuals of all species found was counted out directly, so that in some instances several hundred were recorded. These are reported fully. In most cases the numbers were small and are recorded with those of the net samples without differentiation.

The manner of collection, and of accumulation of physical data, is recorded in the general survey of the expedition, as is also the list of species by station and depth.

Drawings with the camera lucida at standard magnifications were accumulated in great number during the examination of the plankton. Several thousand sketches, with additional notes when necessary, were thus brought together. From these the finished drawings were made up, and the range of variation ascertained. All the

descriptions of species in this report are the result of the examination and measurement of these drawings. In this way it became possible to describe a large fauna accurately and to determine at a later time the exact status of aberrant individuals. Stress was laid on the finding and recording of these unusual individuals. Most of the finished drawings are selected to show some unusual feature of morphology. Since the majority of the oceanic species have been figured previously, it was not considered necessary to illustrate all species, especially in those instances in which the material of the *Carnegie* was not particularly different from that already described. The descriptions in all instances, however, are of loricae of species found in the collection. Thus these descriptions may differ from those given in earlier papers.

In this report each character has approximately the same place in the description and so far as possible is discussed in similar phraseology. For the families, subfamilies, and genera, synonymy, relationships, and general distribution are given. The descriptions of the species include synonymy, description of specimens found in the *Carnegie* material, variations, comparisons, history, and occurrence in the material of the expedition. Because the various genera are distinctly different in form, it is not always possible to apply the same procedure of description to them all, or to use an identical terminology. Adjectives and adverbs used in the descriptions are to be understood in their usual sense, although they are seldom quantitatively exact.

The families, subfamilies, and genera are arranged in a presumed order of natural relationship, based on the comparative structure of the lorica. The species are arranged within each genus alphabetically. A number of changes in nomenclature and systematic arrangement have been made in an attempt more naturally to separate the families, genera, and species. The relations of the species to one another are treated in the paragraph on comparisons.

In the synonymy, only those forms recorded since the publication of the *Conspectus* by Kofoed and Campbell (1929) are given. In that monograph all previous significant literature is reviewed.

The records of distribution are arranged according to the natural areas of distribution of Gerhard Schott, which regions are based on the physical conditions of the sea water. The geographical distribution thus does not strictly follow the ocean currents, since these are difficult to limit and are subject to different physical conditions along their lengths. The accompanying table gives a summary of the route of the *Carnegie*. See also map 1.

Leg	Depart- ing	From	Arriv- ing	At	Dis- tance (miles)
	1928-9		1928-9		
1	May 11	Newport News	June 9	Plymouth	3,669
2	June 18	Plymouth	June 22	Hamburg	614
3	July 7	Hamburg	July 20	Reykjavik	1,329
4	July 27	Reykjavik	Sept. 16	Barbados	5,715
5	Oct. 1	Barbados	Oct. 11	Balboa	1,361
6	Oct. 25	Balboa	Dec. 6	Easter Island	4,788
7	Dec. 12	Easter Island	Jan. 14	Callao	3,334
8	Feb. 5	Callao	Mar. 13	Papeete	4,470
9	Mar. 20	Papeete	Apr. 1	Pago Pago	1,274
10	Apr. 5	Pago Pago	Apr. 6	Apia	80
11	Apr. 20	Apia	May 20	Guam	3,914
12	May 25	Guam	June 7	Yokohama	1,447
13	June 24	Yokohama	July 28	San Francisco	4,839
14	Sept. 3	San Francisco	Sept. 23	Honolulu	2,186
15	Oct. 2	Honolulu	Nov. 18	Pago Pago	5,777
16	Nov. 27	Pago Pago	Nov. 28	Apia	80
Total .....					44,877

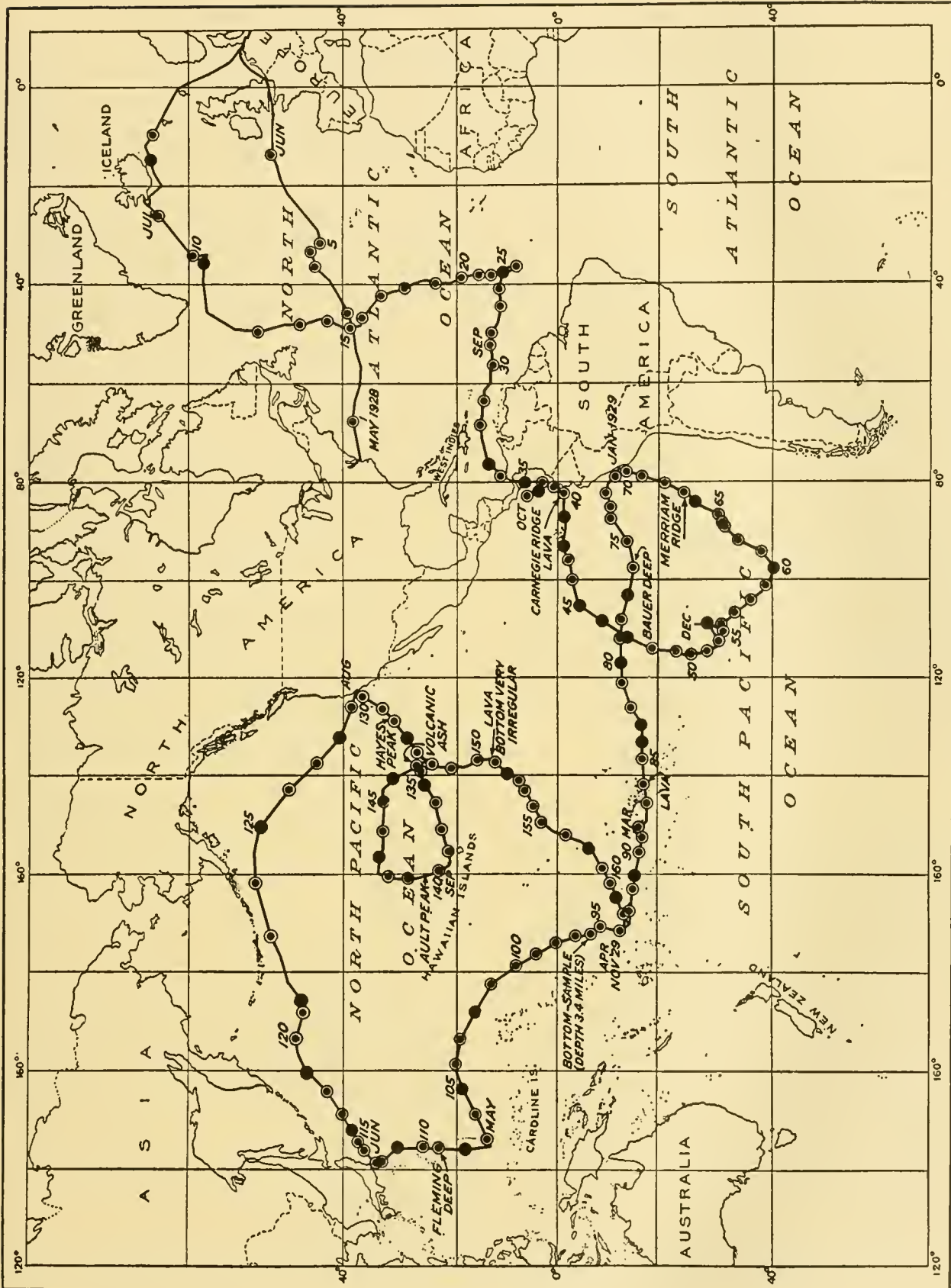
It will be seen that a wider area of the oceans was covered than has been investigated before by almost any other single expedition. The wealth of physical data that accompanies the plankton catches makes this voyage especially valuable.

The natural areas of distribution covered are these: the Gulf Stream, the Atlantic drift, the North Sea, the American cold-water region, the Sargasso Sea, the Atlantic equatorial region, the Caribbean Sea, the East

Asiatic marginal sea, the Alaskan secondary region, the North Pacific middle latitudes, the California region, the North Pacific trade region, the Pacific equatorial region, the Galápagos region, the region of South Pacific island fields, and the South Pacific middle latitudes. In each of these sixteen areas some Tintinnoina were found. In the accounts of occurrence, the order of the ship's route is followed.

A total of 648 phials was examined. Of these, 272 were in net samples and 376 were in pump samples. There were 70 net samples from the Atlantic and 202 from the Pacific. Of pump samples, there were 58 from the Atlantic and 318 from the Pacific. No net samples were available from stations 86 to 94 inclusive, as there was no residual lot remaining at the time this investigation was in progress. Scattered net samples were also missing throughout the collection, but pump samples were obtained at these stations. In 51 of the net samples no Tintinnoina were recorded. These are *Carnegie* samples 9087, 9089, 9090, 9091, 9093, 9094, 9095, 9111, 9112, 9118, 9119, 9120, 9121, 9122, 9123, 9129, 9130, 9131, 9143, 9154, 9172, 9175, 9178, 9181, 9183, 9186, 9202, 9213, 9219, 9220, 9221, 9231, 9234, 9239, 9243, 9248, 9273, 9274, 9284, 9286, 9287, 9291, 9312, 9314, 9315, 9317, 9318, 9321, 9329, 9331, 9347. Most of these are from transitional regions. In 37 pump samples no Tintinnoina were recorded: 2672, 2695, 2715, 2726, 2729, 2761, 2766, 2769, 2771, 2774, 2775, 2778, 2780, 2797, 2816, 2818, 2819, 2820, 2835, 2842, 2843, 2853, 2855, 2859, 2865, 2877, 2903, 2918, 2927, 2928, 2929, 2930, 2964, 2966, 2967, 2973, 3163.





Map 1. Oceanographic stations, cruise VII of the Carnegie, 1928-1929

## TAXONOMY AND DISTRIBUTION OF THE TINTINNOINA FOUND IN THE MATERIAL OF THE CARNEGIE

(Temperatures are given in degrees centigrade. Salinities are expressed per mille. Values of density are in units of the third decimal, and express the excess over unity; thus, 23.26 signifies a density of 1.02326. Values of pH are in the usual units expressing hydrogen-ion concentration.)

### CODONELLIDAE Kent emended

Codonellidae, Kofoid and Campbell, 1929, p. 18.

The family includes four genera: *Tintinnopsis*, *Codonella*, *Codonaria*, and *Codonopsis*. These genera are largely marine, only a few odd species of *Tintinnopsis* and *Codonella* being found in fresh and brackish water. Most species of *Tintinnopsis* and one or two of *Codonella* occur in coastal waters; *Codonaria* and *Codonopsis* are exclusively eupelagic, nearly always in warm seas.

All four genera occur in the *Carnegie* material.

### TINTINNOPSIS Stein emended

*Tintinnopsis*, Kofoid and Campbell, 1929, pp. 19-20.

Species of *Tintinnopsis* are usually rare in oceanic plankton, the genus commonly occurring in neritic or even brackish-water conditions. Under the varied environments of coastal waters, many local species have come into being. Only a few are found in the high sea and these are apparently developed from species of the coasts. *Tintinnopsis* is scarce in warm and temperate water except northward, where there are a number of coastal forms along the shore line. The genus does not enter the Antarctic.

Two species are described, of which one is new.

#### *Tintinnopsis penrhynensis*, new species

(Plate 1, figure 3)

The tiny lorica has a globose bowl and a ringlike collar, and its length is 1.56 oral diameters. The oral margin is irregularly beset with minute blobs of alveolar matter so that its edge is ragged. The collar is a cufflike tube with a length of 0.53 oral diameter, and has a scarcely detectable median bulge with a diameter little greater than that of the oral opening. The globular bowl reaches its greatest diameter, 1.53 oral diameters, at the middle. The upper, open end joins the collar, forming a modest shoulder, and the lower hemisphere rounds out, there being no aboral differentiation.

The wall is 0.14 oral diameter in thickness near its thickest level, which is across the level of the junction of collar and bowl; it gradually thins and becomes extraordinarily thin at the aboral end. There are coarse, irregular, crudely prismatic tertiary structures in the wall. The outer surface shows little irregularity, and few blobs occur.

Length, total 50 $\mu$ , collar 12.5 $\mu$ ; diameter, oral 32 $\mu$ , throat 35 $\mu$ .

This is a locally developed species of *Tintinnopsis*, and differs from all others in shape. It is somewhat like *T. bermudensis* in having a cufflike collar and round bowl, but in

*bermudensis* the collar is much taller and more funnel-like, and the bowl is pointed. It bears a little resemblance to *T. baltica*, but in *baltica* the collar widens out suborally, and again the bowl is aborally pointed. It looks like *T. bornandi*, but the collar is cufflike, taller, and more regular. It is somewhat like *T. conglobata*, but is shorter and stouter, with a rounded instead of ovate bowl, and with a more clearly developed shoulder; it is not much like other species of *Tintinnopsis* described from the coast of Asia or elsewhere in the Pacific.

Recorded from the lagoon of Penrhyn Island, a surface catch on November 10, 1929. Only 2 loricae were observed.

No physical data are available for this exceedingly interesting locality.

Type locality, Penrhyn Island lagoon (between stations 159 and 160), at surface; latitude 9° south, longitude 158° west.

#### *Tintinnopsis rara* Kofoid and Campbell

*Tintinnopsis rara* Kofoid and Campbell, 1939, p. 41, pl. 1, fig. 7.

The stout lorica, with cylindrical collar and globular bowl, has a length of 1.57 oral diameters. The oral margin is thin, spreading, and slightly recurved. The low collar is a cylinder with a length of 0.3 oral diameter, with laterally concave sides and somewhat spreading upper and lower parts. The bowl is practically hemispherical without any special differentiation at the aboral end; its diameter is 1.4 oral diameters.

The wall is coarsely reticulated with large irregular polygons or tertiary prisms, with thickened edges and clear contents. The wall is rather thin, and the cavity follows exactly the outer contour.

Length, 56 $\mu$ .

Kofoid and Campbell (1929) called this species *Tintinnopsis bornandi*; the Pacific form is different from the Mediterranean species, however, as these writers later recognized.

*Tintinnopsis rara* is closest to *T. bornandi* in form and size, but the surface is not beset with adherent irregular particles, the bowl is more symmetrically globular, and the collar is a trifle lower, all these characters possibly being associated with the more definitely pelagic as contrasted with neritic habit.

Recorded from three stations in the Pacific, as follows: one (65) in the South Pacific middle latitudes, one (96) in the region of South Pacific island fields, and one (135) in the California region.

Pump samples only, 2 from 50 meters and 1 from the surface. Frequency, minimum.

Temperature, 16°96-29°30 (22°69); salinity, 34.47-35.27 (34.91); density, 22.19-25.14 (23.87); pH, 8.10-8.37 (8.23).

**CODONELLA** Haeckel emended

*Codonella*, Kofoid and Campbell, 1929, pp. 51-52.

No fresh-water Tintinnoina were recorded in the material of this expedition, although 2 samples were taken in Lake Vohire at Tahiti. In these samples there were diatoms, small annulates, rotifers, and abundant statoblasts of the bryozoan *Plumatella* sp. *Codonella cratera* might have been expected; the lack of fresh-water Tintinnoina in mid-Pacific oceanic island lakes is interesting. Nearly every large body of fresh water on the continents has some of these ciliates. *Codonella* rarely enters coastal waters, being mainly confined to the warm oceans. No species are found in the Antarctic, and only a few in cooler northern seas.

Fifteen species are described, of which one is new.

***Codonella acerca* Jørgensen**

*Codonella acerca*, Kofoid and Campbell, 1929, p. 52, fig. 113.

The short lorica, with funnel-like collar, rotund bowl, and pointed aboral end, has a length of nearly 1.56 oral diameters. The oral margin is thin-edged and entire. The collar is a segment of an inverted, slightly expanded cone ( $20^\circ$ ) with a length of 0.5 oral diameter, and a diameter at the lower end of 0.81 oral diameter. Its sides are strictly plane. The plump bowl reaches its greatest diameter, 1.12 oral diameters, at 1.0 oral diameter below the rim. The lower bowl gradually contracts, reaching 1.0 oral diameter at 1.31 oral diameters below the rim, and then rather more suddenly becomes a wide inverted convex cone ( $110^\circ$ ) with an unmodified, not prolonged point.

The wall is thin, being hardly 0.02 oral diameter in thickness in the bowl. There are feeble laminae with long, rectangular secondary prisms in but one layer. There is a weak internal ledge. The exterior surface has unequal, round to polygonal meshes. The large polygons are best formed in the upper bowl.

Length, 64 to 72 $\mu$ .

*Codonella acerca* differs from *C. nationalis* chiefly in the pointed rather than rounded aboral region.

Recorded from one station (18) in the Sargasso Sea, in a net sample taken at 100 meters. Frequency, minimum.

Temperature,  $20^\circ 32$ ; salinity, 36.81; density, 26.06; pH, 8.21.

***Codonella acuta* Kofoid and Campbell**

*Codonella acuta* Kofoid and Campbell, 1929, p. 52, fig. 104.

The fairly tall lorica, with funnel-like collar, broadly ovate bowl, and acutely pointed aboral end, has a length of 1.57 oral diameters. The entire, thin-edged oral rim has a hyaline band with a width of less than 0.1 oral diameter. The inverted, funnel-shaped ( $20^\circ$ ) collar, the length of which is 0.25 total length, reaches a diameter of 0.83 oral diameter at the neck; sometimes there is a short sigmoid curve in the wall just above its junction with the bowl. The rather plump bowl expands from the throat and reaches 1.08 oral diameters at 0.53 total length from the rim. Below this level the bowl contracts with full, convex sides to the simple, obtusely angular ( $105^\circ$ ) aboral end.

The wall reaches a thickness of 0.06 oral diameter across

the bowl and is much thinner in the collar. There is sometimes a double layer of large, rectangular secondary prisms. The outer surface has very thick-walled, rounded secondary polygons in the upper half and larger ones below. Usually these polygons enclose circular coccoliths and rhabdolites.

Length, 80 to 105 $\mu$ .

The coccolith-bearing habit is well developed in this species, although some loricae apparently lack them. The length is variable, owing, no doubt, to temperature relations.

*Codonella acuta* has a more deeply constricted throat than *C. galea*, as well as a pointed aboral end. There is no projecting point as in *C. cuspidata* or *tropica*. It is not so tall nor so trim as *C. elongata*, and its bowl is much wider; the aboral end is acute rather than narrowly rounded.

Recorded from sixteen stations in the Pacific, as follows: three (45, 46, 71) in the Galápagos region, seven (81, 90, 96, 98, 158, 159, 160) in the region of South Pacific island fields, four (101, 104, 138, 140) in the North Pacific trade region, one (131) in the California region, and one (145) in the North Pacific middle latitudes.

There are 11 pump and 10 net samples, of which 4 were taken at the surface, 8 at 50 meters, and 9 at 100 meters. Maximum frequency, 28 per cent at station 159 at 50 meters; other records above minimum (2 to 5 per cent) from stations 81, 131, 140, 159, 160; average in net samples, 6.8 per cent.

Temperature: pump samples  $16^\circ 58$ - $28^\circ 50$  ( $24^\circ 86$ ), net samples  $12^\circ 12$ - $27^\circ 90$  ( $23^\circ 42$ ). Salinity: pump samples 34.18-35.82 (35.18), net samples 33.30-35.89 (35.31). Density: pump samples 22.62-25.36 (23.44), net samples 22.08-25.31 (23.67). pH: pump samples 7.96-8.34 (8.21), net samples 8.12-8.39 (8.27).

***Codonella amphorella* Biedermann**

(Figure 11)

*Codonella amphorella*, Kofoid and Campbell, 1929, p. 53, fig. 132.

The short, plump lorica, with convex collar, egg-shaped bowl, and short aboral horn, has a length of 1.8 oral diameters. The oral margin is smooth-edged and thin-lipped. The swollen collar has a length of 0.36 oral diameter, and a greatest diameter of 1.12 oral diameters just a little above its middle. The throat attains 0.96 oral diameter. There is an angular ( $82^\circ$ ), rather narrow internal ledge which reduces the aperture between collar and bowl to 0.84 oral diameter. The egg-shaped bowl reaches its greatest diameter of 1.13 oral diameters near 1.0 oral diameter below the rim, the wall rounding off from the collar convexly to that level. The lower bowl is full and convex, and is 0.68 oral diameter in length; the lateral wall tends toward flattening. The short aboral horn, of about 0.32 oral diameter, is conical ( $25^\circ$ ) and blunt at its free tip.

The wall is thin, hardly exceeding 0.04 oral diameter in the ledge and elsewhere much thinner. There is a single layer of large, elongated, subrectangular secondary prisms, including the ledge, where most species have several layers. The surface has a distal aggregate of large round fenestrae and otherwise is provided with rather small, crowded, interpolated subcircular areas. Coccoliths and rhabdolites are

frequent. The cavity of the bowl is cut off from that of the horn by a depressed diaphragm formed by the inner lamina. Rarely a second, thicker one is found about halfway down the horn. A convex closing apparatus may be present. The wall is not particularly dense.

Length, 88 $\mu$ .

There is some difference in wall structure in various individuals; a few are profusely packed with coccoliths, others have small prisms, and commonly there are large fenestrae. The aboral end is generally blunted, but in a few the tip is sharply pointed.

*Codonella amphorella* has a bowl shorter, blunter, and fuller than that of *C. recta* but not so wide as that of *C. rapa*. Its internal ledge is weaker than in these species, and its collar is more convex than that of *recta*, which is a cone.

Recorded from nine stations, five in the Atlantic and four in the Pacific, as follows: one (16) in the Gulf Stream, one (20) in the Sargasso Sea, three (22, 24, 30) in the Atlantic equatorial region, two (81, 95) in the region of South Pacific island fields, one (139) in the North Pacific trade region, and one (149) in the California region.

There are 2 pump and 7 net samples, of which 2 were taken at 50 meters and 7 at 100 meters. Frequencies, minimum.

Temperature: Atlantic, pump sample 19°62, net samples 15°55–27°88 (20°86); Pacific, 22°78 and 20°49–28°74 (25°21), respectively. Salinity: Atlantic, pump sample 36.48, net samples 35.61–36.73 (36.14); Pacific, 35.18 and 34.92–35.85 (35.37), respectively. Density: Atlantic, pump sample 26.01, net samples 23.26–26.34 (24.99); Pacific, 24.15 and 22.43–24.60 (23.53), respectively. pH: Atlantic, pump sample 8.17, net samples 7.96–8.30 (8.15); Pacific, 8.28 and 8.19–8.30 (8.23), respectively.

#### *Codonella apicata* Kofoid and Campbell

*Codonella apicata* Kofoid and Campbell, 1929, p. 53, fig. 116.

The short, stout, acorn-shaped lorica, with rounded collar, strong bowl, and faintly pointed aboral end, has a length of 1.75 oral diameters. The thin-edged oral margin is inturned and smooth. The rounded collar expands from the margin to a diameter of 1.15 oral diameters at 0.4 oral diameter below the rim, and then rapidly contracts to the neck, where the diameter is 0.95 oral diameter. The sides are full, and the angle (142°) at the swollen part is barely rounded off. The ovate bowl expands from the neck to a diameter of 1.35 oral diameters, which is reached near 0.62 total length below the rim. Below this level the bowl contracts rapidly to the decidedly convex-conical (90° to 125°) aboral region. The aboral end is bluntly to sharply pointed and less commonly cuspidate.

The wall averages about 0.05 oral diameter in thickness across the bowl and is much thinner in the upper collar. There is only a single layer of large, rectangular secondary prisms, except in the lower bowl, where two layers are found in some individuals. There is scarcely any nuchal ledge. The external surface is reticulated with coarse secondary polygons with rather thick walls; smaller polygons are sub-oral, and large "duplex" polygons are common postequatorially.

There is a conical closing apparatus.

Length, 52 to 94 $\mu$ .

The length is variable and doubtless reflects the relation between temperature and available material for lorication. The wall and the shape of the aboral end are among the more important variable characters. The "duplex" or tertiary structure is especially interesting.

*Codonella apicata* is smaller than *C. perforata* and has a less angular collar and distinctly different bowl. *Codonella tropica* and *C. cuspidata* have differently shaped collars, and *C. acerca* is less trim and also broader. Had it no collar, *C. dadayi* would be close to *apicata*.

Recorded from forty-five stations, thirteen in the Atlantic and thirty-two in the Pacific, as follows: two (2, 16) in the Gulf Stream, one (4) in the Atlantic drift, four (18, 19, 20, 20-21) in the Sargasso Sea, five (22, 23, 24, 25, 27) in the Atlantic equatorial region, one (31) in the Caribbean Sea, two (37, 153) in the Pacific equatorial region, six (41, 45, 77, 78, 79, 80) in the Galápagos region, four (57, 63, 65, 67) in the South Pacific middle latitudes, nine (81, 83, 84, 85, 87, 90, 92, 94, 95) in the region of South Pacific island fields, four (100, 101, 138, 151) in the North Pacific trade region, five (133, 135, 136, 137, 148) in the California region, and two (141, 144) in the North Pacific middle latitudes. *Codonella apicata* is widely distributed in the warmer regions and is lacking, save for chance drifting loricae, in cooler areas. Its absence from stations 6 to 13 and 118 to 125 is significant. It reaches its maximum near the tropics, where it may be expected in nearly any sample.

There are 34 pump and 29 net samples, of which 9 were taken at the surface, 31 at 50 meters, and 23 at 100 meters. This species apparently prefers deeper levels to the surface, but is not limited to any special level. Maximum frequency, 20 per cent at station 65; other records above minimum (2 to 7 per cent) from stations 4, 16, 20, 20-21, 22, 45, 63, 77, 78, 80, 81, 85, 136, 148; averages, 14.0 and 7.0 loricae in Atlantic and Pacific pump samples, and 19.0 and 5.0 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump samples 14°32–25°72 (21°74), net samples 14°60–27°53 (23°14); Pacific, 14°55–28°05 (23°38) and 15°03–28°74 (22°52), respectively. Salinity: Atlantic, pump samples 36.00–37.15 (36.49), net samples 35.22–38.81 (36.44); Pacific, 31.68–36.49 (35.12) and 34.30–36.98 (35.47), respectively. Density: Atlantic, pump samples 24.34–26.91 (25.38), net samples 23.84–26.62 (25.15); Pacific, 20.20–26.11 (23.77) and 22.43–25.45 (24.31), respectively. pH: Atlantic, pump samples 7.93–8.32 (8.18), net samples 8.15–8.27 (8.22); Pacific, 7.92–8.39 (8.27) and 8.01–8.39 (8.16), respectively.

#### *Codonella aspera* Kofoid and Campbell

*Codonella aspera* Kofoid and Campbell, 1929, pp. 55–56, fig. 101.

*Codonella galea*, Hofker (part), 1931, pp. 352–354, figs. 26, 28 (see also *C. galea*).

*Petalotricha galea*, Haeckel, 1899, pl. 3, fig. 6.

The stout, ovoid lorica, with flaring collar, rotund ovate bowl, and broadly rounded aboral end, has a length of 1.57

oral diameters. The thin-edged, entire oral rim is surrounded by a narrow hyaline band. The collar is an inverted segment of a cone ( $35^\circ$ ) with a length of nearly 0.41 oral diameter, and with a similar diameter at the lower end; the sides are slightly convex in the middle. The ovate bowl expands rapidly from the neck, reaches 1.07 oral diameters at its middle, and then slowly contracts to the blunted, but broad, subrotund aboral end.

The wall is thickened in the bowl to 0.05 oral diameter, but lessens in the fundus and is much thinner in the collar. There are single, or rarely double, layers of large, coarse tertiary structures. The collar is almost transparent, and the bowl is decidedly dense. The outer surface has large, crudely formed polygons of various shapes and sizes, and almost invariably there are large blobs of alveolar material adherent on the surface, especially in the equatorial region of the bowl.

Length, 85 to 90 $\mu$ .

*Codonella aspera* is variable in the shape of the aboral end and in the extent to which adherent matter is found on the surface.

*Codonella aspera* has a more rotund, less trim bowl than *C. elongata* and has coarse adherent matter that *elongata* lacks; its aboral end is less pointed and its collar has lateral convexity. *Codonella grahami*, a close relative of *aspera*, lacks surface blobs, has a less rounded bowl, and has less irregular prismatic structure in the wall. *Codonella aspera* is a species of warmer latitudes than *grahami*, although not tropical.

Recorded from four stations in the Pacific, as follows: one (128) in the North Pacific middle latitudes, and three (130, 131, 132) in the California region.

There are 2 net and 4 pump samples, of which 4 were taken at 50 meters and 2 at 100 meters. Maximum frequency, 99 per cent at station 128 at 100 meters; two other records above minimum (12 and 14 per cent) from same station at 50 and 100 meters respectively; averages, 50 per cent and 7 loricae, respectively, in net and pump samples.

Temperature: net samples  $10^\circ 23$ – $13^\circ 98$  ( $12^\circ 10$ ), pump samples  $10^\circ 23$ – $18^\circ 38$  ( $13^\circ 35$ ). Salinity: net samples 33.14–33.24 (33.19), pump samples 33.07–33.89 (33.37). Density: net samples 25.00–25.48 (25.24), pump samples 24.35–25.48 (25.37). pH: net samples 8.06–8.39 (8.22), pump samples 8.06–8.33 (8.18).

#### *Codonella diomedae* Kofoid and Campbell

*Codonella diomedae* Kofoid and Campbell, 1929, p. 59, fig. 118.

The large lorica, with convex, swollen collar, elongated, saccular bowl, and slightly flattened aboral end, has a length of 2.17 oral diameters. The oral margin is thin and entire. There is a low (0.1 oral diameter), hyaline ring around the opening. The convex, suborally inturred collar expands rapidly from the rim, and reaches 1.15 oral diameters at 0.33 oral diameter below the rim; the lower two-thirds contracts to the neck, the diameter of which is equal to that of the oral opening. The sides are full, and the angle ( $135^\circ$ ) is clearly rounded. The long bowl expands below the throat to about 1.15 oral diameters at 0.31 oral diameter below the throat, becomes 1.23 oral diameters near the equator, and then slowly

contracts in the posterior region to the aboral end. The aboral end is nearly flat (about 0.78 oral diameter in diameter); commonly it is just rounded off.

The wall is 0.05 oral diameter in thickness across the bowl and thinner in the collar. There are only single layers of large, rectangular secondary polygons. The external surface has fine reticulations with small polygons, and rarely "duplex" areas.

Length, 105 to 127 $\mu$ .

*Codonella diomedae* resembles *C. galea* in general form. It differs, however, in the swollen bowl and the usual flat aboral end. These characters serve pretty much to distinguish it from all the other species.

Recorded from sixteen stations in the Pacific, as follows: four (41, 45, 47, 69) in the Galápagos region, three (62-63, 65, 67) in the South Pacific middle latitudes, one (85) in the region of South Pacific island fields, one (109) in the North Pacific trade region, four (134, 146, 147, 148) in the California region, one (144) in the North Pacific middle latitudes, and two (152, 153) in the Pacific equatorial region.

There are 6 pump and 11 net samples, of which 4 were taken at the surface, 3 at 50 meters, and 10 at 100 meters. Maximum frequency, 6 per cent at stations 65, 67; other records above minimum (2 to 3 per cent) from stations 109, 144, 147, 152; average in net samples, 2.5 per cent.

Temperature: pump samples  $17^\circ 46$ – $22^\circ 73$  ( $21^\circ 28$ ), net samples  $11^\circ 48$ – $27^\circ 89$  ( $19^\circ 43$ ). Salinity: pump samples 34.57–36.02 (35.06), net samples 34.19–36.24 (34.92). Density: pump samples 23.83–25.11 (24.46), net samples 23.38–26.50 (24.79). pH: pump samples 8.12–8.37 (8.24), net samples 7.76–8.29 (8.13).

#### *Codonella elongata* Kofoid and Campbell

(Figure 18)

*Codonella elongata* Kofoid and Campbell, 1929, pp. 59–60, fig. 102.

The tall lorica, with funnel-shaped collar, long, rather narrow bowl, and narrowed aboral end, has a length of 1.6 oral diameters. The thin-edged oral margin is entire and sharp. There is a narrow, hyaline cuff below the margin with a width of 0.02 oral diameter. The flaring, inverted, plane, funnel-shaped collar ( $38^\circ$ ) has a length of nearly 0.37 oral diameter, and a diameter at the neck of 0.75 oral diameter. Just above the neck there is a narrow (0.07 oral diameter) locally constricted region. The elongated, ovoid bowl expands from the neck to 1.1 oral diameters at 0.4 its own length. The sides are somewhat flattened in the equatorial region, and above and below. The aboral two-fifths is plainly convex conical ( $90^\circ$ ), and the aboral end is narrowly rounded without distal prolongation.

The wall is 0.05 oral diameter in thickness in the equatorial region and gradually thins in the collar. There is a single layer of large, rectangular prisms. The exterior has thick-walled secondary polygons, and also in some loricae an equatorial band of circular tertiary ones of two sizes.

Length, 85 to 117 $\mu$ .

The *Carnegie* loricae are broader-bowled and less trim

than is typical, and have occasional tertiary wall structure.

*Codonella elongata* differs from its close relative *C. galea* in the more elongated bowl and more nearly pointed aboral end. The collar is less convex than that of *C. aspera*, as well as more regularly contoured and more pointed distally. The bowl is not so broad as that of *C. tropica*, and the collar is not swollen as in the longer *C. diomedae*.

Recorded from ten stations, seven in the Atlantic and three in the Pacific, as follows: four (17, 18, 19, 20) in the Sargasso Sea, three (22, 23, 24) in the Atlantic equatorial region, one (68) in the Galápagos region, one (115) in the North Pacific middle latitudes, and one (131) in the California region.

There are 4 pump and 15 net samples, of which 1 was taken at the surface, 8 at 50 meters, and 10 at 100 meters. Maximum frequency, 25 per cent at station 115; other records above minimum (2 to 12 per cent) from stations 18, 19, 20, 22, 24, 131; average in Pacific net samples, 10 per cent; other averages, 1.2 to 3.6 per cent.

Temperature: Atlantic, pump samples 20°32–25°72 (23°39), net samples 14°60–26°63 (20°30); Pacific, net samples 12°12–16°56 (14°84). Salinity: Atlantic, pump samples 36.60–37.15 (36.79), net samples 35.61–38.60 (36.11); Pacific, net samples 33.36–34.85 (34.27). Density: Atlantic, pump samples 24.34–26.07 (25.22), net samples 24.35–26.62 (25.45); Pacific, net samples 25.31–25.52 (25.39). pH: Atlantic, pump samples 8.21–8.27 (8.24), net samples 7.93–8.34 (8.18); Pacific, net samples 8.10–8.24 (8.15).

#### *Codonella galea* Haeckel

(Figures 14, 17)

*Codonella galea*, Kofoid and Campbell, 1929, p. 60, fig. 106; Hofker (part), 1931, pp. 352–354, fig. 27 (see also *C. aspera*). Not *Petalotricha galea*, Haeckel, 1899, pl. 3, fig. 6 (see *C. aspera*).

The moderately tall lorica, with funnel-like collar, gently constricted throat, ovate bowl, and broadly rounded aboral end, has a length of 1.41 to 1.57 oral diameters. The thin, smooth oral margin is sharp-edged. The collar is an inverted funnel (25° to 43°), sometimes with convex sides, and with a length of 0.32 to 0.38 oral diameter. The diameter at the neck is 0.80 to 0.88 oral diameter. The rather short, rotund bowl expands evenly from the throat, reaches a little over 1.0 oral diameter at its middle, and then evenly rounds off to the broadly rounded to somewhat flattened aboral end.

The thin wall averages 0.05 oral diameter at the equator of the bowl and thins to half as much in the collar. Only a single layer of rectangular prisms occurs (rarely two). The surface has large polygons with rare larger circular ones which enclose several of the smaller. The lorica figured (fig. 14) has a large alveolar blob on the bowl. The collar is hyaline and the bowl dense.

A conical closing apparatus and sac enclose the whole body. There are 8 macronuclei, about 12 to 18 membranelles, and a powerful ciliary membrane.

Length, 78 to 120 $\mu$ .

Like many other widely distributed species, *Codonella*

*galea* varies in most characters, as a survey of the literature clearly shows. For this reason several names have been applied to *galea* (for summary see Kofoid and Campbell, 1929). Most of Hofker's (1931) material belongs to *C. aspera*, but his figure 27 is of *galea*.

*Codonella galea* differs from *C. nationalis* in being taller, with a less stout bowl and a more flaring collar. Other related species, e.g. *C. elongata*, *tropica*, *cuspidata*, *robusta*, and *aspera*, differ mainly in the shape of the aboral region or have different collars.

Recorded from thirty-three stations, twelve in the Atlantic and twenty-one in the Pacific, as follows: two (14, 16) in the Gulf Stream, three (18, 19, 20) in the Sargasso Sea, six (22, 23, 25, 26, 27, 28) in the Atlantic equatorial region, one (33) in the Caribbean Sea, six (40, 45, 46, 71, 77, 78) in the Galápagos region, two (54, 65) in the South Pacific middle latitudes, two (82, 85) in the region of South Pacific island fields, three (100, 140, 151) in the North Pacific trade region, five (130, 135, 137, 147, 148) in the California region, two (142, 145) in the North Pacific middle latitudes, and one (153) in the Pacific equatorial region.

There are 21 pump and 27 net samples, of which 5 were taken at the surface, 21 at 50 meters, and 22 at 100 meters. This species appears to be subsurface by preference. Maximum frequency, 6 per cent at stations 137, 147; other records above minimum (2 to 5 per cent) from stations 14, 16, 18, 23, 25, 26, 45, 46, 54, 77, 130, 145, 148, 151, 153; average in Pacific net samples, 3.3 per cent; other averages, 1.6 to 2.2 per cent.

Temperature: Atlantic, pump samples 14°95–24°10 (20°21), net samples 14°60–26°04 (21°68); Pacific, 16°96–27°62 (23°17) and 12°91–24°84 (20°59), respectively. Salinity: Atlantic, pump samples 35.10–36.81 (36.01), net samples 35.70–38.18 (36.33); Pacific, 33.70–36.46 (35.34) and 33.40–36.04 (34.92), respectively. Density: Atlantic, pump samples 24.49–26.08 (25.44), net samples 23.98–26.62 (25.30); Pacific, 22.31–25.14 (24.56) and 23.50–25.37 (24.52), respectively. pH: Atlantic, pump samples 8.18–8.22 (8.21), net samples 7.93–8.27 (8.19); Pacific, 8:10–8.34 (8.22) and 8.12–8.34 (8.22), respectively.

#### *Codonella grahami*, new species

(Plate 1, figure 6)

The lorica is moderately elongated, and pointed. It has a length of 2.06 oral diameters. The oral rim is smooth and slightly rounded. The collar is the basal segment of an inverted truncated cone (27°); its length is 0.52 oral diameter, and the diameter at the aboral end, which forms the constricted neck, is 0.87 oral diameter. The sides of the collar are regular and smooth and there is little, if any, median bulge. The bowl as a whole is elongated, and olive-like in shape. Its suboral part, which joins with the neck, is a rounded segment of a cone (about 45°), and the basal section is the level of the greatest diameter of the bowl, 1.13 oral diameters, reached near 0.45 total length from the rim. The lower part of the bowl is an inverted cone (53°) with full, curved sides. The aboral end is pointed but not pro-

longed or pedicellated. The sides of the lorica form, in side view, a sigmoid flexure with the lower arm prolonged.

The wall is subuniform in thickness at all levels and approximately 0.01 oral diameter in thickness. There is a slight thickening at the neck. The wall is coarsely and irregularly prismatic, with large, ovoid tertiary structure and enclosed secondary prisms. The tertiary prisms are largest at the ambitus of the bowl and smaller elsewhere, especially in the collar; the thin oral rim is hyaline. The lumen, except for the nuchal thickening, follows the outer contour.

Length, total 87 $\mu$ , collar 18 $\mu$ ; diameter, oral 37 $\mu$ , maximum 53 $\mu$ .

*Codonella grahami* is rather uniform in its general characters, and the many loricae examined were much alike. The surface meshwork, however, is very variable in the sizes and shapes of the prisms; these may be hexagons, pentagons, or subcircles.

*Codonella grahami* resembles *C. elongata* in general form, but the aboral end is distinctly pointed instead of evenly rounded. It never has coccoliths, which *elongata* often has. It bears some likeness to *C. aspera*, but that species has a more rounded bowl, a rotund aboral end, and a coarser and more irregular prismatic structure; it often includes blobs of alveolar material in its walls, and *grahami* consistently lacks these. The latter is much narrower and thinner than *C. acuta*, although both species are aborally pointed; the bowl of *acuta* reaches its maximum at a lower level than does that of *grahami*, and it frequently has many large coccoliths, which are lacking in *grahami*. *Codonella grahami* also comes from generally cooler waters than do most others of the genus.

Recorded from five stations in the Pacific, as follows: four (111, 115, 116, 117) in the North Pacific middle latitudes, and one (118) in the East Asiatic marginal sea.

There are 5 pump and 2 net samples, of which 1 was taken at the surface, 4 at 50 meters, and 2 at 100 meters. Maximum frequency, 6 per cent at stations 111, 117; one other record above minimum (4 per cent), from station 117; remainder at minimum; averages, 5 per cent and 2 loricae in net and pump samples, respectively.

Temperature: net samples 8°93–15°56 (12°74), pump samples 9°77–19°39 (13°55). Salinity: net samples 34.06–34.22 (34.14), pump samples 33.61–34.63 (34.23). Density: net samples 25.89–26.41 (26.15), pump samples 24.62–26.27 (25.62). pH: net samples 7.98–8.06 (8.02), pump samples 8.02–8.21 (8.09).

Type locality, station 117, at 100 meters; latitude 40° 20' north, longitude 150° 58' east.

#### *Codonella nationalis* Brandt

*Codonella nationalis*, Kofoid and Campbell, 1929, p. 63, fig. 107; Hofker, 1931, pp. 356–357, fig. 30.

The short, rather stout, potlike lorica, with fairly regular rim, rotund collar, squat bowl, and broad aboral end, has a length of 1.35 oral diameters. The oral margin is thin-edged, minutely but highly regularly denticulate, and located above a variable hyaline band with a width of approximately 0.03 oral diameter. The collar is a segment of an inverted

funnel (within 10°), and the diameter at the neck is 0.89 oral diameter. A bare nuchal ledge is present. The plump bowl expands from the neck and reaches its maximum diameter of 1.08 oral diameters at the laterally flattened equator. The bowl gently contracts, reaching 0.93 oral diameter at 0.83 total length below the rim, and then rapidly rounds off aborally.

The wall averages 0.04 oral diameter in thickness in the bowl and thins out in the collar. There are two layers of large, irregular, rectangular to pentagonal secondary polygons; primary alveoles are enclosed by them. The external surface has a network of coarse polygons and enclosed smaller ones.

Length, 77 to 117 $\mu$ .

*Codonella nationalis* resembles *C. inflata* but is more trim, with greater nuchal constriction, less wide bowl, and flatter aboral end. *Codonella tropica* and *C. cuspidata* have pointed aboral ends, as does also the much smaller *C. acerca*.

Recorded from ten stations, five each in the Atlantic and Pacific, as follows: four (17, 18, 19, 20) in the Sargasso Sea, one (28) in the Atlantic equatorial region, two (78, 80) in the Galápagos region, two (81, 85) in the region of South Pacific island fields, and one (150) in the North Pacific trade region.

Net samples only, 11 in all, 6 taken at 50 meters and 5 at 100 meters. Maximum frequency, 7 per cent at station 81; other records above minimum (2 to 5 per cent) from stations 17, 18, 19, 78, 80, 85, 150; averages, 2.2 and 4.4 per cent, the latter in the Pacific.

Temperature: Atlantic, 19°82–25°31 (22°58); Pacific, 19°27–27°89 (24°80). Salinity: Atlantic, 36.60–37.15 (36.83); Pacific, 34.63–36.24 (35.74). Density: Atlantic, 24.89–26.05 (25.44); Pacific, 23.38–24.68 (23.94). pH: Atlantic, 8.19–8.27 (8.23); Pacific, 8.14–8.32 (8.21).

#### *Codonella olla* Kofoid and Campbell

(Figures 15, 16)

*Codonella olla* Kofoid and Campbell, 1929, pp. 63–64, fig. 115.

The decidedly potlike, squat lorica, with widely expanded and flattened aboral end, has a length of 1.4 oral diameters. The oral margin is coarsely undulating and minutely irregular, thin, and inturned. The collar bulges; its length is a trifle less than 0.33 oral diameter, with the same diameter at the throat as at the upper end, but the bulge in the middle is 1.1 oral diameters. There is a scarcely developed, angular (80°) internal ledge at the throat, which reduces the diameter of the opening there to 0.83 oral diameter. The bowl swells from the neck to a diameter of 1.33 oral diameters at 0.67 total length from the rim. Below this level, it gradually contracts to the nearly flat aboral end, the diameter of which is 0.67 oral diameter.

The thin wall (which reaches, however, nearly 0.09 oral diameter in thickness across the ledge) is not over 0.02 oral diameter in the bowl. There are single to triple layers of subrectangular, hyaline secondary prisms. Over the whole surface are large, subcircular, clear fenestrae between which are rather faint smaller circles or alveoles.

Length, 75 to 90 $\mu$ .

One of the loricae figured (fig. 16) is unusual. Its length is 1.53 oral diameters. Its bowl is distinctly elongated and reaches its greatest diameter at little above the flat distal end, and its whole surface is studded with elongated rhabdoliths. It is 90 $\mu$  in length. The oral rim is entire.

*Codonella olla* resembles *C. poculum* closely, but differs in the expanded and flattened aboral end. Its internal shelf is less developed, there is constriction at the throat, and its collar bulges. Its aboral end is flat, unlike that of *C. acerca*, which is pointed.

Recorded from three stations in the Atlantic, as follows: two (19, 20) in the Sargasso Sea, and one (27) in the Atlantic equatorial region.

Net samples only, of which 1 was taken at 50 meters and 2 at 100 meters. Maximum frequency, 2 per cent at station 27.

Temperature, 22.42–26.04 (23.70); salinity, 36.25–37.03 (36.71); density, 23.98–25.67 (25.01); pH, 8.19–8.30 (8.24).

#### *Codonella poculum* Kofoid and Campbell

*Codonella poculum* Kofoid and Campbell, 1929, p. 64, fig. 114.

The distinctly stout, pot-shaped lorica, with collar undifferentiated except by an internal ledge and with rounded bowl, has a length of 1.1 oral diameters. The oral margin is regularly denticulate, there being approximately 50 low, wide, equidistant, regular, triangular teeth. These hyaline teeth arise from a narrow, similar band, the width of which is less than 0.2 oral diameter. The collar is distinguished only by the internal ledge or shelf located near 0.3 oral diameter below the rim. The collar is virtually a cylinder with only minor, strictly local modifications in external contour. The internal shelf is triangular (75°) and, because of its width, reduces the opening between collar and bowl to 0.73 oral diameter; its base, against the outer wall, is 0.16 oral diameter in width. The bowl continues the subcylindrical form of the collar for 0.71 total length with a few local irregularities, and has a diameter at this level of 0.95 oral diameter. The aboral region rapidly rounds off so that the thimble-shaped end is 0.29 total length below the level of the cylindrical upper section.

The relatively thick wall reaches, in the mid-region of the bowl, as much as 0.05 oral diameter; in the collar it is about half as much. There are one to five layers of faint, rounded to rectangular secondary prisms as well as a lesser number of much larger tertiary ones. The outer surface shows these prisms in circular shapes.

There is a strong closing apparatus.

Length, 80 to 92 $\mu$ .

*Codonella poculum* closely resembles *C. acutula*, but its aboral end is rounded instead of pointed as in *acutula*. It lacks the nuchal constriction which is found in *C. olla*. The aboral end is less flattened, not expanded, and the wall is different in these two species. *Codonella acerca*, aside from its smaller size, has a pointed aboral end and also nuchal constriction.

Recorded from four stations in the Pacific, as follows: one

(99) in the Pacific equatorial region, two (101, 150) in the North Pacific trade region, and one (148) in the California region.

Pump samples only, of which 1 was taken at the surface, 1 at 50 meters, and 2 at 100 meters. Frequency, minimum.

Temperature, 19.27–27.93 (23.38); salinity, 34.63–34.94 (34.81); density, 22.39–24.72 (24.14); pH, 8.21–8.32 (8.25).

#### *Codonella rapa* Kofoid and Campbell

(Figure 10)

*Codonella rapa* Kofoid and Campbell, 1929, p. 65, fig. 130.

The short, stout, deep-throated lorica, with swollen collar, plump bowl, and small conical aboral horn, has a length of 1.74 oral diameters. The minutely subdenticulate, rather regular oral margin is thin-edged. The short, bulging collar has a length of 0.43 oral diameter; its diameter across the middle is 1.09, and at the throat 0.95 oral diameter. Inside the throat is an angular (80°), rather wide shelf that reduces the aperture to 0.73 the external diameter. The swollen bowl is rotund, reaches its greatest diameter of 1.1 oral diameters near 1.0 oral diameter below the oral rim, and then rather gradually narrows down to the aboral end, where there is a conical (34°) aboral horn (0.26 oral diameter in length) with widely flaring (80°) base and sharply pointed free tip.

The wall is thickest in the upper bowl, where it may attain 0.08 oral diameter, is reduced gradually in the collar and fundus to less than 0.02 oral diameter, and contains, mostly, only a single layer of large, rectangular prisms. The surface shows small hexagonal to circular prisms (primary?), and often each of the large secondary areas has a large coccolith enclosed in it. The aboral horn is hollow, but its cavity is cut off from that of the bowl by a thin-walled diaphragm formed of the inner lamina.

Length, 78 $\mu$ .

The *Carnegie* loricae are not so stout as those described by Kofoid and Campbell (1929).

*Codonella rapa* has a more flaring collar, shorter bowl, and stouter horn than *C. recta*. *Codonella amphorella* has a longer bowl with less rotundity. These three attractive species of the high latitudes can scarcely be confused with others of the tropical oceans.

Recorded from two stations (62-63, 64) in the South Pacific middle latitudes.

Net samples only, 1 taken at the surface and 1 at 1000 meters. There were 2 loricae.

Temperature (at 1000 meters) 3.98; salinity, 34.30; density, 27.25; pH, 7.76.

#### *Codonella recta* Kofoid and Campbell

*Codonella recta* Kofoid and Campbell, 1929, p. 65, fig. 131.

The stout lorica, with shallow throat, erect collar, and stout horn, has a length of 1.78 oral diameters. The oral margin is very thin, erect, and entire. The collar is subconical (10°) with a length of 0.4 oral diameter; its lower diameter is only a little less than the oral diameter, and the



slightly developed, angular ( $70^\circ$ ) internal ledge reduces the aperture between collar and bowl to 0.87 oral diameter. Its sides are practically plane except that they rather suddenly bend inward a little just above the throat. The ellipsoidal bowl has a maximum diameter of 1.1 oral diameters slightly below its middle. Below this level it gradually contracts to the aboral horn. The horn has a wide, asymmetrical conical ( $50^\circ$ ) base and narrower conical ( $10^\circ$ ) stem. Its free tip is blunted.

The wall is very thin, being not over 0.02 oral diameter in thickness in the bowl. There is a single or double layer of narrow, subrectangular to irregular secondary prisms, within which are closely packed primary alveoles. The collar has large subcircular fenestrae which gradually merge in the bowl with smaller circles. These circular structures have thick walls in which minute alveoles are present. The lumen of the horn is cut off from that of the bowl by a depressed diaphragm. The wall is dense.

Length, 95 $\mu$ .

*Codonella recta* has a conical collar which lacks the bulge of that of *C. amphorella* or *C. rapa*. The bowl is less rotund and there is much less constriction at the throat than in either of the above two species.

Recorded from one station (154) in the Pacific equatorial region, in a net sample taken at 100 meters. Frequency, 2 per cent.

Temperature, 25.81; salinity, 34.82; density, 22.98; pH, 7.93.

#### *Codonella tropica* Kofoid and Campbell

*Codonella tropica* Kofoid and Campbell, 1929, p. 67, fig. 110.

The stout, ovate lorica, with bulging collar, wide bowl, and simple, pointed aboral end, has a length of 1.34 oral diameters. The thin-edged oral margin is entire, and below it is a narrow, hyaline cuff, the width of which is about 0.1 oral diameter or less. The convex collar expands from the rim to 1.08 oral diameters near its middle and then somewhat more rapidly contracts to 0.92 oral diameter at the neck. The collar has a length of nearly 0.42 oral diameter. The stout, short bowl expands from the throat and reaches 1.16 oral diameters at 0.66 oral diameter below the rim. Below this widest level it rapidly contracts, with full, convex sides, to the pointed end, which bears a minute, extended point.

The wall reaches approximately 0.05 oral diameter in thickness in the bowl and is thinner in the collar. There is a single layer of large, rectangular prisms. The exterior meshwork is made up of small, subcircular polygons, everywhere of uniform size.

Length, 77 $\mu$ .

*Codonella tropica* is stouter, with less constricted throat, shorter bowl, and more pointed end than *C. acuta*. The wall of the latter also bears large coccoliths. *Codonella cuspidata* is close to *tropica*, but less wide and hence more slender; it has a larger collar with greater nuchal constriction.

Recorded from twelve stations in the Pacific, as follows: one (77) in the Galápagos region, four (81, 82, 84, 95) in the region of South Pacific island fields, two (112, 113) in

the North Pacific middle latitudes, one (151) in the North Pacific trade region, three (152, 153, 154) in the Pacific equatorial region, and one (146) in the California region.

There were 2 pump and 11 net samples, of which 1 was taken at the surface, 5 at 50 meters, and 7 at 100 meters. Maximum frequency, 6 per cent at stations 153, 154; other records above minimum (2 to 3 per cent) from stations 81, 146, 152.

Temperature: pump samples 20.16–23.77 (21.96), net samples 11.48–28.74 (22.92). Salinity: pump samples 34.59–34.71 (34.65), net samples 34.32–36.42 (35.22). Density: pump samples 23.42–24.52 (23.97), net samples 22.43–26.50 (24.06). pH: pump samples 8.20–8.25 (8.22), net samples 7.76–8.28 (8.14).

#### CODONARIA Kofoid and Campbell

*Codonaria* Kofoid and Campbell, 1939, p. 55.

The genus *Codonaria* includes a number of species from the warmer parts of the sea. They have clearly been derived from *Codonella*. Nearly all are inhabitants of the open ocean or of the Mediterranean. They are rare in the Southern Hemisphere save near the equator.

Six species are described.

#### *Codonaria angusta* Kofoid and Campbell

*Codonella angusta* Kofoid and Campbell, 1929, p. 53, fig. 117.

The rotund lorica, with tall, convex collar, deep throat, and distally inflated bowl, has a length of 1.56 oral diameters. The thin, smooth oral margin arises from a hyaline cuff only 0.04 oral diameter in width. The inflated collar is subcylindrical, with a length of 0.32 total length, with its greatest diameter of 1.11 oral diameters at 0.67 of its length from the upper end, and with the barely developed flangelike ledge at 0.18 oral diameter below the rim; this narrow ledge scarcely projects beyond the collar, and is sharply angular ( $32^\circ$ ). The constricted neck of the bowl has a diameter of 0.98 oral diameter. The rotund bowl expands rapidly from the throat, reaches 1.21 oral diameters near 0.6 total length from the rim, and then contracts sharply to the nearly flattened aboral end (0.65 oral diameter), which lacks any trace of special differentiation.

The wall of the bowl is nearly 0.06 oral diameter in thickness, that of the internal ledge is twice as much, and in the collar the wall rapidly declines to one-tenth as much. There are one to three layers of thick-walled, irregular, elongate, alveole-like secondary prisms. The truncate, subtriangular internal ledge at the junction of collar and bowl reduces the cavity to 0.83 the external diameter. The exterior surface has large and small, rather faint subpentagonal to subhexagonal meshes.

Length, 80 to 98 $\mu$ .

*Codonaria angusta* may be distinguished by the narrow external and thick internal ledges, the laterally convex collar, and the swollen, flattened bowl. In a few respects it is transitional between *Codonella diomedae* and *Codonaria cistellula*.

Recorded from one station (19) in the Sargasso Sea,

in a net sample taken at 50 meters. Frequency, minimum.

Temperature, 25°31; salinity, 37.15; density, 24.89; pH, 8.27.

*Codonaria benguelensis* Kofoid and Campbell

*Codonella benguelensis* Kofoid and Campbell, 1929, p. 57, fig. 121.

The stout, potlike lorica, with tall suboral cone and collar, and plump bowl, has a length of 1.56 oral diameters. The very thin, irregular oral margin has a cuff about 0.12 oral diameter in length below it. The suboral cone (50°) with laterally concave sides has a length of nearly 0.15 oral diameter, and a diameter of 1.1 oral diameters at its lower end. The suboral ledge is separated from it by an angular (60°) trough. The thick, slightly wavy, shelflike ledge has a diameter of 1.22 oral diameters, and its thickness reaches 0.07 oral diameter. The collar is an inverted basal segment of a truncated cone (17°) with a length of nearly 0.5 oral diameter, and a diameter of a trifle more than 1.0 oral diameter at its lower end. The suboral cone and the collar together give the upper region of the lorica a decidedly convex form. The rotund, rather squat bowl reaches its greatest diameter of 1.17 oral diameters at 1.0 oral diameter below the rim, below which level it gradually rounds off to the blunt, subhemispherical aboral end.

The wall is thickest in the collar and bowl, where it is less than 0.06 oral diameter. A single layer of large, thick-walled, rectangular secondary prisms is everywhere present save in the internal ledge, where there are two layers. The cuff is hyaline, the suboral cone and collar and the ledge have moderately large, thick-walled hexagons, and the bowl has very large "duplex" circular fenestrae in a wide equatorial band. The internal angular ledge at the junction of collar and bowl reduces the aperture between them to 0.85 oral diameter.

Length, 80 to 88 $\mu$ .

*Codonaria angusta* has a more convex suboral section less sharply distinguishable into cone and collar, and also a thinner, less evident ledge than does *C. benguelensis*. The former, too, lacks duplex structure, and its bowl is not particularly similar. *Codonaria oceanica* has a wider bowl and lower suboral region.

Recorded from one station (100) in the North Pacific trade region, in a net sample taken at 50 meters. Only 1 lorica was present.

Temperature, 27°67; salinity, 34.71; density, 22.31; pH, 8.22.

*Codonaria cistellula* (Fol) Kofoid and Campbell

*Codonella cistellula*, Kofoid and Campbell, 1929, p. 57, fig. 125; Hofker, 1931, pp. 354-356, fig. 29.

The rather elongate, tall lorica, with flaring collar, modestly inflated bowl, and pointed aboral end, has a length of 2.0 oral diameters. The minutely subdenticulate oral margin is thin and there is a low cuff below the rim. The suboral cone is a slightly concave basal segment of a cone (25°) with a length of only 0.11 oral diameter, and with a basal diameter of 1.26 oral diameters. It is separated from the upper

edge of the collar by a shallow, subangular trough. The ledge is the smooth, free upper edge of the collar, the diameter of which is 1.39 oral diameters. The collar is an inverted truncated basal segment of a plane to barely convex cone (45°) with a length of 0.62 oral diameter and a diameter at the neck of 1.0 oral diameter. The bowl rounds off and reaches its greatest diameter at 0.65 total length below the margin; this maximum is 1.57 oral diameters (only a little less than the length of the whole lorica). The wall quickly and convexly rounds to the sharp but not prolonged aboral end, which is 0.7 oral diameter below the level of the maximum diameter.

The wall is thickest in the lower collar and upper bowl, where it reaches almost 0.09 oral diameter. It thins out in the suboral cone and toward the aboral end to about 0.06. There are one to four, mostly two to three, layers of subhexagonal, thick-walled secondary prisms. The walls of these prisms, under the best magnification, show primary alveoles in one or two layers. The cuff is hyaline, but the remainder of the surface has large, fairly heavy subrectangular to subhexagonal meshes. Large "simplex" fenestrae are scattered over collar and bowl, mostly around the equator. There is a conical closing apparatus of 12 truncated triangular blades and a somatic enclosing sac. There are 12 or more membranelles, and 16 macronuclei.

Length, 90 to 125 $\mu$ .

*Codonaria cistellula* is taller and longer than the other species. Its bowl is less inflated, its aboral end less sharply pointed, and its maximum inflation lower than in others. It is not easily confused with them, the aboral characters in general serving to distinguish it. Had it no suboral cone it might be confused with *Codonella diomedae*, which, however, is a different form.

Recorded from eight stations, three in the Atlantic and five in the Pacific, as follows: two (17, 18) in the Sargasso Sea, one (22) in the Atlantic equatorial region, two (69, 75) in the Galápagos region, two (111, 145) in the North Pacific middle latitudes, and one (146) in the California region.

There are 2 pump and 6 net samples, of which 1 was taken at the surface, 3 at 50 meters, and 4 at 100 meters. Frequency above minimum (2 to 3 per cent) at stations 18, 69, 145, 146.

Temperature: Atlantic, net samples 17°50-21°85 (19°89); Pacific, pump samples 19°39-21°13 (20°26), net samples 18°40-20°07 (19°21). Salinity: Atlantic, net samples 36.60-36.81 (36.70); Pacific, pump samples 34.58-35.24 (34.91), net samples 34.32-35.47 (34.70). Density: Atlantic, net samples 25.49-26.07 (25.78); Pacific, pump samples 24.62-24.66 (24.64), net samples 24.24-25.55 (24.89). pH: Atlantic, net samples 8.21-8.27 (8.24); Pacific, 1 pump sample 8.12, net samples 8.10-8.34 (8.23).

*Codonaria lata* Kofoid and Campbell

(Figure 12)

*Codonella lata* Kofoid and Campbell, 1929, p. 62, fig. 126.

The stout, small lorica, with flaring collar, rotund bowl, and flattened aboral region, has a length of 1.47 oral diam-

eters. The thin oral margin is subdenticulate and enclosed by an exceedingly low (0.11 oral diameter), subcylindrical suboral cuff. The suboral ledge has a diameter of 1.13 oral diameters and is separated from the cuff by a concave-angular trough. The rather long, inverted-conical ( $34^\circ$ ) collar, with plane sides, has a length of little more than 0.4 oral diameter, and a diameter at the constricted throat of over 0.87 oral diameter. The subglobose bowl reaches its greatest diameter of 1.13 oral diameters near 1.0 oral diameter below the rim; from that level to the aboral end is about 0.53 oral diameter. The aboral end is flattened and has a diameter of nearly 0.5 oral diameter.

The wall has a thickness of nearly 0.05 oral diameter except in the cuff, where it is less than half as much. There are one to three layers of irregular secondary prisms. The outer surface has small subcircular reticulations which crowd in the ledge and near the aboral end. There is an equatorial and southern temperate band of subequal circular fenestrae around the bowl.

Length, 78 to 90 $\mu$ .

The *Carnegie* loricae tend toward aboral flattening, flat sides, and steeply pitched flare in the collar.

*Codonaria lata* is longer than *C. australis* and has a flatter aboral end. Its bowl is not so long as that of *C. benguelensis* or so wide as that of *C. oceanica*. There is no trace of the aboral point which distinguishes *C. mucronata*, *dadayi*, or *cistellula*. The collar lacks the submedian bulge that characterizes *C. angusta*.

Recorded from six stations, two in the Atlantic and four in the Pacific, as follows: one (19) in the Sargasso Sea, one (28) in the Atlantic equatorial region, one (78) in the Galápagos region, one (113) in the North Pacific middle latitudes, one (109) in the North Pacific trade region, and one (146) in the California region.

There are 7 net samples, of which 3 were taken at 50 meters and 4 at 100 meters. Maximum frequency, 8 per cent at station 113; other records above minimum (2 to 3 per cent) from stations 78, 109; average in the Pacific, 3.2 per cent.

Temperature: Atlantic, 25°31–27°57 (26°44); Pacific, 19°81–24°38 (21°92). Salinity: Atlantic, 36.24–37.15 (36.69); Pacific, 34.32–36.03 (34.92). Density: Atlantic, 23.49–24.89 (24.19); Pacific, 23.74–24.72 (24.21). pH: Atlantic, 8.27–8.30 (8.28); Pacific, 8.14–8.26 (8.20).

#### *Codonaria mucronata* Kofoid and Campbell

(Figure 13)

*Codonella mucronata* Kofoid and Campbell, 1929, pp. 62–63, fig. 123.

The stout lorica, with deep constriction at the throat and with pointed aboral end, has a length of 1.72 oral diameters. The thin, subdenticulate oral margin is enclosed by the low suboral cuff. The cuff is a low band or basal segment of a concave cone ( $12^\circ$ ) with a length of less than 0.1 oral diameter. The cuff is superimposed on the wider, flaring, plane, irregularly swollen, inverted-conical ( $58^\circ$ ) collar, the length of which is a little over 0.4 oral diameter; its lower diameter

is approximately 0.93 oral diameter and its diameter at the upper end is 1.34 oral diameters. The upper margin is roughly undulating although without teeth, and connects with the suboral cuff by means of a concave-angular trough. The rather short, squat bowl expands from the constricted throat, forming a segment of a cone ( $32^\circ$ ), and reaches a diameter equal to that of the upper end of the collar at 0.67 total length below the rim. Below this widest level the bowl rapidly contracts as an inverted decidedly convex cone ( $98^\circ$ ); the convexity reaches its greatest width within the upper three-tenths and quickly declines so that the aboral end is pointed, without, however, being produced.

The wall is uniformly about 0.06 oral diameter in thickness in the collar, and less in the cuff. There are one to three layers of irregularly arranged, subrectangular secondary prisms enclosed within thin laminae.

Length, 75 to 108 $\mu$ .

The *Carnegie* loricae are a little longer than those earlier recorded.

*Codonaria mucronata* agrees with *C. dadayi* in the sharply pointed aboral end, but differs in its wide, more squat bowl, constricted throat, and better-developed ledge. *Codonaria cistellula*, also pointed, differs in being narrower and taller, and in its fuller ledge. The other species are not likely to be confused with *mucronata*, which is easily distinguished even in rapidly examined plankton.

Recorded from nine stations, four in the Atlantic and five in the Pacific, as follows: one (14) in the Gulf Stream, two (17, 18) in the Sargasso Sea, one (33) in the Caribbean Sea, two (45, 71) in the Galápagos region, and three (152, 153, 154) in the Pacific equatorial region.

There are 4 pump and 10 net samples, of which 2 were taken at the surface, 4 at 50 meters, 8 at 100 meters. Maximum frequency, 12 per cent at station 71; other records above minimum from stations 45, 71, 152, 153, 154; average in Pacific net samples, 5.1 per cent.

Temperature: Atlantic, net samples 19°82–23°17 (21°29), pump sample 14°95; Pacific, 11°48–25°81 (21°24) and 11°48–23°46 (19°10), respectively. Salinity: Atlantic, net samples 36.49–36.81 (36.62), pump sample 35.10; Pacific, 34.73–35.24 (35.00) and 34.73–35.24 (35.06), respectively. Density: Atlantic, net samples 25.03–26.07 (25.66), pump sample 26.08; Pacific, 22.98–26.50 (24.34) and 24.00–26.50 (24.93), respectively. pH: Atlantic, net samples 8.18–8.27 (8.22), pump sample 8.18; Pacific, 7.76–8.28 (8.05) and 7.76–8.13 (8.00), respectively.

#### *Codonaria oceanica* (Brandt) Kofoid and Campbell

*Codonella oceanica*, Kofoid and Campbell, 1929, p. 63, fig. 122.

The short, wide lorica, with inflated bowl and rather low collar, has a length of 1.7 oral diameters. The ragged, irregular oral margin is thin-edged and a low cuff lies below it. The suboral cone ( $80^\circ$ ) is a low, truncated, concave basal segment with a length of nearly 0.17 oral diameter and a basal diameter of 1.2 oral diameters. The suboral ledge is not wide (1.3 oral diameters), is widely angular ( $90^\circ$ ), and is not especially differentiated from the upper edge of the

collar, of which it forms the wavy, free end. The wide, plane collar is an inverted truncated cone ( $50^\circ$ ), the lower diameter of which is 0.92 oral diameter, reached at a little over 0.54 oral diameter below the rim. The swollen, wide bowl attains its greatest diameter of 1.35 oral diameters near 0.66 total length below the rim. The aboral end is widely but bluntly angular ( $133^\circ$ ) and undifferentiated.

The wall is thickest in the lower collar and upper bowl, where it reaches 0.07 oral diameter. It thins above and below to one-fourth this thickness, or even less. Single layers of large, rectangular secondary prisms occur except in the thicker regions, where there are two or even three layers of smaller, commonly hexagonal ones. The cuff is hyaline, the suboral cone has small prisms, and the collar and upper bowl have larger, variously shaped ones, there being as many as 72 around the equator of the bowl. An internal ledge is lacking.

Length, 70 to 95 $\mu$ .

*Codonaria oceanica* has a wide bowl like *C. mucronata*, from which it differs in having a bluntly hemispherical instead of pointed end. The lorica is more squat than that of *C. cistellula*, which also is taller. It is not likely to be confused with the other species.

Recorded from twenty-one stations, eight in the Atlantic and thirteen in the Pacific, as follows: two (2, 15) in the Gulf Stream, three (18, 19, 20) in the Sargasso Sea, two (23, 24) in the Atlantic equatorial region, one (34) in the Caribbean Sea, one (35) in the Pacific equatorial region, five (40, 45, 46, 71, 78) in the Galápagos region, two (66, 67) in the South Pacific middle latitudes, one (81) in the region of South Pacific island fields, two (112, 145) in the North Pacific middle latitudes, one (136) in the California region, and one (151) in the North Pacific trade region.

There are 8 pump and 16 net samples, of which 4 were taken at the surface, 11 at 50 meters, and 9 at 100 meters. Maximum frequency, 5 per cent at station 45; other records above minimum (2 per cent) from stations 2, 34, 46; average in Pacific net samples, 2 per cent.

Temperature: Atlantic, pump samples  $20^\circ 32-24^\circ 81$  ( $22^\circ 41$ ), net samples  $20^\circ 35-25^\circ 31$  ( $22^\circ 81$ ); Pacific,  $16^\circ 58-23^\circ 25$  ( $18^\circ 64$ ) and  $14^\circ 33-26^\circ 42$  ( $21^\circ 17$ ), respectively. Salinity: Atlantic, pump samples 36.39–36.82 (36.67), net samples 36.02–37.15 (36.46); Pacific, 34.60–35.13 (34.87) and 34.42–36.03 (35.32), respectively. Density: Atlantic, pump samples 24.47–26.07 (25.70), net samples 24.67–25.76 (25.15); Pacific, 23.58–26.21 (24.87) and 24.00–26.06 (24.56), respectively. pH: Atlantic, pump samples 8.21–8.24 (8.23), net samples 8.14–8.27 (8.19); Pacific, 7.85–8.39 (8.17) and 7.88–8.19 (8.10), respectively.

#### CODONOPSIS Kofoid and Campbell

*Codonopsis* Kofoid and Campbell, 1939, pp. 60–61.

Only a single species of this genus is known. It is peculiar to the western part of the Pacific, not having been reported elsewhere, even in the Indian Ocean. Evidently the distribution of Tintinnoina is not conditioned solely by temperature or other physical factors, but by geographical conditions

as well. One other genus of some importance, *Epicranella*, is exclusively Pacific, being limited to the cool waters of the Humboldt Current. No species of *Epicranella* were found in Carnegie material, but the Humboldt Current was not extensively explored. In the *Albatross* and *Zaca* material several species have been found; these two ships have intensively explored the coasts of Peru and Chile.

#### *Codonopsis ollula* (Brandt) Kofoid and Campbell

*Cyttarocyclus ollula*, Kofoid and Campbell, 1929, p. 115, fig. 212.  
*Codonopsis ollula*, Kofoid and Campbell, 1939, pp. 61–62.

The stout, egg-shaped lorica, with distinct external suboral ledge below the squarely truncated oral rim, and evenly blunted aboral end, has a length of 1.41 oral diameters. The thin, erect oral rim is entirely free of irregularity. The collar region extends to the external ledge at 0.19 oral diameter below the rim. It is ringlike, and triangular in section, the apex forming the oral margin. The ledge is a horizontal shelf 1.26 oral diameters in diameter, the sides of which thin out distally and give the ledge a blunt free edge. The ledge has a thickness, proximally, of nearly 0.08 oral diameter. The bowl, below the collar, swells out to its maximum diameter of 1.31 oral diameters at 0.73 oral diameter below the rim. The sides of the bowl are full and somewhat lumpy locally in contour. The aboral end is evenly rounded to blunt ( $110^\circ$ ) and without any special differentiation. The end is closed.

The wall is relatively thick, being 0.07 oral diameter in thickness across the bowl. In the collar region it thins down rapidly to the sharp-edged oral rim. The wall has a distinct, thin inner lamina which coats the interior of the collar and bowl. There are thin-walled, large, radial secondary polygons in a single layer in the bowl; in the ledge these are in two rows, and just below the oral margin there are minute ones in several rows. There are about 33 hexagons across the bowl before the ledge and 24 from ledge to aboral end. Those immediately below the rim are minute and become larger at the rim. Below the ledge they are subuniformly still larger. The wall is soft and flaccid and is easily flattened by pressure; the texture is not at all like that of *Cyttarocyclus*.

Length, 85 to 90 $\mu$ .

Loricae of *Codonopsis ollula* have been obtained only in a limited area of the Pacific under rather uniform external conditions. There seems to be little difference between them, save, perhaps, in the shape of the aboral ends, and this difference may be due to cover-slip pressure when the specimens were examined in formalin-sea water under rather heavy, long slips.

*Codonopsis ollula* is unique. It bears some superficial likeness to *Cyttarocyclus longa*, but the wall structure is altogether different, and the ledge of *ollula* is sufficient to distinguish it from any *Cyttarocyclus*.

Kofoid and Campbell (1929) followed Brandt (1907) in the assignment of this species to *Cyttarocyclus*, but later (1939) these authors reassigned it to a new genus, *Codonopsis*, in which it is here retained.

Recorded from five stations in the Pacific, as follows: one (47) in the Galápagos region, one (48) in the region of

South Pacific island fields, one (54) in the South Pacific middle latitudes, one (99) in the Pacific equatorial region, and one (100) in the North Pacific trade region. *Codonopsis ollula* has a limited distribution in the central Pacific.

There are 5 net samples, of which 2 were taken at the surface, 1 at 50 meters, and 2 at 100 meters. Maximum frequency, 4 per cent at stations 48, 54; elsewhere, minimum only; average, 2.5 per cent.

Temperature, 18°74–27°84 (24°35); salinity, 34.71–36.44 (35.50); density, 22.31–25.37 (23.89); pH, 8.16–8.23 (8.21).

#### CYTTAROCYLIDAE Kofoid and Campbell

Cyttarocylidae Kofoid and Campbell, 1929, p. 108.

Only one genus is included in this family, and this one is allied to the higher members of the Codonellidae. It is exclusively eupelagic, mostly in warmer seas.

#### CYTTAROCYLIS Fol emended

*Cyttarocylis*, Kofoid and Campbell, 1929, p. 109.

*Cyttarocylis* is an isolated genus with some alliance to *Codonella*, with which it agrees in general, although more complex and finished in form and wall structure.

*Cyttarocylis* is widely distributed in warm seas as well as in more temperate waters. It does not enter the Arctic Ocean, although *Cyttarocylis magna* occurs in Mutsu Bay to the north, and as far south as below Australia. The majority of the species are tropical but not limited to either of the oceans investigated in this report.

Nine species are described.

#### *Cyttarocylis acutiformis* Kofoid and Campbell

(Figures 35, 36, 37, 45, 48)

*Cyttarocylis acutiformis* Kofoid and Campbell, 1929, p. 111, fig. 221.

The elongated, conical lorica, with flaring, distinct collar and pointed aboral end, has a length of 1.78 to 2.35 (2.07) oral diameters. The oral margin is minutely denticulate with about 70 triangular, sharply pointed denticles, ragged in a few instances, or with few larger, outward-directed teeth. The collar is a basal segment of an inverted truncated cone (40° to 50°), with a length of 0.12 to 0.15 total length. The sides of the collar are usually flattened or, in very perfect individuals, flat sigmoid. The nuchal shelf reduces the aperture between collar and bowl to 0.77 oral diameter. It is triangular and horizontal, with barely concave sides. The long, conical bowl is slightly convex (about 30°); it is 25° near the throat and for 0.67 of the length, and 35° in the aboral region. The latter region is sharply pointed to minutely truncated and always ends as an open canal which in a few individuals may be relatively wide open.

The wall has about 56 to 60 polygons across one face and 75 to 90 from rim to tip. These polygons are mostly minute, and prevalently pentagonal to hexagonal, with some triangular ones. Large and small reticulations are intermingled, but, in general, they are larger below the throat

and in the upper three-tenths of the bowl. There are one or two rows of large polygons in the collar and several rows of smaller ones, especially immediately below the oral rim. The wall is thickest in the upper part of the bowl, being 0.04 oral diameter at the most. It is only barely thinner in the lower bowl. Only a single layer of rectangular prisms occurs except in the nuchal shelf, where there are two layers of pentagons. The cavity of the lorica conforms to the outer contour closely save as the nuchal shelf constricts the opening. The narrow aboral canal is usually a tube.

There are 20 macronuclei, and zooxanthellae are present. The membranelles are large blades.

Length, 213 to 326 (228.6)  $\mu$ .

The five loricae figured are extremes picked out from a large number of specimens. The oral margin, flare of collar, shape of bowl, and shape of aboral end are the principal characters subject to variation. These loricae are longer and less stout than those originally described by Kofoid and Campbell, which are 200 to 257  $\mu$  in length, 1.54 to 1.96 oral diameters. Possibly these came from cooler waters. The fine meshwork is a most uniform character.

*Cyttarocylis acutiformis* is most like *C. magna*, but is generally smaller, with a more slender bowl, a more clearly flaring collar, and finer reticulations. It resembles *C. cassis*, but is greatly elongated and less convex, and lacks a terminal peg; its surface is more finely reticulated. The aboral end is not truncated like that of *C. conica*, and the bowl is not so full. It lacks the aboral contraction of both *C. mucronata* and *C. obtusa*.

Recorded from thirty-one stations, twelve in the Atlantic and nineteen in the Pacific, as follows: two (2, 16) in the Gulf Stream, two (17, 20) in the Sargasso Sea, seven (22, 23, 24, 25, 27, 28, 30) in the Atlantic equatorial region, one (34) in the Caribbean Sea, six (45, 46, 47, 75, 78, 80) in the Galápagos region, two (84, 85) in the region of South Pacific island fields, one (64) in the South Pacific middle latitudes, three (113, 144, 145) in the North Pacific middle latitudes, five (131, 137, 146, 148, 149) in the California region, and two (150, 151) in the North Pacific trade region.

There are 7 pump and 28 net samples, of which 2 were taken at the surface, 18 at 50 meters, and 15 at 100 meters. Maximum frequency 43 per cent at station 23 at 100 meters; other records above minimum (2 to 42 per cent) from stations 2, 16, 17, 22, 23, 25, 27, 28, 30, 34, 45, 75, 80, 131, 137, 145, 146, 148, 149, 150, 151; averages, 1.5 and 1.0 loricae in Atlantic and Pacific pump samples, and 11.6 and 3.6 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump samples 14°60–21°49 (18°04), net samples 14°60–36°02 (22°07); Pacific, 17°46–26°06 (21°52) and 12°12–27°89 (21°48), respectively. Salinity: Atlantic, pump samples 35.70–36.02 (35.86), net samples 35.61–36.73 (36.21); Pacific, 34.42–36.17 (35.34) and 34.32–36.42 (35.14), respectively. Density: Atlantic, pump samples 25.15–26.62 (25.88), net samples 23.79–26.62 (25.24); Pacific, 23.42–25.11 (24.43) and 22.48–25.55 (24.75), respectively. pH: Atlantic, pump samples 7.93–8.22 (8.07), net samples 7.93–8.30 (8.18); Pacific, 8.14–8.33 (8.22) and 8.10–8.38 (8.34), respectively.

*Cyrtarocyli brandti* Kofoid and Campbell

(Figure 39)

*Cyrtarocyli brandti* Kofoid and Campbell, 1929, pp. 111-112, fig. 215.*Cyrtarocyli plagiostoma*, Hofker, 1931, pp. 371-372, figs. 51-53.

The aborally blunt lorica is acorn-shaped and 0.87 to 0.98 oral diameter in length. The oral margin is finely denticulate. The collar is a short basal segment of an inverted truncated cone ( $90^\circ$  to  $100^\circ$ ) with a length of 0.1 oral diameter. Its sides are slightly convex. The nuchal shelf is a thin, upturned ( $50^\circ$ ) ridge at the throat. The bowl is baggy and convex conical (about  $35^\circ$  at the upper end and  $130^\circ$  near the apex). The aboral end is blunt, barely pointed, and usually undifferentiated.

The wall has about 75 small polygons below the collar and about 40 from throat to tip. The polygons are prevalently hexagons and a few large ones are scattered near the upper end of the bowl. The bowl is thickest near the shelf, being less than 0.01 oral diameter, and has only a single layer of more or less subuniform secondary prisms. The lumen follows the outer contour save as the nuchal shelf alters it.

Length, 90 to 120 $\mu$ .

The lorica figured (fig. 39) differs from the usual type in the shape of the bowl, and also in having a tiny nipple. Its nuchal shelf is almost horizontal.

*Cyrtarocyli brandti* resembles *C. longa* in being generally more pointed, and in having a less baggy bowl. It is usually longer than *C. eucecryphalus*, and that species has a flat aboral end. The bowl of *C. brandti* is less conical than that of *C. cassis*, and proportionately stouter. It is most likely to be confused with *longa*.

Hofker (1931) figures 2 loricae called *Cyrtarocyli plagiostoma*, but these appear to belong to the present species. The general proportions, shape of collar, and aboral end are the same, as is also the wall pattern. Hofker finds 18 membranelles with no intercalary platelets, and records 80 macronuclei. He suggests, probably correctly, that most of these are zooxanthellae. Careful cytological investigation will probably show that most members of this genus are photosynthetic.

Recorded from thirty-seven stations, nine in the Atlantic and twenty-eight in the Pacific, as follows: four (18, 19, 20, 21) in the Sargasso Sea, five (22, 23, 24, 25, 27) in the Atlantic equatorial region, four (41, 42, 45, 75) in the Galápagos region, four (54, 55, 65, 67) in the South Pacific middle latitudes, three (84, 95, 96) in the region of South Pacific island fields, four (101, 140, 150, 151) in the North Pacific trade region, three (115, 141, 145) in the North Pacific middle latitudes, eight (131, 132, 135, 136, 146, 147, 148, 149) in the California region, and two (153, 154) in the Pacific equatorial region.

There are 9 pump and 36 net samples, of which 11 were taken at 50 meters and 34 at 100 meters. Maximum frequency, 45 per cent at station 153; other records above minimum (2 to 37 per cent) from stations 18, 19, 20, 22, 23, 27, 41, 45, 54, 55, 65, 67, 75, 115, 131, 136, 145, 146, 147, 148, 149, 150, 151, 154; averages, 1.0 lorica in both Atlantic and

Pacific pump samples, and 6.0 and 12.5 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump sample  $21^\circ.49$ , net samples  $14^\circ.60$ - $36^\circ.02$  ( $22^\circ.29$ ); Pacific,  $14^\circ.42$ - $28^\circ.41$  ( $20^\circ.04$ ) and  $12^\circ.12$ - $28^\circ.74$  ( $18^\circ.76$ ), respectively. Salinity: Atlantic, pump sample 36.02, net samples 35.61-37.05 (36.26); Pacific, 33.40-35.63 (34.80) and 33.36-36.42 (34.87), respectively. Density: Atlantic, pump sample 25.15, net samples 23.98-26.64 (25.29); Pacific, 22.75-24.88 (24.05) and 22.98-26.11 (24.91), respectively. pH: Atlantic, pump sample 8.22, net samples 7.93-8.25 (8.15); Pacific, 8.19-8.34 (8.29) and 7.91-8.39 (8.22), respectively.

*Cyrtarocyli cassis* (Haeckel) Fol*Cyrtarocyli cassis*, Kofoid and Campbell, 1929, p. 112, fig. 219;

Alzamora, 1929, p. 11, fig. 24; Hofker, 1932, p. 370, figs. 49, 50.

*Tintinnus* sp., Lindeman, 1924, p. 889, fig. 10.

The conical lorica, with widely flaring collar and pointed aboral end, has a length of 1.43 oral diameters. The oral margin is slightly ragged and there are minute teeth around its edge. The short collar is a basal segment of an inverted truncated cone ( $50^\circ$ ), and its length is about 0.08 total length; it is well developed and flares widely. Its sides are mildly convex. The lower edge is marked by an optically dark line. The nuchal shelf is angular ( $90^\circ$ ) and horizontal, and barely narrows the aperture between collar and bowl. The full conical bowl changes from about  $14^\circ$  in the anterior three-fifths to  $52^\circ$  in the aboral section. There is a tiny but distinctive nipple-like aboral peg at its free tip. The bowl as a whole is decidedly convex.

The wall is coarsely reticulated, with about 30 polygons across the throat and about 36 from oral rim to tip. The polygons are prevalently rounded, and some are pentagons. They are of various sizes, small ones being scattered among the larger. Those of the upper half, including the collar, are larger than those of the lower part of the bowl near the aboral end, where they are much smaller and more nearly circular. The wall has a subuniform thickness of 0.03 oral diameter, except at the nuchal shelf, where it is 0.05. Single layers of polygons occur. The cavity of the lorica is altered by the nuchal shelf. The aboral peg is solid.

There are 18 to 20 macronuclei.

Length, 170 to 215 $\mu$ .

The *Carnegie* specimens hardly differ from the usual form found in the Mediterranean.

*Cyrtarocyli cassis* differs from *C. mucronata* and *C. obtusa* in having a convex-conical bowl instead of one narrowed down to a pedicel-like aboral region. It lacks the aboral flattening of *C. conica*. It is less elongated and more convex conical than *C. acutiformis*; it is also stouter and shorter, and has a terminal peg. *Cyrtarocyli magna* is longer and more slender and has a less distinct flaring collar. *Cyrtarocyli cassis* is long familiar, and recent records conform to type.

Recorded from twenty-two stations, twelve in the Atlantic and ten in the Pacific, as follows: one (2) in the Gulf Stream, two (17, 18) in the Sargasso Sea, seven (22, 23, 24, 25, 27, 28, 29) in the Atlantic equatorial region, two (31, 32)

in the Caribbean Sea, three (55, 65, 67) in the South Pacific middle latitudes, three (68, 75, 80) in the Galápagos region, two (131, 146) in the California region, and two (140, 151) in the Pacific trade region.

There are 29 net samples, of which 1 was taken at the surface, 6 at 50 meters, and 22 at 100 meters. Maximum frequency, 7 per cent at station 27; other records above minimum (2 to 6 per cent) from stations 2, 17, 22, 23, 24, 28, 32, 75, 80, 131; averages, 3.0 and 1.6 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, 14°60–26°97 (20°97); Pacific, 12°12–26°06 (18°70). Salinity: Atlantic, 35.11–36.81 (36.14); Pacific, 34.30–35.95 (34.72). Density: Atlantic, 23.98–26.62 (25.40); Pacific, 22.80–25.52 (24.83). pH: Atlantic, 7.93–8.26 (8.16); Pacific, 8.09–8.39 (8.17).

#### *Cyttarocyclus conica* Brandt

(Figure 40)

*Cyttarocyclus conica*, Kofoid and Campbell, 1929, pp. 112–113, fig. 220.

The truncated-conical lorica has a length of 1.47 oral diameters. The oral margin is irregular and ragged. The collar forms a short segment of an inverted truncated cone (48°) with even, regular sides, and its length is 0.12 total length. The nuchal shelf is developed inside at its lower edge. The shelf is feebly developed, angled, and horizontal. The generally conical bowl is formed below the shelf and there is almost no nuchal constriction. The bowl has a length of 0.88 total length. It changes from about 22° suborally to 60° in the aboral region and has well filled sides. The aboral end is squarely truncated, and about 0.18 oral diameter in diameter. At the middle of the aboral end there is a minute conical aboral peg, which is closed.

The wall is regularly and evenly reticulated, with 50 or more polygons around the suboral region and 35 to 42 around the meridian. The polygons are prevalingly pentagonal to hexagonal, and subequal; each has an enclosing mesh with thickened, heavy beams. The wall is about 0.04 oral diameter in thickness just below the throat, at the thickest level, and elsewhere is thinner. The large secondary prisms occur always in a single layer.

Length, 157µ.

The *Carnegie* loricae are somewhat shorter than those recorded elsewhere, the latter reaching to 210µ. In proportions and general shape the agreement with others is, however, close, and the smaller specimens may have come from warmer water than others from the Atlantic.

This species is unlike any of the others in the shape of the aboral end, there being aboral flattening. For this reason there can be little opportunity to confuse it with others. In *Cyttarocyclus cassis* the aboral end is pointed and the whole bowl is a broad cone.

Recorded from two stations in the Atlantic, 19 and 20, both in the Sargasso Sea.

There are 2 net samples. Frequency, minimum.

Temperature, 22°42–22°56 (22°49); salinity (one record), 37.05; density (one record), 25.67; pH, 8.18–8.25 (8.21).

#### *Cyttarocyclus eucecryphalus* (Haeckel) Kofoid

(Figure 42)

*Cyttarocyclus eucecryphalus*, Kofoid and Campbell, 1929, p. 113, fig. 211.

The stout, acorn-shaped lorica, with flaring collar and flat aboral end, has a length of 1.0 oral diameter. The oral margin is regularly beset with numerous subequal, equidistant, triangular, pointed teeth. The collar is a basal segment of an inverted truncated cone (57°), with a length of 0.14 total length. Its sides are slightly convex. The nuchal shelf is a concave, virtually horizontal triangle (43°), and its width is such that the diameter of the aperture between collar and bowl is reduced to 0.72 oral diameter. The bowl is baggy, increasing from about 12° in the upper 0.5 to 58° in the lower section; nearer the aboral end it increases to 100°. The aboral end is flattened, although not squarely truncated, and its diameter is 0.32 oral diameter. There is no point.

The wall is coarsely reticulated with about 23 polygons across the throat and 17 from rim to tip. There is but a single row around the collar. The polygons are largest in the upper half of the bowl and become progressively smaller in the lower part. They are prevalingly pentagonal, although some are rounded triangles and some are hexagons with rounded edges. The wall is subuniformly 0.03 oral diameter in thickness, and the rectangular prisms occur in a single layer in the gray, semitransparent wall. The lumen is reduced by the internal shelf but otherwise follows the outer contour.

Length, 115 to 140µ.

A few loricae tend toward a thimble-like bowl like the one figured (fig. 42).

*Cyttarocyclus eucecryphalus* is closely related to *C. brandti*, but its aboral end is flattened instead of blunted. It is like *C. longa*, but its aboral end, again, is different. It is more slender than *C. ricta* and has coarser meshwork. *Cyttarocyclus plagiostoma* is sharply pointed and has yet coarser meshwork.

Recorded from forty-eight stations, sixteen in the Atlantic and thirty-two in the Pacific, as follows: two (2, 16) in the Gulf Stream, one (4) in the Atlantic drift, four (17, 18, 19, 20) in the Sargasso Sea, eight (22, 23, 24, 25, 26, 27, 28, 29) in the Atlantic equatorial region, one (33) in the Caribbean Sea, eleven (41, 42, 45, 46, 47, 69, 75, 77, 78, 79, 80) in the Galápagos region, five (48, 49, 81, 82, 95) in the region of South Pacific island fields, three (54, 66, 67) in the South Pacific middle latitudes, two (113, 144) in the North Pacific middle latitudes, seven (131, 135, 136, 137, 146, 147, 149) in the California region, and four (109, 139, 150, 151) in the North Pacific trade region.

There are 20 pump and 53 net samples, of which 7 were taken at the surface, 32 at 50 meters, and 34 at 100 meters. Maximum frequency, 86 per cent at station 17 at 100 meters; other records above minimum (2 to 74 per cent) from stations 2, 16, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 33, 41, 45, 46, 47, 48, 75, 77, 78, 80, 81, 95, 109, 131, 136, 137, 139, 146, 147, 149, 150; averages, 1.5 and 18.0 per cent in Atlantic pump and net samples, and 1.0 and 4.8 per cent in Pacific pump and net samples, respectively.

Temperature: Atlantic, pump samples 20°99–26°98 (23°28), net samples 12°12–28°74 (21°85); Pacific, 14°77–26°70 (21°58) and 13°37–26°79 (21°29), respectively. Salinity: Atlantic, pump samples 36.04–37.00 (36.50), net samples 33.36–36.44 (35.22); Pacific, 34.59–36.04 (35.36) and 35.61–37.15 (36.38), respectively. Density: Atlantic, pump samples 24.25–25.58 (24.95), net samples 22.43–26.17 (25.47); Pacific, 23.42–25.91 (24.02) and 23.79–27.01 (25.43), respectively. pH: Atlantic, pump samples 8.14–8.27 (8.22), net samples 7.91–8.39 (8.20); Pacific, 8.10–8.39 (8.26) and 7.93–8.27 (8.23), respectively.

### *Cyttarocyclus longa* Kofoid and Campbell

(Figures 41, 43)

*Cyttarocyclus longa* Kofoid and Campbell, 1929, p. 113, fig. 217.

The stout, saccular lorica, with rounded to barely pointed aboral end, has a length of 0.76 to 1.08 oral diameters. The oral margin is minutely denticulate and irregular. The collar is a basal segment of an inverted truncated cone (65° to 75°) with a length of 0.12 to 0.15 oral diameter. The nuchal shelf is horizontal, narrow, and concave on the superior face. The bowl is sac-shaped, with its greatest diameter at the throat, 30° suborally and 115° to 130° aborally. The aboral end is evenly rounded to blunt; rarer instances show a trace of aboral pointing.

The wall is finely reticulated with triangular, pentagonal, or hexagonal polygons. There are 40 to 60 polygons around the throat and 32 to 45 from oral rim to tip. In general, the polygons are graded in size from larger to smaller from the rim downward. There is a double row of large ones with interspersed tiny ones in the collar. The wall has a subuniform thickness of 0.03 oral diameter in the bowl. The wall of the collar thins out from the internal ledge to the rim. There is a single layer of prisms in the wall, and interprismatic substance is pronounced between the prisms.

Length, 103 to 106µ.

There is considerable variation in the shape of the aboral end, which may be evenly rounded, blunt, or rarely pointed, but there is never a nipple. The oral rim is rarely ragged. The *Carnegie* loricae are 0.76 to 1.08 oral diameters, as against 0.76 to 0.96 recorded by Kofoid and Campbell (1929).

*Cyttarocyclus longa* differs from *C. brandti* in being longer, more saccular in bowl, and less evidently pointed, and in having much finer reticulations. It differs from *C. euencyphalus* in the shape of the aboral end, that of the latter species being flat. The wall of the two species is also different.

*Cyttarocyclus plagiostoma* has a fuller, sharply pointed bowl and a coarse surface, is longer and less stout, and has better separation of collar and bowl than is found in *C. ricta*. The latter is most likely to be confused with *brandti*.

Recorded from thirty-two stations, nine in the Atlantic and twenty-three in the Pacific, as follows: one (2) in the Gulf Stream, seven (22, 23, 24, 25, 26, 27, 30) in the Atlantic equatorial region, one (34) in the Caribbean Sea, eight (46, 47, 68, 70, 72, 77, 78, 80) in the Galápagos region, three (48,

159, 160) in the region of South Pacific island fields, three (54, 63, 67) in the South Pacific middle latitudes, two (109, 151) in the North Pacific trade region, four (131, 136, 147, 148) in the California region, one (145) in the North Pacific middle latitudes, and two (153, 156) in the Pacific equatorial region.

There are 10 pump and 30 net samples, of which 5 were taken at the surface, 11 at 50 meters, and 24 at 100 meters. Maximum frequency, 29 per cent at station 46; other records above minimum (2 to 27 per cent) from stations 2, 22, 27, 47, 48, 54, 67, 70, 78, 109, 131, 136, 145, 147, 151, 153, 156, 159, 160; averages, 1.5 and 6.0 per cent in Atlantic pump and net samples, and 1.0 and 7.9 per cent in Pacific pump and net samples, respectively.

Temperature: Atlantic, pump samples 18°40–26°04 (18°72), net samples 14°60–36°02 (22°33); Pacific, 12°73–24°38 (20°52) and 12°12–28°52 (21°24), respectively. Salinity: Atlantic, pump samples 36.08–36.25 (36.16), net samples 35.61–36.58 (36.09); Pacific, 34.58–36.04 (35.50) and 33.36–36.04 (35.30), respectively. Density: Atlantic, pump samples 23.98–26.01 (24.99), net samples 23.26–26.62 (25.22); Pacific, 24.33–26.28 (24.99) and 22.76–26.28 (24.50), respectively. pH: Atlantic, pump samples 8.11–8.30 (8.20), net samples 7.93–8.30 (8.13); Pacific, 7.68–8.19 (8.09) and 7.68–8.44 (8.21), respectively.

### *Cyttarocyclus magna* Brandt

(Figures 44, 46, 47)

*Cyttarocyclus magna*, Kofoid and Campbell, 1929, p. 114, fig. 222; Hada, 1932b, p. 564, fig. 16.

The tall, conical lorica, with low, ill defined collar and short, pedicellated aboral end, has a length of 2.41 to 3.18 (2.77) oral diameters. The oral margin is finely to roughly ragged. The short collar is a basal segment of an inverted truncated cone which rarely flares as much as 40°, and has a length of 0.10 to 0.15 oral diameter. The collar is poorly or scarcely at all delimited from the long bowl. The nuchal shelf is triangular in section, horizontal, and feebly developed. The sides of the collar are flat to convex, usually the former. The full conical bowl changes from about 25° below the collar to 45° near the apex, and there is a small, conical aboral horn (25°) with a length of only 0.1 oral diameter.

The wall is coarsely reticulated with subuniform hexagonal polygons. There are about 25 of these across the face at the throat and 45 to 50 from the throat to the apex. Those of the collar do not differ from those of the throat, and they are only slightly smaller aborally. The wall is about 0.01 oral diameter in thickness. There is but a single layer of polygons, even in the nuchal shelf. The lumen follows the outer contour neatly save as the low internal shelf breaks the collar and bowl into two divisions. The aboral horn is hollow and the tip is usually open.

Length, 267 to 400µ.

There is considerable variation in these large loricae. In actual length, Kofoid and Campbell (1929) record 250 to 320µ and Hada (1932b) 300µ; the *Carnegie* specimens are 267 to 400µ, and in proportions also they are more variable.



In form, these conform to the general shape of others; the collar is sometimes more definitely separated from the bowl, and the horn is lacking in a few.

*Cyttarocyclus magna* is most nearly like *C. acutiformis*, but is larger, being up to 400 $\mu$  as against a maximum of 326 $\mu$ ; its proportions are also different and there is less distinction between collar and bowl. The ragged margin and aboral horn are added differences. It differs in these characters from *C. cassis*, and also in being longer and less stout, and having a less flaring collar. It is unlike the other species and can seldom be confused with them.

Recorded from twelve stations, four in the Atlantic and eight in the Pacific, as follows: one (16) in the Gulf Stream, two (17, 18) in the Sargasso Sea, one (27) in the Atlantic equatorial region, two (35, 35-36) in the Pacific equatorial region, three (45, 70, 75) in the Galápagos region, one (67) in the South Pacific middle latitudes, and two (109, 151) in the North Pacific trade region.

There are 14 net samples, of which 1 was taken at the surface, 5 at 50 meters, and 8 at 100 meters. Maximum frequency, 32 per cent at station 35; other records above minimum (2 to 25 per cent) from stations 35-36, 45, 67, 70, 75, 151; average in the Pacific, 9.2 per cent; in the Atlantic there were only minimum occurrences.

Temperature: Atlantic, 18°08–23°64 (21°20); Pacific, 14°33–21°69 (17°24). Salinity: Atlantic, 36.03–36.82 (36.53); Pacific, 34.42–35.47 (35.02). Density: Atlantic, 24.84–26.07 (26.00); Pacific, 24.48–26.28 (25.36). pH: Atlantic, 8.09–8.27 (8.20); Pacific, 7.68–8.18 (7.98).

#### *Cyttarocyclus mucronata* Kofoid and Campbell

(Figure 38)

*Cyttarocyclus mucronata* Kofoid and Campbell, 1929, p. 114, fig. 216.

The elongated, acorn-shaped lorica, with contracted aboral cone and aboral peg, has a length of 1.56 oral diameters. The oral margin is coarsely irregular and rather ragged. The short collar forms a segment of an inverted truncated cone (50°), and has evenly convex, full sides. Its length is only 0.11 total length. The nuchal shelf is developed inside at its lower edge. The shelf is thin, angled, upright, and not well developed. The generally conical bowl is formed below the clear-cut collar. The bowl is subdivided into a long suboral inverted truncated conical section (20°), with a length of 1.0 oral diameter, and an aboral section which is a shorter, wider inverted cone (62°) with a length of 0.4 oral diameter. The sides are barely convex. The aboral portion is a pedicel-like inverted cone (58°) with a length of 0.2 oral diameter and with convex sides. At its posterior end is a tiny aboral peg.

The wall has about 60 to 65 prevalingly hexagonal, rather fine polygons around the throat, and 45 or more from oral to aboral end. The polygons are larger and subuniform near the rim, and become progressively smaller below. The wall has a subuniform thickness of less than 0.02 oral diameter. There is a single layer of secondary prisms. The aboral peg is solid but otherwise the cavity follows the outer contour.

Length, 152 $\mu$ .

The lorica figured (fig. 38) differs from that figured by Kofoid and Campbell (1929) in having a coarsely ragged oral rim and in being a little longer.

*Cyttarocyclus mucronata* differs from *C. obtusa* in its finer surface reticulations and in the presence of an aboral peg. This terminal point is distinct and invariable. The aboral end of *obtusa* is blunt and squarely cut and lacks a peg. The aboral cone of both species lacks a parallel in the genus. The aboral truncation of *C. mucronata* is like that of *C. conica*, but that species is longer and more slender as well as different in other ways.

Recorded from four stations in the Atlantic, as follows: two (19, 20) in the Sargasso Sea, and two (22, 25) in the Atlantic equatorial region.

There are 4 net samples, all taken at 100 meters. Maximum frequency, 3 per cent at station 19; other records at the minimum; average, 1.6 per cent.

Temperature, 14°60–22°56 (19°27); salinity, 35.70–37.05 (36.49); density, 25.38–26.67 (25.69); pH, 7.93–8.25 (8.12).

#### *Cyttarocyclus obtusa* Kofoid and Campbell

*Cyttarocyclus obtusa* Kofoid and Campbell, 1929, p. 115, fig. 218.

The elongate, rather slender, acorn-shaped lorica, with contracted aboral cone and flattened end without peg, has a length of 1.06 to 1.36 oral diameters. The oral margin is minutely denticulate. The short collar forms a segment of an inverted truncated cone (90°), and has a length of 0.1 total length. Its sides are flat except just below the margin, where they turn upward. The nuchal shelf is inconspicuous, upright, and thin-edged. The bowl is quite convex conical (30°) in the suboral seven-tenths, and contracted (80°) below. Its sides are slightly sinuous. The aboral subdivision is a flat-ended cone (36°) and its aboral end has a diameter of 0.14 oral diameter. Its sides are even. There is no trace of an aboral peg.

The wall has about 36 to 40 polygons around the neck and 37 to 42 from oral edge to tip. The polygons are prevalingly hexagonal, and larger in size in the suboral three-tenths than below; in the posterior section they are only one-third to one-half the size of those superior, and they tend to be round. The wall is subuniformly 0.01 oral diameter in thickness at the nuchal shelf, and there is but a single layer of prisms. The cavity neatly conforms to the outer contour.

Length, 135 to 157 $\mu$ .

Significant variations in length are probably correlated with temperature adjustment.

*Cyttarocyclus obtusa* differs from *C. mucronata* in the distinct lack of an aboral peg, and in the generally smaller surface polygons, more regular oral rim, and slimmer loricae. The aboral end of *C. conica* is also truncated, but that species has no aboral cone and the proportions are unlike, being 1.41 to 1.47 in *conica*.

Recorded from three stations in the Atlantic, as follows: two (18, 19) in the Sargasso Sea, and one (22) in the Atlantic equatorial region.

There are 3 net samples, of which 1 was taken at 50

meters and 2 at 100 meters. Maximum frequency, 5 per cent at station 22; other records minimum; average, 3 per cent.

Temperature, 17°50–25°31 (21°04); salinity, 36.81–37.15 (36.98); density, 24.89–26.07 (25.48); pH, 8.21–8.27 (8.24).

#### CODONELLOPSIDAE Kofoid and Campbell

Codonellopsidae Kofoid and Campbell, 1929, p. 67.

This family includes three genera, *Stenosemella*, *Codonellopsis*, and *Laackmanniella*, of which the first two occur in the material of this expedition. *Laackmanniella* is exclusively antarctic, *Codonellopsis* is eupelagic in warm seas, and *Stenosemella* is almost always coastal.

#### STENOSEMELLA Jörgensen

*Stenosemella*, Kofoid and Campbell, 1929, pp. 67–68.

*Stenosemella* is apparently the stem of the Codonellopsidae, and its wall structure allies it to *Tintinnopsis*, to the general form of which it adds a collar. Closely related is the new genus *Wangiella*, with the type, *Wangiella dicollaria*, from the Bay of Amoy (D. Nie, 1934), in which the collar is *Dictyocysta*-like. Also allied is *Luminella*, a new genus founded by Kofoid and Campbell (1939, p. 284), which has as its principal character the demilunar openings in the collar.

*Stenosemella* is rare in the open ocean except as drifting empty loricae may be carried from the coast; in harbors and close to shore it is frequently the most common tintinnid. In San Francisco harbor it is often found exclusively, and off La Jolla it is often the most abundant. Most records of the genus are from northern European waters.

One species is described here.

#### *Stenosemella nivalis* (Meunier) emended Kofoid and Campbell

*Stenosemella nivalis*, Kofoid and Campbell, 1929, pp. 69–70, fig. 136; Campbell, 1931, pp. 347–348; Hada, 1932b, p. 561, fig. 11; Marshall, 1934, p. 638.

*Stenosemella nucula*, Hofker, 1931, pp. 362–364, figs. 40–42.

The small, olive-shaped lorica, with thick, irregular wall and narrow, hyaline collar lacking windows, has a length of 2.2 oral diameters. The oral margin is recurved outward, and the glassy collar is a concave ring with a length of only 0.06 oral diameter; it lacks the spiral turns and demilunes characteristic of some species, and the tall windows of *Wangiella dicollaria*. The plump, dense, potlike bowl is inflated from the lower edge of the collar and reaches its greatest diameter, which is equal to the total length, at 0.61 oral diameter below the oral rim, forming a rather strong, rounded shoulder. Below this level it contracts in regular contour to the bluntly pointed or narrowly rounded end.

The wall of the collar is clear, but that of the bowl is coarse, thick, and heavy, up to 0.2 oral diameter laterally. No structure may be detected in the collar, but the bowl has two or three layers of large, irregular tertiary polygons with thickened margins and clear interiors. Foreign bodies adhere to the outer surface.

The animal has been carefully studied. There are 2 macronuclei, and 24 large, squarish membranelles of elaborate structure (Campbell, 1931).

Length 40 to 46 $\mu$ .

Considerable variation is apparent, especially in the relative narrowness or width of the bowl, the level at which the greatest diameter is reached, the shape of the aboral end, and the character of the collar. Cytological details also differ.

*Stenosemella nivalis* is closest to *S. ventricosa* in form, but *nivalis* is always shorter, and rotund and sharper aborally. The greatest diameter is reached at a level closer to the collar in *ventricosa*. *Stenosemella nivalis* has a different collar from *Wangiella dicollaria* from the Chinese coast; it is smaller than *S. steini*, and lacks the trough below the collar which distinguishes that species. *Stenosemella avellana* is of about the same size, but its greatest diameter is nearer the middle and there are long, sloping shoulders below the collar. *Stenosemella oliva* has a narrower bowl and higher collar, and is differently proportioned.

Hofker (1931) suggests that the western species is *nivalis*, and that the loricae from off Holland are *nucula*. This proposition is largely based on inadequate cytological material. In form, loricae from Holland as examined by us seem similar in every way to those from off California.

Recorded from one station (130) in the California region, in a net sample taken at 50 meters. Frequency, 5 per cent.

Temperature, 12°91; salinity, 33.40; density, 25.19; pH, 8.26.

#### CODONELLOPSIS Jörgensen

*Codonellopsis*, Kofoid and Campbell, 1929, p. 73.

*Stenosemella* may be considered the stem of *Codonellopsis*, and *Luminella* that of *Dictyocysta*. Both these primitive genera are probably derived from *Tintinnopsis*. This hypothesis leaves the more highly differentiated genera less isolated.

*Codonellopsis* is widely distributed in the warmest oceans, although a few species enter the cold North Pacific, for example, *C. frigida*, *C. limosa*, and *C. orientalis* northward of Japan, and the latter and *aleutiensis* southward of the Bering Sea. A few, such as *C. contracta*, also occur in the tropics in deep water. None of the species enters the Antarctic, but the allied genus *Laackmanniella* is peculiar to that region. *Laackmanniella* has two, or possibly more, species peculiar to the south, where they occur under the ice; this genus does not occur in the Humboldt Current, although the water of that current arises from the Antarctic Current. It has not been reported, either, from the Cape Horn Current. *Laackmanniella* is remote from *Coxiella* and related genera, and belongs properly to the Codonellopsidae. Its open aboral end is secondary. Most species of *Codonellopsis* are circumtropical.

Nineteen species are described here, of which one is new.

#### *Codonellopsis aleutiensis*, new species

(Plate 1, figure 9)

The lorica has a long collar and a round bowl; its length is 2.66 oral diameters. The oral margin is entire, rounded

over, and comparatively thin. The long collar is subdivided into a short anterior widely flaring funnel, and a longer sub-cylindrical posterior section. The suboral funnel is an inverted truncate cone ( $28^\circ$ ). Its sides are full, although they do not bulge, and the length is 0.17 total length, or about 0.52 oral diameter. The funnel includes the upper 4 turns of the spiral lamina which forms the collar. The remaining part of the collar is a truncated cone (about  $7^\circ$ ). Its diameter at the oral end where it joins the suboral funnel is 0.78 oral diameter, and its length is approximately 1.6 oral diameters (0.6 total length). The diameter at the aboral end where it joins with the bowl is 0.92 oral diameter. The sides are even, regular, not serrated or with anything more than minor local bulges or contractions. Twelve turns of the spiral lamina are included in this section of the collar; there are 1 or 2 small oval fenestrae in the seventh turn of the lamina. The bowl is globular, and in general is evenly rounded, but a little suggestion of flattening is obscurely apparent at the aboral end. The bowl reaches its greatest diameter a little below its middle, where it is 1.35 oral diameters (0.44 total length). The bowl is 1.22 oral diameters or 0.33 total length in length. The aboral end lacks any special differentiation other than slight flattening.

The wall of the bowl is roughened by large, uneven-sized blobs of tertiary alveoles, about 25 in number across one face. Secondary prismatic structures occur between these blobs; about 50 prisms, or more, are found across the middle of the bowl. The wall of the collar is glassy-translucent, formed by 16 spiral turns, and under the highest powers of the microscope faint primary prisms may be sometimes detected. The small fenestrae that are included are about 0.17 oral diameter in length, and the full width of the spiral turn across. The edge of the spiral lamina is not thickened, nor does one turn overlap the next; they simply join without special differentiation. The wall of the bowl, in distinct contrast with that of the collar, is dense and heavy. That of the collar is subuniformly about 0.01 oral diameter in thickness, whereas that of the bowl reaches nearly 0.1 at the equator. The junction of collar and bowl is abrupt.

Length, total 88 $\mu$ , collar 53 $\mu$ ; diameter, oral 33 $\mu$ , greatest diameter of bowl 38 $\mu$ .

Aside from usual dimensional and proportional variations, *Codonellopsis aleutiensis* frequently has a less flaring suboral region, a more or less cylindrical collar, a bowl proportionately longer than wide, and the extraneous alveolar matter replaced by a precise network of small secondary prisms.

*Codonellopsis aleutiensis* is one of the medium-sized species of the genus, and one of the few of northern distribution. It differs from the tropical *C. ecaudata*, and from close relatives of that species, in the character of the bowl; in *ecaudata* the bowl is smooth, trim, and lacking in blobs of excess prismatic matter. The bowl of *aleutiensis* is more rotund and obscurely flattened instead of having a tendency toward pointing. The general facies of the whole lorica is quite different from that of *C. erythraensis*, which species also tends to have a flat-sided bowl. *Codonellopsis americana* has a proportionately longer bowl and the collar and bowl are subequal, whereas in *aleutiensis* the bowl is much less

than half the length of the collar. *Codonellopsis aleutiensis* differs from *C. orientalis* of the Japanese area in the rounded instead of pointed bowl, distinctly longer collar, and more slender build. Its collar has a greater number of spiral turns and the suboral funnel is better developed. It is not at all like *C. frigida*, or any of the tropical species related to *C. orthoceras*.

Recorded from ten stations in the Pacific, as follows: two (117, 126) in the North Pacific middle latitudes, six (118, 119, 120, 121, 122, 123) in the East Asiatic marginal sea, and two (124, 125) in the Alaskan secondary region. The distribution of *Codonellopsis aleutiensis* is exceptionally compact.

There are 17 pump and 12 net samples, of which 7 were taken at the surface, 12 at 50 meters, and 10 at 100 meters. Maximum frequency, 125 loricae at station 123; all other records above minimum (2 to 100) except at station 126; averages, 26.6 loricae and 22.5 per cent in pump and net samples, respectively.

Temperature: pump samples  $1^\circ 71-8^\circ 33$  ( $4^\circ 91$ ), net samples  $2^\circ 01-8^\circ 93$  ( $4^\circ 95$ ). Salinity: pump samples 32.73-33.72 (33.02), net samples 32.76-34.06 (33.21). Density: pump samples 25.47-26.52 (26.09), net samples 22.52-26.76 (26.22). pH: pump samples 7.84-8.04 (7.95), net samples 7.68-8.03 (7.82).

Type locality, station 120, at 100 meters; latitude  $47^\circ 02'$  north, longitude  $166^\circ 20'$  east.

#### *Codonellopsis americana* Kofoid and Campbell

*Codonellopsis americana* Kofoid and Campbell, 1929, p. 75, fig. 159.

The moderately tall lorica, with bowl and collar subequal, slightly everted brim, cylindrical collar, rather elongated rough bowl, and subrotund aboral end, has a length of 2.16 oral diameters. The oral margin is sharp-edged and has a little trace of narrow brim. The cylindrical collar (0.41 total length) has 8 spiral turns; of these the uppermost 3 are very narrow, the middle 3 are twice as wide, and the last 2 are yet wider. The fifth turn has a couple of faint oval fenestrae, nearly the width of the turn. The diameter at the neck of the collar is almost the same as the oral diameter; there is a trace of lateral suboral contraction, and there is a slight molding along the edges of each of the turns. The collar is almost transparent. The dense, heavy bowl expands from the neck to its greatest diameter of 1.54 oral diameters near the equator. Below the equator it rapidly rounds off ( $82^\circ$  to  $120^\circ$ ), and the aboral end is blunted.

The wall of the bowl reaches, in places, a thickness of 0.13 oral diameter. Its blobby, rough surface prevents accurate determination. The exterior has large, irregular masses of heavy alveolar tertiary structure.

Length, 76 to 112 $\mu$ .

The *Carnegie* loricae are shorter and stouter, and have wider bowls and more pointed aboral ends than those from the eastern tropical Pacific.

*Codonellopsis americana* resembles *C. indica* (see Marshall, 1934, p. 639) closely, but the aboral end is less pointed, the collar has traces of eversion, and it is without a wide group

of narrow suboral spiral turns; possibly these two species are founded on extremes of a widely distributed species subject to considerable physical variation.

Recorded from four stations, two each in the Atlantic and the Pacific, as follows: one (2) in the Gulf Stream, one (33) in the Caribbean Sea, one (40) in the Galápagos region, and one (158) in the region of South Pacific island fields.

There are 2 pump samples (from the Caribbean Sea) and 3 net samples, of which 1 was taken at the surface, 3 at 50 meters, and 1 at 100 meters. Frequency, minimum.

Temperature: Atlantic, pump samples  $28^{\circ}25-28^{\circ}49$  ( $28^{\circ}36$ ), net sample  $20^{\circ}35$ ; Pacific, net samples  $15^{\circ}33-28^{\circ}14$  ( $21^{\circ}73$ ). Salinity: Atlantic, pump samples  $35.63-36.19$  ( $35.90$ ), net sample  $36.41$ ; Pacific, net samples  $34.89-35.58$  ( $35.23$ ). Density: Atlantic, pump samples  $22.73-23.23$  ( $22.98$ ), net sample  $25.76$ ; Pacific, net samples  $22.80-25.83$  ( $24.31$ ). pH: Atlantic, pump samples  $8.23-8.24$  ( $8.235$ ), net sample  $8.21$ ; Pacific, net samples  $7.87-8.39$  ( $8.13$ ).

**Codonellopsis biedermanni** (Brandt) Kofoid and Campbell

*Codonellopsis biedermanni*, Kofoid and Campbell, 1929, p. 75, fig. 181.

The tall, rather slender lorica, with tightly wrapped spiral collar, slim, elongated bowl, and pointed aboral horn, has a length of 3.88 oral diameters. The thick oral margin is entire. The collar flares ( $43^{\circ}$ ) within the upper one-sixth, and then becomes virtually a cylinder with a diameter of 0.77 oral diameter for the remainder of its length (0.45 total length). It is made up of 28 subequal spiral turns; the uppermost 7 are, however, distinctly narrower than the others. The heavy, narrow bowl forms a subcylindrical neck (within 0.33 oral diameter), and then increases evenly to the maximum diameter of 1.05 oral diameters at 0.7 total length from the rim. Below this level it rapidly declines for about 0.74 oral diameter, reaching, at 0.12 total length above the aboral end, only 0.36 oral diameter. The aboral horn contracts below as a cone ( $33^{\circ}$ ). Its free end is slightly rounded, its sides are full, and the very end is opened by a minute pore.

The wall of the collar is relatively thick (nearly 0.05 oral diameter), and is paralleled by the wall of the bowl (0.065). The horn is also thick (0.13). The wall of the collar has thin, dark inner and outer laminae with three to four layers of minute hexagons enclosed. The wall of the bowl has an inner dark lamina, and there are two to four layers of secondary hexagons or rectangles. The whole bowl is dense brown, and the collar is a lighter shade. The outer surface is neatly trim, and the bowl has small surface hexagons, about 40 across its equator. The surface of the horn is reticulated with larger areas. The horn has a narrow, subcylindrical canal.

Length, 230 to 380 $\mu$ .

*Codonellopsis biedermanni* is closest to *C. meridionalis*, and differs from it in the more tapering, wider bowl as well as in the less abrupt, less sharply distinct aboral horn; the collar, also, is usually relatively longer. These are a unique pair of species, hardly to be confused with others of the group of longer species.

Recorded from two stations in the Pacific, as follows: one

(46) in the Galápagos region, and one (99) in the equatorial region.

There are 2 net samples, of which 1 was taken at 50 and 1 at 100 meters. Frequency, 3 per cent at station 99; average, 2 per cent.

Temperature,  $23^{\circ}26-27^{\circ}84$  ( $25^{\circ}55$ ); salinity,  $35.04-35.33$  ( $35.18$ ); density,  $22.50-24.13$  ( $23.31$ ); pH,  $8.16-8.22$  ( $8.19$ ).

**Codonellopsis brasiliensis** (Brandt) Kofoid and Campbell

*Codonellopsis brasiliensis*, Kofoid and Campbell, 1929, p. 77, fig. 153.

The short, trim lorica, with laterally concave cylindrical collar, conical bowl, and pointed aboral end, has a length of 2.6 oral diameters. The oral margin is rounded over and forms a minute brim. The generally cylindrical, hyaline collar flares ( $20^{\circ}$ ) in the upper 0.52 oral diameter and reaches 0.59 oral diameter at the lower level. There are 6 spiral turns in this section. Below, it rapidly expands ( $14^{\circ}$ ) to the neck, which has a diameter of 1.0 oral diameter and includes 7 progressively wider spiral turns. Some local bulge occurs near the upper end of the section, and one or two round fenestrae are found in the tenth spiral turn. The collar itself has a length of almost 0.47 total length. The dense bowl is rotund; it expands from the neck to nearly 1.35 oral diameters at 0.65 total length, and rapidly ( $45^{\circ}$  to  $110^{\circ}$ ) becomes convex conical below. The aboral end is subhemispherically blunted.

The wall reaches 0.1 oral diameter in thickness across the equator, and thins out above and below. The thickness of the collar is about 0.02 oral diameter. There are large, subrectangular tertiary prisms which enclose three to five layers of smaller hexagons. The wall of the collar has thin laminae which enclose a clear substance. The edges of the successive spiral turns are not thickened. The surface of the bowl has large, irregular areas with smaller hexagons between adjacent patches.

Length, 76 to 111 $\mu$ .

*Codonellopsis brasiliensis* bears close resemblance to *C. caudata*, but has a distinct lateral concavity in the collar, and large surface patches on the bowl; in this latter respect it recalls *C. americana* and its relatives, but differs from these in that the patches are never adherent blobs. Its collar is clearly unlike that of *C. turgescens*, and its bowl is not shaped like that of *C. robusta*.

Recorded from two stations (31, 33) in the Caribbean Sea, in net samples taken at 100 meters. Frequency, 2 to 3 per cent.

Temperature,  $22^{\circ}56-23^{\circ}17$  ( $22^{\circ}86$ ); salinity,  $36.49-36.51$  ( $36.50$ ); density,  $25.03-25.22$  ( $25.12$ ); pH,  $8.18-8.19$  ( $8.185$ ).

**Codonellopsis brevicaudata** (Brandt) Kofoid and Campbell

(Figure 6)

*Codonellopsis brevicaudata*, Kofoid and Campbell, 1929, p. 77, fig. 178; Marshall, 1934, p. 640.

The tall lorica, with greatly elongated collar with brim, round, irregular bowl, and short aboral horn, has a length of 5.1 oral diameters. The smooth oral rim forms a wide ( $80^{\circ}$ ) brim. The distinctly elongated, hyaline, cylindrical

collar continues with the same diameter (0.87 oral diameter) to the bowl, from which it is sharply set off, and is without even traces of local modification. Its length is approximately 0.68 total length. The collar is made up of 26 spiral turns, the uppermost 6 of which are progressively a little less wide than the others; no fenestrae were found. The globose, dense bowl, with a maximum diameter of 1.45 oral diameters, arises from just below the collar, forming a round-shouldered neck with a width of 0.14 oral diameter, and then rapidly curves to the equator. Below its equator the bowl rounds to the aboral end. The aboral horn is conical (25°), and its free end is broken off (?) or else is normally open.

The wall of the collar is rather thick (0.07 oral diameter) and the spiral turns that compose it have optically dense margins. The heavy bowl reaches a thickness little greater than that of the collar (0.08). The collar has laminae which enclose a hyaline substance, and the bowl has one to four layers of small to large rectangular, hexagonal, or irregular alveoles. The surface of the bowl is irregular, and somewhat blobby near its equator, and has irregular secondary structure. In the lorica under discussion there was a large circular internal boss or button *inside* the mid-region of the bowl. The cavity of the horn is cut off from that of the bowl by a thin diaphragm.

Length, 275 $\mu$ .

This lorica is more trim than those described elsewhere. Marshall states that hers was 178 $\mu$  in length.

*Codonellopsis brevicaudata* bears little resemblance to others of the longer species of the genus. Its markedly irregular, swollen bowl, short (?) open horn, and very long, regular collar are characters that distinguish it. The species of the *C. orthoceras* group generally have neat bowls and long aboral horns.

Recorded from one station (18) in the Sargasso Sea, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 20°32; salinity, 36.81; density, 26.07; pH, 8.21.

#### *Codonellopsis contracta* Kofoid and Campbell

*Codonellopsis contracta* Kofoid and Campbell, 1929, p. 78, fig. 147.

The tiny, stout, ovate lorica, with collar shorter than bowl, wide bowl, and broad, rounded aboral end, has a length of 2.5 oral diameters. The simple oral margin is thin-edged. The collar increases in diameter from the margin to the lower end, being a segment of a distinctly concave cone (25°) the length of which is less than 0.33 total length. It has approximately 12 spiral turns, which progressively increase in width as they descend. The lowermost of these distinct, thin-edged turns has a single row of rounded fenestrae (8 to 10) which are the full width of the turn. The aboral flare of the collar merges into the bowl below. The plump little bowl expands from the throat and reaches 2.0 oral diameters at its equator. Below the equator it rapidly rounds off. The aboral end is hemispherical.

The wall of the bowl is thin (as nearly as could be determined, about 0.02 oral diameter). There are minute sec-

ondary (?) alveoles. The aboral half of the bowl is commonly plastered with fecal matter, and small coccoliths are frequent.

Length, 42 to 49 $\mu$ .

The tiny loricae of *Codonellopsis contracta* are difficult to study, but the material collected appears to agree closely with the typical forms. Length is probably related to temperature.

*Codonellopsis contracta* is shorter (42 to 49 $\mu$ ) than *C. pusilla* (56 to 59 $\mu$ ), and stouter (length 2.5 as against 3.08 oral diameters). Its bowl is wider and its aboral end broadly rounded. The bowl lacks surface flecks, is never irregular, and often has coccoliths. It is not closely related to *C. ovata* or to *C. inornata*, both of which are also among the smaller species.

Recorded from six stations, three each in the Atlantic and the Pacific, as follows: two (3, 5-6) in the Atlantic drift, one (13) in the Gulf Stream, one (123) in the East Asiatic marginal sea, and one (130) in the California region.

There are 3 pump and 5 net samples, of which 3 were taken at the surface, 2 at 50 meters, and 3 at 100 meters. Maximum frequency, 16 per cent at station 130; other records above minimum (4 to 8 per cent) from stations 5-6, 13; averages, 1.0 and 3.5 per cent in Atlantic net and Pacific pump samples, respectively.

Temperature: Atlantic, net samples 11°27-13°79 (12°58); Pacific, pump samples 5°0-11°88 (8°61), net sample 8°96. Salinity: Atlantic, net samples 32.68-36.06 (34.88); Pacific, pump samples 32.87-33.72 (33.22), net sample 33.72. Density: Atlantic, net samples 24.94-26.95 (25.94); Pacific, pump samples 25.13-26.14 (25.82), net sample 26.14. pH: Atlantic, net samples 8.10-8.15 (8.12); Pacific, pump samples 7.96-8.11 (8.04), net sample 8.06.

#### *Codonellopsis ecaudata* (Brandt) Kofoid and Campbell

(Figure 7)

*Codonellopsis ecaudata*, Kofoid and Campbell, 1929, p. 79, fig. 154.

The short, neat lorica, with tall, cylindrical collar and oval bowl with aborally rounded end, has a length of 2.88 oral diameters. The thin oral rim is sharp-edged. The long, distinctly hyaline collar (0.47 total length) is a cylinder with only the slightest traces of strictly local contractions and bulges. It is made up of 13 spiral turns. Of these, the first and third are very narrow, but the remainder are subuniform in width. There are 1 or 2 small, faint oval fenestrae (the full width of a single turn) in the seventh and ninth turns. The sides of the collar are not serrate, each turn simply fitting on the top of the succeeding one with a fine, dark external ridge along the edge as a sort of molding. The oval, very dense bowl (contrasting sharply with the collar) expands from the neck, which has the same diameter as the oral opening, to a diameter of 1.47 oral diameters at 0.7 total length below the oral rim. Below this widest level it contracts rapidly, although with full convex sides of approximately 70°, to the aboral end. The aboral end is bluntly but narrowly contracted or, less often, simply rounded off.

The wall of the bowl reaches almost 0.09 oral diameter in thickness at the equator; it thins out above and below. That of the collar is uniformly less than 0.03 oral diameter. There are two or three (usually three) layers of thin-walled hexagonal prisms in the bowl between very thin inner and outer hyaline laminae. In the collar the laminae enclose much finer, primary alveoles. A faint tracery of tertiary structure of coarser mesh encloses the surface mesh of secondary hexagons.

Length, 98 to 110 $\mu$ .

The lorica figured (fig. 7) has an uncommonly sharp aboral end.

*Codonellopsis ecaudata* is close to *C. robusta*, *C. brasiliensis*, and *C. turgescens*. From them it differs mainly in the shape of the aboral end, which is flat in *robusta*, conical-pointed in *brasiliensis*, and pointed in *turgescens*. The bowl is also flat-sided in *robusta*, and wider in *turgescens* than in *ecaudata*. The collar of *turgescens* is swollen in the middle, whereas that of *ecaudata* is cylindrical. All these four species of the equatorial sea are trim, and distinctly different from others.

Recorded from nine stations in the Pacific, as follows: four (45, 46, 78, 80) in the Galápagos region, four (81, 82, 84, 85) in the region of South Pacific island fields, and one (139) in the North Pacific trade region. *Codonellopsis ecaudata* is, thus, fairly compactly distributed.

There are 7 pump and 8 net samples, of which 2 were taken at the surface, 10 at 50 meters, and 3 at 100 meters. Maximum frequency, 6 per cent at station 78; other records above minimum (2 to 5 per cent) from stations 46, 80, 81; averages, 3.1 loricae and 2.1 per cent in pump and net samples, respectively.

Temperature: pump samples 22°78–26°42 (23°73), net samples 22°37–27°89 (25°15). Salinity: pump samples 35.18–36.17 (35.76), net samples 35.23–36.42 (35.79). Density: pump samples 23.56–25.11 (24.29), net samples 23.64–24.33 (23.90). pH: pump samples 8.14–8.28 (8.18), net samples 8.13–8.22 (8.17).

#### *Codonellopsis inflata* Kofoid and Campbell

*Codonellopsis inflata* Kofoid and Campbell, 1929, pp. 80–81, fig. 176.

The moderately tall and stout lorica, with collar somewhat longer than bowl, with everted rim, rotund bowl, and slender, fairly long aboral horn, has a length of 3.74 oral diameters. The oral rim is thin-edged and entire. The collar (0.42 total length in length) has distinct suboral flare (40°) within the uppermost one-tenth. It is cylindrical, with a diameter of 0.83 oral diameter at the aboral end, and has a clean, unmodified lateral contour. There are about 38 decidedly wavy spiral turns, of which the anterior 18 are very narrow (uppermost 0.37 of the collar), and the posterior 20 are subuniformly wider, yet as wavy, save for the last 2 or 3. The neck of the bowl has a width of approximately 0.29 oral diameter, and a diameter at its lower end of 1.0 oral diameter; its sides are rounded concave. The bowl expands from the lower end of the neck to 1.32 oral diameters at 0.58 total length from the rim. Below this widest level it

rapidly contracts (90°) to the aboral end, which has a diameter of nearly 0.25 oral diameter. The aboral horn is almost cylindrical, with a length of 1.0 oral diameter and with a bluntly pointed free tip.

The wall of the collar hardly reaches 0.02 oral diameter in thickness, but that of the more or less uniform bowl has a thickness of 0.08. The collar is hyaline and the bowl is dense. There are thin laminae in both collar and bowl; in the layer thus enclosed are two or three rows of rounded alveoles. The surface of the bowl has tiny, rounded secondary areas, as does also the horn. The horn has a wide cavity, quite cut off from that of the bowl by a depressed diaphragm.

Length, 130 to 224 $\mu$ .

The *Carnegie* loricae agree precisely with those of the authors of the species.

*Codonellopsis inflata* has a wider bowl than any other of the species related to *C. orthoceras*. Of these, it is closest to *C. pacifica*, from which it may be distinguished by the cylindrical aboral horn and the many wavy spiral turns in the collar.

Recorded from one station (80) in the Galápagos region, in a net sample taken at 50 meters. Frequency, 2 per cent.

Temperature, 26°06; salinity, 35.95; density, 23.75; pH, 8.19.

#### *Codonellopsis longa* Kofoid and Campbell

(Figure 5)

*Codonellopsis longa* Kofoid and Campbell, 1929, p. 82, fig. 180.  
*Codonellopsis orthoceras*, Hofker, 1931, pp. 367–369, figs. 47–48A.

The elongated lorica, with long collar, egg-shaped bowl, and long aboral horn, has a length of 4.35 oral diameters. The oral margin is flat. The collar has little flare (53°), well within the upper one-tenth. The long collar (0.45 total length in length) is virtually a cylinder with a diameter at the base of over 0.85 oral diameter. It is made up of 20 subequal spiral turns with molded edges. The bowl has a length of 1.6 oral diameters and reaches its maximum diameter of 1.21 oral diameters near 0.63 total length below the rim. The neck is swollen to 1.0 oral diameter just below its junction with the collar and contracted to 0.85 oral diameter at 0.49 total length below the rim. The aboral diameter of the bowl is only 0.28 oral diameter. The aboral horn is conical (12°), 0.82 oral diameter in length, and sharply pointed.

The wall of the hyaline collar has a thickness of about 0.03 oral diameter, and that of the dense, brown bowl is 0.09 oral diameter. There are thin laminae which, in the collar, enclose hyaline material; in the bowl there are two to five layers of small hexagons, and larger tertiary structures enclose the smaller hexagons in groups. The surface of the bowl has small secondary hexagons enclosed by faint, larger tertiary hexagonal meshwork. The cavity of the horn is separated from that of the bowl by a thin diaphragm.

Length, 235 to 294 $\mu$ .

Hofker's material may not all belong to *Codonellopsis longa*; his figure 48A strongly suggests *C. parva*.

*Codonellopsis longa* has a subcylindrical rather than wide conical collar, the latter shape being distinctive of *C. orthoceras*. It has a longer collar than *C. pacifica*, and, in addition, a longer bowl and horn than *C. speciosa*. The collar is concave in *C. tessellata*, and the bowl is egg-shaped rather than potlike. It is not especially difficult to separate *longa* from related species of the tropical plankton.

Recorded from thirty-six stations, thirteen in the Atlantic and twenty-three in the Pacific, as follows: three (2, 15, 16) in the Gulf Stream, two (17, 18) in the Sargasso Sea, six (22, 25, 27, 28, 29, 30) in the Atlantic equatorial region, two (31, 32) in the Caribbean Sea, two (35-36, 99) in the Pacific equatorial region, five (46, 47, 75, 77, 80) in the Galápagos region, seven (48, 81, 82, 85, 95, 158, 159) in the region of South Pacific island fields, three (100, 150, 151) in the North Pacific trade region, one (113) in the North Pacific middle latitudes, and five (133, 136, 137, 147, 149) in the California region. *Codonellopsis longa* is a widely distributed species of the warmer regions of the ocean, and avoids, as these and other records show, only the cooler waters of the polar seas and waters contributed by them.

There are 8 pump and 42 net samples, of which 9 were taken at the surface, 18 at 50 meters, and 23 at 100 meters. Maximum frequency, 29 per cent at station 81; other records above minimum (2 to 18 per cent) from stations 2, 16, 22, 32, 35-36, 46, 48, 75, 77, 80, 81, 85, 95, 99, 100, 113, 136, 137, 147, 149, 151, 158, 159; averages in net samples, 2.9 and 6.8 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, pump samples  $19^{\circ}27-23^{\circ}64$  ( $21^{\circ}50$ ), net samples  $14^{\circ}60-27^{\circ}88$  ( $21^{\circ}57$ ); Pacific,  $18^{\circ}51-27^{\circ}62$  ( $24^{\circ}35$ ) and  $18^{\circ}40-28^{\circ}74$  ( $24^{\circ}32$ ), respectively. Salinity: Atlantic, pump samples 36.41-36.47 (36.44), net samples 35.70-36.82 (36.37); Pacific, 34.70-36.46 (35.67) and 34.42-36.44 (35.34), respectively. Density: Atlantic, pump samples 24.84-26.12 (25.48), net samples 23.26-26.62 (24.79); Pacific, 22.31-26.65 (24.35) and 22.31-25.55 (22.71), respectively. pH: Atlantic, pump samples 8.21-8.23 (8.22), net samples 7.93-8.30 (8.19); Pacific, 8.18-8.31 (8.21) and 8.10-8.39 (8.25), respectively.

#### *Codonellopsis meridionalis* Kofoid and Campbell

*Codonellopsis meridionalis* Kofoid and Campbell, 1929, pp. 82-83, fig. 177.

The stout lorica, with subequal collar and bowl and long aboral horn, has a length of 3.82 oral diameters. The rather thick oral margin is smooth and flat. The long collar (0.43 total length) is abruptly everted ( $50^{\circ}$ ) well within the upper one-tenth and forms an inverted truncate cone ( $5^{\circ}$ ) in the remainder. The diameter at its lower end is 0.83 oral diameter. There are no local changes in lateral contour save as the spiral turns form a serrate edge as they overlap one another. There are 22 spiral turns, of which the anterior 10 are very narrow and the posterior 12 are at least twice as wide. The wider turns are not strictly subequal in width. The bowl forms a low neck, the width of which is approximately 0.33 oral diameter and the aboral diameter 1.0 oral diameter. The rather stout bowl expands rapidly below the

truncate laterally concave-subconical ( $22^{\circ}$ ) neck, which is rounded at its junction with the collar, and reaches a maximum diameter of 1.25 oral diameters at 0.59 total length from the rim. The aboral part is rotund subangular ( $90^{\circ}$ ), and reaches a diameter of 0.33 oral diameter near 0.8 total length from the rim. The aboral horn is long (0.6 oral diameter), conical ( $12^{\circ}$ ), rough-walled, and blunt at the free tip.

The wall of the collar reaches the unusual thickness of nearly 0.05 oral diameter, and that of the bowl is nearly 0.16. The wall of the collar has a dark inner lamina and there are three to five layers of minute hexagons. The wall of the bowl also has a thick inner lamina and two to four layers of large secondary hexagons. The surface of the bowl is rather trim, with small hexagons, but the horn is roughly canaliculate. The horn is penetrated by a wide canal and cut off from the cavity of the bowl by a thick diaphragm. Collar and bowl are of a rich brown color, the latter more strongly so.

Length, 197 to 245 $\mu$ .

*Codonellopsis meridionalis* is close to *C. biedermani*, from which species it differs in the abruptly set-off, narrow aboral horn, tapering collar, and wider bowl. These two species can scarcely be confused with others.

Recorded from three stations (35, 35-36, 155) in the Pacific, all in the equatorial region.

There are 4 net samples, of which 1 was taken at the surface, 2 at 50 meters, and 1 at 100 meters. Frequency, 50 per cent at station 35-36, 10 per cent at station 35; elsewhere, minimum.

Temperature,  $14^{\circ}33-27^{\circ}71$  ( $19^{\circ}44$ ); salinity, 34.88-34.93 (34.90); density, 22.46-26.06 (24.70); pH, 7.88-8.30 (8.03).

#### *Codonellopsis minor* (Brandt) Kofoid and Campbell

*Codonellopsis minor*, Kofoid and Campbell, 1929, p. 83, fig. 168.

The rather short lorica, with conical, everted collar, long bowl, and short, conical aboral horn, has a length of 2.3 oral diameters. The oral margin is sharp-edged. The collar flares ( $32^{\circ}$ ) within the upper one-tenth and is inverted subconical ( $10^{\circ}$ ) for the remainder of its length. Its diameter at the lower end is 0.92 oral diameter. In lateral contour it is full but with local modifications. There are 11 spiral turns, of which the anterior 2 are somewhat less wide than the others. All the turns are outwardly concave and have optically dark thickened margins. The neck of the bowl is contracted from the throat, having a diameter at its lower end of 0.85 oral diameter at 0.34 total length from the rim. The line of junction with the collar and bowl is wavy. The bowl rapidly expands below the neck to 1.25 oral diameters at 0.57 total length below the rim. Below this equator it contracts ( $85^{\circ}$ ) as a decidedly convex hemisphere. The aboral horn is short (0.33 oral diameter), conical ( $25^{\circ}$ ), and blunt; its anterior diameter is 0.26 oral diameter.

The wall of the collar is thick (over 0.08 oral diameter) and that of the bowl is similar. There are thin laminae with enclosed hyaline material in the collar, and two to three layers of small hexagons in the bowl; in the bowl are also

larger, rectangular, thick-walled tertiary areas. The surface of the bowl clearly shows the tertiary areas as hexagons, about 20 in number, across its equator, and 10 to 14 secondary hexagons are enclosed by each of the thicker-walled, larger areas. The horn is similar to the bowl. The cavity of the horn is cut off from that of the bowl by a diaphragm formed by the inner lamina. This cavity is wide and rather closely follows the outer contour.

Length, 125 to 207 $\mu$ .

*Codonellopsis turgida* and *C. pura* both have much shorter and wider bowls than the present species. The collar of *C. minor* is longer than in these two species. *Codonellopsis parva* has a longer horn, wider bowl, and shorter, more conical collar. *Codonellopsis californiensis* hardly has a horn at all, and its bowl is wider than in *minor*. *Codonellopsis speciosa* has a longer horn and different bowl.

Recorded from ten stations, five each in the Atlantic and the Pacific, as follows: one (16) in the Gulf Stream, three (24, 25, 27) in the Atlantic equatorial region, one (33) in the Caribbean Sea, three (41, 46, 80) in the Galápagos region, one (107) in the North Pacific trade region, and one (153) in the Pacific equatorial region.

There are 9 pump and 3 net samples, of which 7 were taken at 50 meters and 5 at 100 meters. Maximum frequency, 3 per cent at station 46; frequency 2 per cent at stations 16, 24; other records, minimum; average in Atlantic net samples, 1.5 per cent.

Temperature: Atlantic, pump samples 14°60–28°25 (23°13), net samples 23°12–23°64 (23°38); Pacific, 22°73–26°92 (24°12) and 14°55, respectively. Salinity: Atlantic, pump samples 35.70–36.25 (36.11), net samples 36.00–36.41 (36.20); Pacific, 34.73–36.21 (35.27) and 35.02, respectively. Density: Atlantic, pump samples 23.23–26.02 (24.66), net samples 24.67–24.84 (24.75); Pacific, 22.63–24.70 (23.82) and 26.11, respectively. pH: Atlantic, pump samples 7.93–8.30 (8.16), net samples 8.14–8.23 (8.18); Pacific, 8.16–8.28 (8.21) and 7.92, respectively.

#### *Codonellopsis orientalis* Hada

*Codonellopsis orientalis* Hada, 1932b, pp. 563–564, fig. 15.

The fairly tall, clean lorica, with subcylindrical collar, ovate bowl, and broadly convex-conical aboral region, has a length of 2.60 to 2.76 oral diameters. The thin oral margin is rounded. The collar is generally cylindrical, although there is slight suboral flare (45°) within the upper 0.21 of the length of the collar in some loricae; in these the aboral diameter of the collar is 0.91 oral diameter. The collar is made up of 8 to 12 spiral turns, the uppermost 3 or 4 being much narrower than the others, which are more or less uniform. Oval fenestrae (the full width of a turn) occur in the sixth and also sometimes in the seventh turn. The collar has a length of 0.3 to 0.4 total length, and commonly, but not always, bulges in the middle (0.92 oral diameter). The ovate bowl expands from the neck to its greatest diameter of 1.52 to 1.57 oral diameters near 0.55 total length from the rim. Below this level the bowl contracts with full convex-conical sides (85° to 105°) to the blunt, rounded aboral end.

The wall of the collar is hyaline and uniformly thin (0.04

oral diameter), and has fine primary alveoles enclosed within its laminae. The wall of the dense bowl is thicker (0.08 oral diameter) across the middle and thins above and below; it is made up of large, blobby secondary prisms. The outer surface is decidedly irregular, with coarse blocks of alveolar material of diverse shapes.

Length, 84 to 93 $\mu$ .

*Codonellopsis orientalis* bears some likeness to members of the *C. morchella* group, but differs from them mainly in the shape of the aboral end. This tropical assembly of species has a distinctive facies rather difficult to describe in words.

Recorded from one station (117) in the North Pacific middle latitudes, in 2 net samples, 1 each taken at 50 and 100 meters. Frequency not over 2 per cent.

Temperature, 8°93–12°56 (10°74); salinity, 34.06–34.22 (34.14); density, 25.89–26.41 (26.15); pH, 7.98–8.06 (8.02).

#### *Codonellopsis pacifica* (Brandt) emended Kofoid and Campbell

*Codonellopsis pacifica*, Kofoid and Campbell, 1929, p. 85, fig. 175.

The moderately tall lorica, with collar longer than bowl, wide, globose bowl, and long, narrow horn, has a length of 3.67 oral diameters. The thin oral margin is everted and flaring (63°) within the uppermost one-tenth. The collar is 0.41 total length, truncate, inverted conical (5°), with a diameter at the lowermost end of nearly 0.75 oral diameter, and with bare lateral concavity. There are 24 spiral turns, the upper 6 being narrow and the remainder wider. Of the wide ones, some are narrower than others. The bowl has a more or less cylindrical neck with a width of 0.3 oral diameter, and a diameter at its lower end of 0.91 oral diameter. The bowl rounds from this neck to 1.17 oral diameters at 0.57 total length below the rim, and then contracts convex-conically (90°) to the aboral end, the diameter of which is less than 0.33 oral diameter. The conical (6°) aboral horn has a length of 1.0 oral diameter, and its free tip is blunt.

The wall of the collar is thin (0.02 oral diameter), and that of the bowl is thicker (0.08). Thin, hyaline laminae enclose colorless material, and the bowl has single or double layers of large, often rectangular secondary prisms. The surface of the bowl has rather small rounded areas, and scattered yet larger round areas of several sizes. Coccoliths are common on the surface. The horn has a similar surface and is hollow and irregularly but widely canaliculate, and has a thin, depressed diaphragm which cuts its cavity from that of the bowl. The collar is glass-clear and the bowl dense.

Length, 195 to 270 $\mu$ .

*Codonellopsis pacifica* differs from *C. longa* in being shorter and rather more plump, and having a shorter horn and a collar with fewer turns. The bowl is not so expanded as that of *C. inflata*; the collar is longer than in *C. speciosa*, and less conical than in *C. orthoceras*.

Recorded from four stations in the Pacific, as follows: three (45, 46, 78) in the Galápagos region, and one (81) in the region of South Pacific island fields.



There are 5 net samples, all taken at 50 meters. Frequency, 2 per cent at stations 78, 81.

Temperature, 22°37–26°42 (23°94); salinity, 35.23–36.03 (35.55); density, 23.56–24.33 (24.08); pH, 8.13–8.17 (8.15).

### *Codonellopsis parva* Kofoid and Campbell

(Figures 2, 3)

*Codonellopsis parva* Kofoid and Campbell, 1929, p. 86, fig. 170.

The rather short, stout lorica, with collar and bowl more or less subequal, and with short neck, rounded bowl, and conical aboral horn, has a length of 2.16 to 3.34 oral diameters. The oral margin is thin-edged, and there is some suboral eversion with flare (58°), or even a flat brim. The collar (0.32 to 0.38 total length) is a segment of an inverted truncated cone (3° to 4°) with a diameter at the aboral end of 0.79 oral diameter. The sides show almost no lateral modification in contour. The collar is made up of 15 to 17 spiral turns, of which the anterior 3 or 4 are a little narrower than the others; the remainder are subequal, and all have thin, molded edges. One or two of the turns overlap. The neck is rounded, with a maximum diameter of 0.93 oral diameter and contraction below (0.83 oral diameter); this contraction is at 0.37 to 0.46 total length below the rim and marks the lower limit of the neck. The bowl swells rapidly from the neck and reaches as much as 1.32 oral diameters near 0.56 total length. The full, convex lower bowl contracts evenly and reaches 0.28 oral diameter at 0.83 total length. The aboral horn is conical (11° to 15°), with a length of 0.52 to 0.62 oral diameter, and has a blunted to sharply pointed free tip.

The wall of the collar is only 0.02 oral diameter in thickness, or less, but that of the bowl is nearly 0.07. The bowl has large, mostly rectangular tertiary areas in one or two layers, with pallid contents. The surface of the bowl has a subequal mesh of tertiary areas; rarely are there (4) hemispherical bosses of small secondary hexagons built into the equatorial region. The wall of the horn is reticulate. The cavity of the bowl is separated from that of the horn by a thin diaphragm.

Length, 145 to 187 $\mu$ .

The *Carnegie* loricae are longer and commonly more slender than those described elsewhere.

*Codonellopsis parva* has a shorter, less stout, narrower bowl and longer horn than *C. pura*. Its collar is not so long as that of *C. speciosa*, and its horn is narrower and more abruptly limited. The horn is not so long as in *C. minor*, and the bowl not so swollen as that of *C. turgida*. *Codonellopsis pacifica* has a taller collar and much longer horn.

Recorded from thirteen stations, seven in the Atlantic and six in the Pacific, as follows: one (2) in the Gulf Stream, one (20) in the Sargasso Sea, three (23, 25, 28) in the Atlantic equatorial region, two (33, 34) in the Caribbean Sea, one (77) in the Galápagos region, one (100) in the North Pacific trade region, three (153, 154, 155) in the Pacific equatorial region, and one (157) in the region of South Pacific island fields.

There are 15 net samples, of which 2 were taken at the

surface, 6 at 50 meters, and 7 at 100 meters. Maximum frequency, 26 per cent at station 154; other records above minimum (2 to 8 per cent) from stations 2, 20, 23, 25, 77, 100, 153, 157; average in the Pacific, 8.4 per cent.

Temperature: Atlantic, 14°60–26°79 (22°12); Pacific, 22°73–27°76 (25°96). Salinity: Atlantic, 35.70–36.73 (36.32); Pacific, 34.71–36.04 (35.08). Density: Atlantic, 23.79–26.02 (25.18); Pacific, 22.31–24.53 (23.16). pH: Atlantic, 7.93–8.26 (8.16); Pacific, 7.93–8.32 (8.20).

### *Codonellopsis pura* (Brandt) emended Kofoid and Campbell

(Figure 1)

*Codonellopsis pura*, Kofoid and Campbell, 1929, pp. 86–87, fig. 169.

The short, plump lorica, with collar shorter than bowl, wide bowl with stout neck, and tiny knoblike aboral horn, has a length of 2.22 oral diameters. The thin oral margin has a recurved brim (not clearly shown in the figure), and a subcylindrical collar the length of which is only 0.29 total length; its aboral diameter is 0.83 oral diameter. Local modifications are absent. There are 9 subequal spiral turns, each with thickened edges. The neck is a convex ring. Its greatest diameter is 0.89 oral diameter, its least, at the lower end, is 0.83, and its width is nearly 0.29 oral diameter. The rotund bowl swells out to a maximum, at its equator, of 1.29 oral diameters; this is at 0.63 total length from the rim. Below its equator the bowl is hemispherical. The short aboral horn is conical (25°), and only 0.2 oral diameter in length; its free tip is squared off.

The wall of the collar is only 0.02 oral diameter in thickness, and that of the bowl is subuniformly nearly 0.07. There is a dark inner lamina. The bowl is rather pallid, with only large, narrow, rectangular tertiary areas clearly marked. The surface shows large, thin-walled, overlapping circles. The collar is nearly transparent and the bowl is somewhat denser. A diaphragm separates the cavity of bowl and horn.

Length, 125 to 195 $\mu$ .

The *Carnegie* loricae are shorter, with a convex neck, and have shorter horns than the originals.

*Codonellopsis pura* has a shorter horn, a wider bowl, and a shorter collar than either *C. parva* or *C. minor*. Its collar is shorter and its horn better developed than in *C. californiensis*. The bowl is not so wide as that of *C. turgida*.

Recorded from eleven stations, six in the Atlantic and five in the Pacific, as follows: one (18) in the Sargasso Sea, five (22, 23, 24, 25, 27) in the Atlantic equatorial region, two (77, 80) in the Galápagos region, two (81, 157) in the region of South Pacific island fields, and one (100) in the North Pacific trade region.

There are 2 pump samples from the Pacific, and 10 net samples, of which 6 were taken at 50 meters and 6 at 100 meters. Maximum frequency, 6 per cent at station 81; frequency 4 per cent at station 157; all the remainder minimum; the average frequency in Pacific net samples is 3.6 per cent.

Temperature: Atlantic, net samples 14°60–26°04 (19°16); Pacific, pump samples 23°69–27°62 (25°65), net samples

26°06–27°03 (26°47). Salinity: Atlantic, net samples 35.61–36.81 (36.07); Pacific, pump samples 34.70–36.04 (35.37), net samples 35.24–35.95 (35.68). Density: Atlantic, net samples 23.98–26.62 (25.66); Pacific, pump samples 22.31–24.54 (23.42), net samples 22.91–23.75 (23.40). pH: Atlantic, net samples 7.93–8.30 (8.13); Pacific, pump samples 8.19–8.22 (8.20), net samples 8.19–8.32 (8.23).

*Codonellopsis pusilla* (Cleve) Kofoid and Campbell

(Figure 8)

*Codonellopsis pusilla*, Kofoid and Campbell, 1929, p. 87, fig. 146; Hada, 1932b, pp. 561–562, fig. 12.

The short, plump lorica, with short collar of few turns and longer swollen bowl with blunted aboral end, has a length of 3.08 oral diameters. The oral margin is thin and rounded. The hyaline collar is a concave segment of a cone (14°) the basal diameter of which is 1.28 oral diameters. It is composed of 5 turns, the lower 3 of which are wider than the upper 2. There is a single ovate fenestra between the last 2 turns. The swollen, dense bowl expands from the throat, reaches nearly 2.0 oral diameters at its equator, and then contracts (within 125°) to the broadly oval aboral end.

The wall reaches 0.07 oral diameter in thickness in the bowl, where it is practically uniform; in the collar it is less than half as thick. There is only a single layer of rectangular secondary alveoles in the bowl; in both collar and bowl very fine primary alveoles are visible under the best magnification. The outer surface is made up of distinct but small hexagons. Rarely are there a few agglomerated alveolar flecks on the surface.

Length, 56 to 59 $\mu$ .

Some loricae have pointed instead of ovate aboral ends. The collar may have as many as 13 narrow spiral turns, fenestrae may be lacking, and the length may reach 2.6 oral diameters.

*Codonellopsis pusilla* differs from *C. contracta* in size and proportions, in having fewer fenestrae if any, and in the shape of the aboral end, which is decidedly broad in *contracta*. These two are the smaller species of the cooler, northern ocean, and are not readily comparable with those of the tropics or Antarctic; among the latter are two (*C. glacialis* and *C. gausi*) peculiar species, the origin of which must have been in tropical species. So also must have been the origin of the northern neritic *C. frigida* and *C. borealis*. The former of these last two species is much like *pusilla*.

Recorded from five stations, two in the Atlantic and three in the Pacific, as follows: two (5-6, 6) in the Atlantic drift, two (116, 117) in the North Pacific middle latitudes, and one (118) in the East Asiatic marginal sea.

There are 1 pump sample and 6 net samples, of which 3 were taken at the surface, 3 at 50 meters, and 1 at 100 meters. Maximum frequency, 50 per cent at station 117; other records above minimum (2 to 23 per cent) from stations 6, 116, 118; averages, 11.2 and 33 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, net samples 11°62–12°44 (11°97); Pacific, pump sample 10°18, net samples 11°18–12°56

(11°87). Salinity: Atlantic, net samples 35.51–35.55 (35.53); Pacific, pump sample 33.61, net samples 33.79–34.22 (34.00). Density: Atlantic, net samples 26.95–27.21 (27.03); Pacific, pump sample 25.85, net samples 25.83–25.89 (25.86). pH: Atlantic, net samples 8.08–8.15 (8.12); Pacific, pump sample 8.21, net samples 8.06–8.11 (8.08).

*Codonellopsis speciosa* Kofoid and Campbell

(Figure 4)

*Codonellopsis speciosa* Kofoid and Campbell, 1929, p. 88, fig. 174.

The elongated lorica, with long, little-everted collar, stout bowl, and stout, long aboral horn, has a length of 4.2 oral diameters. The oral margin is thin-edged and sharp. The long collar (0.42 total length) has some suboral eversion and a low, rounded brim. The collar is a truncated segment of an inverted cone (8°) and has a basal diameter of 0.81 oral diameter. It is made up of 18 subequal spiral turns. The neck is swollen (0.85 oral diameter) and then constricted (0.81 oral diameter), all within 0.22 oral diameter. The wide, elongated bowl rapidly swells to a maximum of 1.26 oral diameters at 0.59 total length below the rim. Below this level it gradually decreases (75° to 80°), reaching at 0.75 total length a diameter of nearly 0.56 oral diameter. Below this last level it becomes a short segment of an inverted truncated cone (35°) with a length of 0.37 oral diameter, and has a diameter at its lower end of almost 0.3 oral diameter. The aboral horn is conical (15°), with a length of 0.7 oral diameter, and is blunted at its free tip.

The thin, hyaline collar (0.02 oral diameter in thickness) is in contrast with the thicker (0.075), dense bowl. There are thin laminae which in the collar develop hyaline enclosed material, and in the bowl two or three layers of small prisms; large tertiary structures in one or two layers enclose the secondary prisms. The surface of the bowl shows a faint tracery of large, circular tertiary areas. The cavity of the bowl is cut off from that of the horn by a horizontal diaphragm.

Length, 181 to 225 $\mu$ .

In the aboral projection of the bowl as well as in the greater elongation, the *Carnegie* loricae differ from those originally described. The collars are longer, and the horns more emergent.

*Codonellopsis speciosa* has a longer, stouter bowl and shorter, stouter horn than *C. pacifica*. Its collar is longer, its bowl different, and its horn longer than in *C. parva*. *Codonellopsis inflata* has an even wider, shorter bowl, a longer, more slender aboral horn, and a collar with wavy margins on the spiral turns.

Recorded from three stations, one in the Atlantic and two in the Pacific, as follows: one (23) in the Atlantic equatorial region, one (45) in the Galápagos region, and one (152) in the Pacific equatorial region.

There are 2 pump samples from the Pacific, and 3 net samples, of which 2 were taken at 50 meters and 3 at 100 meters. Maximum frequency, 2 per cent at station 152; other records all minimum; average in Pacific pump samples, 1.5 loricae.

Temperature: Atlantic, net sample 36°02; Pacific, pump samples 11°48–14°32 (12°90), net samples 21°69–22°37 (22°03). Salinity: Pacific, pump samples 34.50–34.73 (34.61), net samples 35.21–35.23 (35.22). Density: Pacific, pump samples 25.75–26.50 (26.12), net samples 24.30–24.48 (24.39). pH: Atlantic, net sample 8.18; Pacific, pump samples 7.76–7.87 (7.81), net samples 8.12–8.13 (8.125).

#### *Codonellopsis turgescens* Kofoid and Campbell

*Codonellopsis turgescens* Kofoid and Campbell, 1929, p. 90, fig. 155.

The short, neat lorica, with swollen cylindrical collar, rather wide, distinctly oval bowl, and pointed aboral end, has a length of 3.5 oral diameters. The thin oral rim is sharp-edged. The collar flares (37°) within its upper one-tenth, expands slowly and evenly, and reaches 1.17 oral diameters near 1.0 oral diameter below the rim. This swollen region occupies a band with a width of approximately 0.8 oral diameter. The diameter of the collar at the neck is about 0.91 oral diameter. The collar itself has a length of 0.43 total length and there are 14 subuniform spiral turns. The clean-cut bowl expands from the neck rapidly, reaching 1.43 oral diameters at 0.62 total length below the rim, and rapidly contracts as an inverted full convex-conical (47° to 110°) section. The aboral end is barely pointed.

The wall reaches nearly 0.09 oral diameter in thickness at the equator of the dense, brown bowl, and rapidly thins above and below. That of the collar is uniformly about 0.03 oral diameter. There are two or three layers of thin-walled, hexagonal prisms in the bowl, enclosed by laminae. In the hyaline collar there are very fine alveoles. A faint tertiary mesh encloses irregular groups of secondary meshes in the bowl.

Length, 88 to 100 $\mu$ .

*Codonellopsis turgescens* resembles *C. ecaudata*, but differs in having a swollen collar instead of a cylindrical one. From *C. robusta* it differs in that the latter has a short, potlike bowl as well as a different collar. *Codonellopsis turgescens* may be distinguished from *C. brasiliensis* mainly by the collar, which in *brasiliensis* is concave-cylindrical. The shape of the aboral end is less distinctive in *turgescens* than in *robusta*.

Recorded from one station (46) in the Galápagos region, in a net sample taken at the surface. Frequency, minimum.

Temperature, 23°30; salinity, 35.32; density, 24.11; pH, 8.16.

#### *Codonellopsis turgida* Kofoid and Campbell

(Figure 9)

*Codonellopsis turgida* Kofoid and Campbell, 1929, p. 90, fig. 167.

The short, stout lorica, with short, wide collar, very plump, rotund bowl, and strictly conical aboral horn, has a length of 1.75 oral diameters. The thin oral margin is sharp-edged. The collar (0.63 total length) is an inverted truncated cone (18°) with a lower diameter of 0.84 oral diameter; the full sides lack even local modifications in contour. There are 12 subuniform, narrow spiral turns with dark edges and plane sides. The bowl has a very low neck, the lower diameter of which is only a little more than at the throat, and which is at

0.66 total length from the rim. The bowl rapidly swells to 1.24 oral diameters at 1.0 oral diameter from the rim. Below its equator the bowl decreases as a hemisphere in diameter. The aboral horn (0.18 oral diameter in length) is conical (45°), with a basal diameter of 1.33 its own length, and is blunt at the free tip.

The wall of the collar is only 0.02 oral diameter in thickness, and that of the bowl is thicker (0.04). There are thin laminae which in the collar enclose hyaline material, but which in the bowl enclose two or three layers of hexagons. The surface has uniform small circles of secondary prisms. The contour of the dense bowl is irregular. The cavity of the horn is cut off from that of the bowl by a continuation of the inner lamina of the bowl.

Length, 112 $\mu$ .

The *Carnegie* loricae are shorter (112 $\mu$  as against 143 to 170 $\mu$ ) and wider and have more and narrower spiral turns in the collar than do those figured elsewhere, and have no suboral flare.

The wide, swollen bowl and short horn at once set *Codonellopsis turgida* apart from its near relatives, *C. pura* and *C. parva*. Its bowl is not so long as in *C. minor*, nor is the horn so short as in *C. californiensis*.

Recorded from five stations, two in the Atlantic and three in the Pacific, as follows: two (23, 25) in the Atlantic equatorial region, one (77) in the Galápagos region, one (81) in the region of South Pacific island fields, and one (99) in the Pacific equatorial region.

There are 5 net samples, of which 1 was taken at the surface, 1 at 50 meters, and 3 at 100 meters. Maximum frequency, 9 per cent at station 99; frequency, 4 per cent at station 81; other records minimum; average in the Pacific, 4.6 per cent.

Temperature: Atlantic, 14°60; Pacific, 22°72–27°84 (24°29). Salinity: Atlantic, 35.70–36.02 (35.86); Pacific, 35.04–36.04 (35.64). Density: Atlantic, 26.62; Pacific, 22.50–24.53 (23.53). pH: Atlantic, 7.93–8.18 (8.05); Pacific, 8.19–8.22 (8.20).

#### DICTYOCYSTIDAE Haeckel emended

Dictyocystidae, Kofoid and Campbell, 1929, p. 285.

The family includes four genera: *Luminella*, *Wangiella*, *Dictyocysta*, and *Waillesia*. Of these only *Dictyocysta* was found in the *Carnegie* material. The other genera are coastal, and *Luminella* and *Waillesia* are being newly established by Kofoid and Campbell (1939, p. 284). *Wangiella* is also rather recently established (D. Nie, 1934). The family is allied to the Codonellidae but not closely, and to the Codonellopsidae but perhaps more distantly. *Dictyocysta* is eupelagic.

#### DICTYOCYSTA Ehrenberg emended

*Dictyocysta*, Kofoid and Campbell, 1929, p. 285.

The extraordinary genus *Dictyocysta* is allied to *Luminella*, a genus being established by Kofoid and Campbell (1939, p. 284). *Luminella* is like *Stenosemella* save that the collar has demilunes. Closer, perhaps, is *Wangiella*, with *W. dicol-*

*laria*, from the coast of China. Kofoid and Campbell (1929) placed *Dictyocysta* among the more complex Tintinnoina, between the Undellidae and Tintinnidae, only to insure its isolation from *Codonella*, to which it had previously been allied.

*Dictyocysta* is found abundantly in the tropics, although some species are northern in distribution in the Atlantic. None is antarctic.

Seventeen species are described here.

#### *Dictyocysta dilatata* Brandt

*Dictyocysta dilatata*, Kofoid and Campbell, 1929, p. 288, fig. 549.

The regular, fairly large lorica, with *mitra*-like fenestration, distinct set-off collar, and pointed aboral end, has a length of 1.4 oral diameters. The oral rim has 8 flattened arches and is decidedly undulating. The collar is inverted subconical, flaring ( $22^\circ$ ); its length is 0.23 total length; its diameter at the lower end is 0.89 oral diameter; and it has 8 rounded, subequal, rectangular windows with heavy beams and mullions. The bowl is acorn-like, without shoulder, and reaches a maximum diameter of 1.0 oral diameter at 0.58 total length from the oral rim. The aboral region is convex conical ( $62^\circ$ ), and the aboral end is pointed.

The wall of the bowl has a maximum of 7 vertical rows of unequal, squarish to rounded, rarely subpentagonal fenestrae. These fenestrae number 12, 12, 16, 8, 6, and 5 respectively in horizontal rows. The smaller ones are mostly in the aboral 3 rows. The framework which encloses the windows is thick and heavy. All windows are closed by hyaline panes.

Length, 58 to 70 $\mu$ .

*Dictyocysta dilatata* is of the general *D. mitra* type. It differs from *mitra* in the shape of the collar, pointed aboral end, and trimmer form. *Dictyocysta obtusa* lacks clear distinction between collar and bowl, as does also *D. fenestrata*; and *D. spinosa*, though of similar type, has oral spinules. On the whole, *dilatata* is a clear-cut, easy species to recognize.

Recorded from ten stations in the Pacific, as follows: four (54, 62-63, 64, 65) in the South Pacific middle latitudes, one (68) in the Galápagos region, one (110) in the North Pacific trade region, two (131, 148) in the California region, and two (142, 145) in the North Pacific middle latitudes.

There are 4 pump and 8 net samples, of which 3 were taken at the surface and 9 at 100 meters. Maximum frequency, 12 per cent at station 131; other records above minimum from stations 54, 65, 68, 145; average in net samples, 4.3 per cent.

Temperature: pump samples  $16^\circ 58$ – $20^\circ 10$  ( $17^\circ 88$ ), net samples  $12^\circ 12$ – $20^\circ 61$  ( $17^\circ 62$ ). Salinity: pump samples 34.47–34.95 (34.71), net samples 34.30–35.35 (34.56). Density: pump samples 24.72–25.15 (24.96), net samples 24.33–25.52 (25.00). pH: pump samples 8.14–8.31 (8.24), net samples 8.10–8.32 (8.15).

#### *Dictyocysta duplex* Brandt emended Kofoid and Campbell

*Dictyocysta duplex*, Kofoid and Campbell, 1929, p. 289, fig. 564.

The large lorica, with collar resembling a colonnade of a Greek temple, globose bowl, and "duplex" fenestration, has

a length of 1.56 oral diameters. The oral rim is smooth, and lacks the arches characteristic of many other species. The collar is 0.75 oral diameter in length, cylindrical, and formed by 7 tall, rectangular, subequal windows with rounded edges (height of windows is 1.2 their width) and with hyaline, rodlike beams and mullions. All the windows are open. The bowl is globular, with its maximum diameter of 1.22 oral diameters near its middle. There is no distinct shoulder, the bowl simply rounding from the neck to its widest level. The aboral end is hemispherical.

The wall of the bowl is made up of large doubled or "duplex" overlapping circles with hyaline areas enclosed. Overlapping areas commonly include smaller circles. The circles are the sites of coccoliths.

Length, 60 to 75 $\mu$ .

*Dictyocysta duplex* bears some similarity to *D. polygonata*, but the duplex wall and collar are different. None of the other species has similar walls, and, indeed, this character is shared only by isolated examples in other genera, especially *Codonella* and *Codonaria*.

Recorded from four stations, one in the Atlantic and three in the Pacific, as follows: one (23) in the Atlantic equatorial region, one (48) in the region of South Pacific island fields, one (100) in the North Pacific trade region, and one (148) in the California region.

There are 2 pump and 2 net samples, of which 2 were taken at the surface and 1 each at 50 and 100 meters. Maximum frequency, 3 per cent at station 148; other records 2 per cent.

Temperature: Atlantic, net sample  $20^\circ 90$ ; Pacific, pump samples  $20^\circ 10$ – $27^\circ 73$  ( $23^\circ 91$ ), net sample  $23^\circ 63$ . Salinity: Atlantic, net sample 36.04; Pacific, pump samples 34.72–34.95 (34.83), net sample 36.44. Density: Atlantic, net sample 25.30; Pacific, pump samples 22.29–24.72 (23.50), net sample 24.86. pH: Atlantic, net sample 8.14; Pacific, pump sample 8.21, net sample 8.23.

#### *Dictyocysta elegans* Ehrenberg emended Kofoid and Campbell

*Dictyocysta elegans*, Kofoid and Campbell, 1929, pp. 289–290, fig. 570.

The moderately large lorica, with double row of windows, acorn-like bowl with 3 rows of fenestrae, and rounded aboral end, has a length of 1.46 oral diameters. The undulating oral margin has a thin vertical list and 8 flattened arches. The collar is cylindrical, with a length of 0.5 total length, and with the diameter at the lower end equal to that of the oral margin. The upper half of the collar has 8 inverted pentagonal windows, and the lower part has 10 smaller, squarish to pentagonal ones. The beams and mullions are heavy and rounded, and the windows are all open. The bowl is shaped like an acorn cup with traces of shoulder (1.1 oral diameters in diameter) a little below the lower limit of the collar, and thence it rapidly contracts ( $53^\circ$  in the flat-sided upper two-thirds, and  $89^\circ$  lower down). The aboral end is rounded.

The bowl has 3 rows of major, closed fenestrae; one of these rows, of 10 subequal, rounded fenestrae, is near the

shoulder region; the second row, of 12 larger, more or less circular ones, is equatorial; and the third row, of 6 large circular ones, is postequatorial. In addition, there are scattered smaller ones on the bowl. The interfenestral area is reticulated. Primary alveoles occur in the upper framework and between the reticulations on the bowl.

Length, 70 to 77 $\mu$ .

*Dictyocysta elegans* differs from *D. magna* in shortness and in less conical bowl, from *D. inaequalis* in less ovoid bowl, from *D. ampla* in less shoulder and in bowl shape, and from *D. speciosa* in size and bowl shape. The bowl is not so pointed as in *D. mülleri* and it has different proportions from that of *D. fundlandica*. The remaining species differ from *elegans* in having only a single row of windows.

Recorded from seven stations, two in the Atlantic and five in the Pacific, as follows: one (14) in the Gulf Stream, one (23) in the Atlantic equatorial region, three (116, 117, 128) in the North Pacific middle latitudes, one (118) in the East Asiatic marginal sea, and one (130) in the California region.

There are 7 pump and 7 net samples, of which 1 was taken at the surface, 9 at 50 meters, and 4 at 100 meters. Maximum frequency, 5 per cent at station 130; other records above minimum (2 to 4 per cent) from stations 116, 117; average in net samples from the Pacific, 3 per cent.

Temperature: Atlantic, pump sample 14°95, net sample 20°99; Pacific, 10°18–12°91 (11°44) and 8°93–12°91 (10°79), respectively. Salinity: Atlantic, pump sample 35.10, net sample 36.04; Pacific, 33.07–34.22 (33.53) and 33.14–34.22 (33.72), respectively. Density: Atlantic, pump sample 26.08, net sample 25.30; Pacific, 25.13–25.89 (25.56) and 25.19–26.41 (25.82), respectively. pH: Atlantic, pump sample 8.18, net sample 8.14; Pacific, 8.00–8.26 (8.13) and 7.98–8.26 (8.08), respectively.

#### *Dictyocysta inaequalis* Kofoid and Campbell

*Dictyocysta inaequalis* Kofoid and Campbell, 1929, p. 293, fig. 571.

The rather tall lorica, with *elegans*-like fenestration, full ovoid bowl, and rounded aboral end, has a length of 1.6 oral diameters. The oral rim is undulating, with 7 flat arches and a thin list. The collar is cylindrical, with lateral concavity, with a length of 0.54 total length, with the least diameter near its middle (0.89 oral diameter), and with 7 subpentagonal, subequal windows in the upper row and 9 quite irregular ones in the lower row. The bowl swells regularly from the throat, reaches 1.43 oral diameters a little below the neck, and then contracts convexly (93° in the upper three-fifths and 105° in the aboral section). The aboral end is rounded off evenly.

The wall of the bowl has 2 postequatorial rows of fenestrae, of which the upper row of 12 are large circles, subequal, and the lower row of 6 are unequal, less regular subcircles. A few odd, scattered ones occur. The interfenestral surface is reticulated with many small polygons. The windows of the collar are apparently open, and the rather thick beams and mullions are hyaline.

Length, 64 to 66 $\mu$ .

*Dictyocysta inaequalis* resembles *D. ampla* closely, but has a less full bowl, less regular lower row of fenestrae, and fainter polygons. Its bowl is more convex than that of *D. elegans*, and its collar is laterally concave.

Recorded from one station (23) in the Atlantic equatorial region, in a net sample taken at 50 meters. Frequency, minimum.

Temperature, 20°99; salinity, 36.04; density, 25.30; pH, 8.14.

#### *Dictyocysta lata* Kofoid and Campbell

*Dictyocysta lata* Kofoid and Campbell, 1929, p. 293, fig. 562.

The rather short, squat lorica has tall, rectangular windows in the collar, a wide, dishlike bowl, and *lepida*-like fenestration, and its length is 1.18 oral diameters. The oral margin undulates only slightly. The collar is cylindrical, with a length of 0.44 total length, and has 8 tall, rectangular windows. The beams and mullions are relatively thin. The dishlike bowl is shaped much like a deep mush bowl. It lacks shoulders, and contracts, or rather rounds, from the throat to the aboral end, forming virtually a hemisphere. The aboral end is unmodified.

The wall of the bowl has a single irregular equatorial row of 8 very large, roughly ovoid fenestrae. The remaining surface is faintly reticulated, and the framework of the collar glistens. The collar windows are open.

Length, 57 to 62 $\mu$ .

*Dictyocysta lata* differs from *D. reticulata* not only in the shape of the bowl, but in the size and irregularity of the fenestrae. It has a shorter, fuller bowl than does *D. grandis*, and is much shorter. It has only a single row of fenestrae, and a bowl differently shaped from that of *D. lepida*. The bowl lacks the shoulder and distal contraction of *D. mexicana* and is less dense than in most species.

Recorded from one station (27) in the Atlantic equatorial region, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 18°08; salinity, 36.03; density, 26.06; pH, 8.09.

#### *Dictyocysta lepida* Ehrenberg emended Kofoid and Campbell

*Dictyocysta lepida*, Kofoid and Campbell, 1929, p. 294, fig. 558; Alzamora, 1929, p. 11, fig. 25.

The moderately small lorica, with single row of collar windows and generally acorn-shaped bowl with 2 minor and 1 major rows of fenestrae, has a length of 1.28 oral diameters. The oral margin is only slightly undulating. The collar is cylindrical, with a length of 0.35 total length, and with 6 rectangular windows with rounded edges. The beams and mullions are exceptionally heavy. The bowl is relatively squat, acorn-shaped, rounding from the neck to 1.08 oral diameters at 0.47 total length from the rim, then contracting (40° in the upper half, 85° below, and near the aboral end 125°). The aboral end is blunted.

The bowl has a major equatorial row of 8 large, squarish to oval fenestrae, and a double row of minor ones; the upper, minor ones form a row of approximately 24 elongate-oval

ones, and the distal row has about 10 somewhat larger, rounded ones. The latter row is less regular than either of the others. A few isolated, scattered fenestrae also occur here and there. The interfenestral surface is reticulated, and the framework of the collar has large primary alveoles. The collar windows are all open.

Length, 62 $\mu$ .

Loricae of *Dictyocysta lepida* are commonly confused with those of the more frequent *D. reticulata*, which species has a single row of fenestrae, a flatter-sided middle bowl, and a relatively longer collar. *Dictyocysta lepida* is not so squat as *D. lata*, so big as *D. grandis*, nor so pointed aborally as *D. mexicana*.

Recorded from two stations in the Pacific, as follows: one (109) in the North Pacific trade region, and one (137) in the California region.

There are 1 pump and 1 net sample, the former taken at 100 meters, the latter at 50 meters. Frequency, minimum.

Temperature: pump sample 19°81, net sample 24°84. Salinity: pump sample 34.86, net sample 35.12. Density: pump sample 24.72, net sample 23.50. pH: pump sample 8.18, net sample 8.34.

#### *Dictyocysta magna* Kofoid and Campbell

*Dictyocysta magna* Kofoid and Campbell, 1929, p. 294, fig. 569.

The tall, wide lorica, with *elegans*-like fenestration and conical bowl, has a length of 1.44 oral diameters. The oral margin is only slightly undulating and has a thin vertical list. The collar has a length of 0.48 total length and is subcylindrical, the diameter at the throat being 1.12 oral diameters. It has an upper row of 8 squarish windows with rounded edges, and a lower row of 10 subrectangular ones which are subequal to those of the upper row. The beams and mullions are hyaline, rather heavy, rounded, and thick. All are open. The bowl is acorn-like with a trace of shoulder, the upper seven-tenths being within 52°, and the remaining part 113°. The aboral end is obtuse and blunted.

The wall of the bowl has an equatorial row of 12 large, subequal, subcircular fenestrae, and a second row of smaller ones in similar number below the major row. A third row of 6 yet smaller ones is below the second row, and a cluster of tiny ones is found near the aboral end. The interfenestral space is filled with tiny, subequal, prevailing subcircular areas. All fenestrae are closed by thin, hyaline panes.

Length, 75 to 95 $\mu$ .

*Dictyocysta magna* is unusually large. It differs from *D. mülleri* not only in general surface pattern, but also in the shape of the collar. It has a more pointed bowl than either *D. ampla* or *D. inaequalis*, and is unlike all three species in its collar fenestrae, all of which are subequal. It is not so large as *D. grandis*, but has a double row of collar fenestrae and not a single row as in *grandis*.

Recorded from two stations (3, 5-6) in the Atlantic drift.

There is 1 net sample from the surface, and 1 pump sample from 50 meters. Frequency, 9 per cent at station 3. Temperature (station 3 only), 14°66; salinity, 35.96; density, 26.81; pH, 8.19.

#### *Dictyocysta minor* Jörgensen

*Dictyocysta minor*, Kofoid and Campbell, 1929, p. 295, fig. 550.

The small, stout lorica, with *mitra*-like fenestration but with small subuniform windows near the bowl, has a length of 1.39 oral diameters. The oral margin has 8 flat arches. The collar is truncated subconical, flaring (15°), straight-sided, with a diameter of 0.92 oral diameter at the neck, and with 8 subequal, rounded rectangular windows. The bowl is plump, reaching 1.08 oral diameters at or near the middle. The aboral end is obtusely pointed.

The bowl has 4 vertical, unequal rows of subpentagonal, subhexagonal, or even squarish fenestrae, 10 to 12, 8 to 10, 12 to 14, 6 to 9, respectively, in number horizontally. Interpolated are minute fenestrae, and near the aboral end are clustered about 40 very tiny ones. The framework of the collar is heavy, thick, and lifted above the surface. The windows have neat frames, and appear to be closed with hyaline panes.

Length, 47 to 54 $\mu$ .

*Dictyocysta minor*, though it has the *mitra* type of wall structure, differs from *D. mitra* not only in having aboral clusters of small fenestrae, but also in being shorter and wider. *Dictyocysta dilatata* is somewhat similar but has an aboral spine, more flaring collar, and slimmer proportions, and lacks the small fenestrae.

Recorded from sixteen stations, ten in the Atlantic and six in the Pacific, as follows: one (3) in the Atlantic drift, three (14, 15, 16) in the Gulf Stream, three (18, 19, 20) in the Sargasso Sea, three (22, 23, 24) in the Atlantic equatorial region, two (46, 47) in the Galápagos region, three (63, 64, 65) in the South Pacific middle latitudes, and one (110) in the North Pacific trade region.

There are 9 pump and 11 net samples, of which 2 were taken at the surface, 5 at 50 meters, and 13 at 100 meters. Maximum frequency, 10 per cent at station 110; other records above minimum (all 3 per cent) from stations 16, 18, 63, 64; average in Atlantic net samples, 4.2 per cent.

Temperature: Atlantic, pump samples 14°02-23°64 (18°35), net samples 14°02-24°10 (19°19); Pacific, 15°03-17°06 (16°18) and 23°30-23°88 (23°59), respectively. Salinity: Atlantic, pump samples 35.10-36.48 (36.00), net samples 35.59-37.05 (36.29); Pacific, 34.30-34.73 (34.53) and 35.32-35.96 (35.64), respectively. Density: Atlantic, pump samples 24.84-26.66 (25.97), net samples 24.49-26.81 (25.76); Pacific, 25.10-25.48 (25.46) and 24.11-24.42 (24.36), respectively. pH: Atlantic, pump samples 8.06-8.23 (8.16), net samples 8.06-8.25 (8.17); Pacific, 8.16-8.23 (8.19) and 8.08-8.14 (8.10), respectively.

#### *Dictyocysta mitra* Haeckel emended Kofoid and Campbell (Figures 60, 61)

*Dictyocysta mitra*, Kofoid and Campbell, 1929, p. 296, fig. 548; Hofker, 1931, pp. 381-382, figs. 74-75.

The relatively plump lorica, with scant division between collar and bowl, large, window-like meshwork, and rounded aboral end, has a length of 1.47 oral diameters. The oral rim is arched with 7 (8) broad frames. The collar region is generally biconical (33° in the upper and 35° in the lower

half); its least diameter, 0.88 oral diameter, is at the junction of the upper and lower sections. At the neck the diameter equals that of the oral rim. The bowl expands from the throat to a diameter of 1.13 oral diameters at 0.54 total length from the rim, the collar being 0.33 total length. The lower bowl rounds off below the maximum diameter, and the aboral end is blunt to rotund.

The wall is extremely thin. The whole surface is fenestrated, with the upper windows squarish. The fenestrae of the second row are smaller and more irregular, and the fenestrae of the bowl are less uniform, 5 to 7 in vertical rows and 10 to 12 in each horizontal row; at the aboral end is a nest of tiny ones, and odd minute ones are scattered among the larger ones of the bowl. All fenestrae are enclosed by thickened beams and mullions, with a fine molding around each window. All windows are closed by transparent panes.

Length, 60 to 80 $\mu$ .

Hofker's (1931) material appears typical although his figures are generalized.

*Dictyocysta mitra* is less stout and has a narrower aboral end than *D. obtusa*. It has a less distinctly set-off and less flaring collar region than *D. dilatata* (some of the *Carnegie* loricae, as fig. 61, approach *dilatata* in this character), and less acute aboral end. The fenestration differs markedly from that of *D. fenestrata*, as does the general shape of the bowl; in *fenestrata* the bowl is much less elongate. *Dictyocysta californiensis* is smaller and has a greatly swollen bowl; *D. spinosa* and *D. extensa* have oral spines lacking in *mitra*.

Recorded from twenty-one stations, six in the Atlantic and fifteen in the Pacific, as follows: two (2, 15) in the Gulf Stream, three (3, 4, 5) in the Atlantic drift, one (23) in the Atlantic equatorial region, four (42, 43, 44, 68) in the Galápagos region, four (61, 63, 64, 65) in the South Pacific middle latitudes, three (111, 128, 144) in the North Pacific middle latitudes, and four (131, 133, 134, 135) in the California region.

There are 18 pump and 11 net samples, of which 1 was taken at the surface, 9 at 50 meters, 18 at 100 meters, and 1 at 1000 meters. Maximum frequency, 6 per cent at station 65; other records above minimum (2 to 3 per cent) from stations 3, 4, 44, 63, 64, 111, 131; averages, 2.1 and 2.5 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump sample 18°56, net samples 13°79–20°35 (15°06); Pacific, 3°98–15°03 (11°36) and 10°23–19°97 (15°40), respectively. Salinity: Atlantic, pump sample 36.45, net samples 35.88–36.41 (36.02); Pacific, 33.07–35.04 (34.46) and 33.36–35.04 (34.25), respectively. Density: Atlantic, pump sample 26.26, net samples 25.76–27.01 (26.72); Pacific, 24.64–26.19 (25.25) and 25.31–27.25 (26.04), respectively. pH: Atlantic, pump sample 8.19, net samples 8.10–8.21 (8.15); Pacific, 7.88–8.39 (8.15) and 7.76–8.32 (8.02), respectively.

*Dictyocysta mülleri* (Imhoff) Jörgensen emended Kofoid and Campbell

*Dictyocysta mülleri*, Kofoid and Campbell, 1929, pp. 296–297, fig. 572.

The short lorica, with spool-shaped collar with double

row of windows, and angled, aborally pointed bowl, has a length of 1.51 oral diameters. The oral rim is undulating, with 6 very flat arches. The collar is spool-like, contracting from the rim to 0.94 oral diameter near 0.48 oral diameter from the rim, and then expanding to 1.11 oral diameters at the neck, which is 0.81 oral diameter below the rim. There is a double row of open windows, the upper row being of 6 squarish ones, the lower being formed by 9 rounded rectangles. The beams and mullions are thick and heavy-set. The bowl is subconical (55° in the upper two-thirds, increasing to 115° in the lower section). There is a rounded but short shoulder below the collar, the maximum diameter of which is 1.16 oral diameters. The aboral end is obtuse and blunted.

The wall of the bowl has an anterior row of 24 double, circular fenestrae, and this row is followed by an incomplete row of smaller circles. A row of 10 to 12 large, oval, post-equatorial fenestrae adorns the bowl, and a lower row of 4 to 6 small windows is also present. The remaining surface is covered with much smaller, relatively thick-walled fenestrae, although the area near the large fenestrae is free of tiny circles. The fenestrae all have clear panes.

Length, 55 to 63 $\mu$ .

*Dictyocysta mülleri* differs from all other species in the shape of the aboral end, which, combined with its wall characters, differentiates it at once with little difficulty. Its nearest relative is, possibly, *D. magna*, which not only is longer, but also lacks the spool-like collar. *Dictyocysta ampla* has a less angled bowl.

Recorded from three stations, two in the Atlantic and one in the Pacific, as follows: one (16) in the Gulf Stream, one (20) in the Sargasso Sea, and one (82) in the region of South Pacific island fields.

There are 2 pump and 1 net sample, all taken at 100 meters. Frequency, minimum.

Temperature: 19°62, 26°02, and 24°34 in the Atlantic pump and net samples and Pacific pump sample, respectively. Salinity: 36.48, 36.51, and 36.46 in the Atlantic pump and net samples and Pacific pump sample, respectively. Density: 26.01, 24.19, and 24.65 in the Atlantic pump and net samples and Pacific pump sample, respectively. pH: 8.17, 8.32, and 8.19 in the Atlantic pump and net samples and Pacific pump sample, respectively.

*Dictyocysta nidulus* Kofoid and Campbell

*Dictyocysta nidulus* Kofoid and Campbell, 1929, pp. 297–298, fig. 565.

The fairly tall lorica, with *tiara*-like fenestration and a long bowl, has a length of 1.6 oral diameters. The oral margin is simple and has a narrow list. The collar is 0.4 total length in length, virtually a cylinder, with a single row of 7 rectangular (width 0.53 height) windows; in some individuals the windows, which are always open, have single, somewhat oblique crossbars which subdivide them into two more or less equal sections. The beams and mullions are thin, rounded, and hyaline. The bowl is acorn-like in shape, with some swelling a little below the collar (reaching 1.1 oral diameters in diameter), and below it becomes angular

subconical ( $42^\circ$  in the flat-sided upper seven-tenths and  $114^\circ$  in the lowermost rounded section). The aboral end is obtusely rounded.

The wall of the bowl has an irregular row of 10 closed, subrectangular, large fenestrae and a pre-equatorial row of large *Syracosphaera*. Minute circular areas (coccoliths?) cover the remainder of the surface.

Length, 75 $\mu$ .

*Dictyocysta nidulus* resembles *D. reticulata* but differs mainly in proportions, regularity of large fenestrae, presence of large Coccolithophoridae, and general shape of bowl. *Dictyocysta mexicana* has greater angularity, more projecting aboral end, more localized fenestrae, and shorter length (57 to 66 $\mu$ ).

Recorded from one station (4) in the Atlantic drift, in a net sample taken at 50 meters. Frequency, 6 per cent.

Temperature,  $14.32$ ; salinity, 36.00; density, 26.91; pH, 8.15.

#### *Dictyocysta occidentalis* Kofoid and Campbell

*Dictyocysta occidentalis* Kofoid and Campbell, 1929, pp. 298-299, fig. 556.

The fairly small, symmetrical lorica, with *mitra*-like fenestration, *lepada*-like collar, and globose bowl, has a length of 1.57 oral diameters. The oral margin is undulating, with 7 arches. The collar is subcylindrical, 0.63 of the length of the bowl in length, with 7 subquadrangular, closed windows, and thick beams and mullions. The bowl is globular, its greatest diameter, at the middle, being 1.15 oral diameters. There is a rounded shoulder just below the throat. The aboral end is hemispherical.

The wall of the bowl has an equatorial zone of 8 to 10 subequal, round fenestrae, a post-equatorial one of 6 to 8, and an aboral group of very small ones. The meshwork is heavy and pronouncedly minutely alveolar. Coccoliths are often found, especially in the aboral fenestrae.

Length, 55 to 62 $\mu$ .

*Dictyocysta occidentalis* has a globose bowl somewhat like that of *D. polygonata*, but the latter species has large circles forming the wall of the bowl, and has no equatorial or other limited zones of fenestrae. *Dictyocysta duplex* has "duplex" walls and a very different collar. *Dictyocysta tiara* has thinner beams and an ovoid bowl.

Recorded from three stations in the Pacific, as follows: one (136) in the California region and two (141, 144) in the North Pacific middle latitudes.

There are 3 pump samples, of which 1 was taken at the surface and 2 at 50 meters. Frequency, minimum.

Temperature,  $18.69-25.31$  ( $22.86$ ); salinity, 34.64-35.38 (35.09); density, 23.46-24.84 (24.02); pH, 8.33-8.37 (8.34).

#### *Dictyocysta pacifica* Kofoid and Campbell

*Dictyocysta pacifica* Kofoid and Campbell, 1929, p. 299, fig. 555.

The short lorica, with the general shape of *mitra* as well as with similar fenestration, but with oral denticles, has a length of 1.43 oral diameters. The oral margin is regularly set with about 40 sparsely spaced, triangular denticles. The collar is a segment of an inverted cone ( $10^\circ$ ) with a length

of 0.57 total length, a diameter of 0.86 oral diameter at the throat, and 6 squarish windows, each set into a relatively wide frame. The windows are all closed, and the beams and mullions are rather thick. The collar merges with the plump bowl. The bowl expands from the throat to 1.14 oral diameters near its equator. Below this it is convex conical ( $60^\circ$  in the anterior part, increasing to  $125^\circ$  in the lower half). The aboral end is pointed.

The wall of the bowl has 2 rather regular and 1 irregular row of fenestrae. The fenestrae of the first row, 10 in number, are similar in size to those of the second row, which number 12; both sets are subcircular in shape and subequal in size. The fenestrae of the distal set form an irregular row of 6 small windows. The interfenestral area has smaller polygons; coccoliths are not rare in this distal region.

Length, 41 to 52 $\mu$ .

*Dictyocysta pacifica* differs from the species of the *mitra* type in having oral denticles; *D. extensa* and *D. spinosa*, however, have larger spinelike teeth instead of tiny spikes. In some ways *D. pacifica* recalls *D. minor*, but it has smaller fenestrae in the distal group, as well as oral denticles.

Recorded from four stations in the Pacific, as follows: two (35, 35-36) in the Pacific equatorial region, one (45) in the Galapagos region, and one (136) in the California region.

There are 3 net samples and 1 pump sample, of which 1 was taken at the surface, 1 at 50 meters, and 2 at 100 meters. Frequency, 2 per cent at station 136; other records minimum.

Temperature: pump sample  $18.87$ , net samples  $16.30-21.69$  ( $18.99$ ). Salinity: pump sample 35.02, net samples 34.88-35.21 (35.04). Density: pump sample 25.09, net samples 24.48-25.60 (25.04). pH: pump sample 8.39, net samples 7.92-8.12 (8.02).

#### *Dictyocysta reticulata* Kofoid and Campbell

*Dictyocysta reticulata* Kofoid and Campbell, 1929, p. 300, fig. 560; Marshall, 1931, pp. 653-654.

*Dictyocysta lepida*, Hofker, 1931, pp. 382-384, figs. 76-78.

The plump lorica, with arched collar windows in a single row resembling the columns of a Greek temple, wide, low bowl, rounded aboral end, and large oval fenestrae in the bowl, has a length of 1.37 oral diameters. The oral margin has 6 (7) flattened arches. The collar is nearly cylindrical, 0.46 total length in length, and there are 6 (7) tall, subequal windows. The subhemispherical bowl reaches 1.15 oral diameters at 0.5 total length, and thence more or less evenly rounds to the unmodified aboral end.

The wall of the bowl is hardly 0.03 oral diameter in thickness. The whole bowl is fenestrated with subuniform, rounded, deeply pitted polygons except for a single row of large subequal, closed, oval fenestrae, 6 (7) in number, which are in the bowl's equatorial region. The beams and mullions of the closed fenestrae of the collar are hyaline, rounded, and squarish in form.

Length, 55 to 65 $\mu$ .

Hofker's material probably includes several related species, as this writer does not closely differentiate the species of this group.



*Dictyocysta reticulata* is shorter and has a longer bowl than *D. grandis*; it has no aboral point like *D. mexicana*; and its bowl is more angled at the shoulder than is that of *D. lata*. Most of the remaining species either are of the *D. mitra* type, or else have 2 rows of clear-cut windows in the collar. This species is by far the most common in warm water.

Recorded from forty-seven stations, seventeen in the Atlantic and thirty in the Pacific, as follows: three (2, 14, 16) in the Gulf Stream, three (3, 4, 5) in the Atlantic drift, two (18, 19) in the Sargasso Sea, seven (22, 23, 24, 25, 26, 28, 30) in the Atlantic equatorial region, two (33, 34) in the Caribbean Sea, five (35, 35-36, 36, 37, 154) in the Pacific equatorial region, twelve (40, 41, 42, 44, 45, 47, 69, 71, 77, 78, 79, 80) in the Galápagos region, three (48, 84, 92) in the region of South Pacific island fields, five (59, 62, 64, 65, 67) in the South Pacific middle latitudes, two (109, 110) in the North Pacific trade region, one (111) in the North Pacific middle latitudes, and two (133, 149) in the California region. *Dictyocysta reticulata* is apparently absent only in cool regions such as the North Sea, the American cold-water region, the East Asiatic marginal sea, and the Alaskan secondary region.

There are 34 pump and 44 net samples, of which 19 were taken at the surface, 31 at 50 meters, and 28 at 100 meters. Maximum frequency, 13 per cent at station 77; other records above minimum (2 to 11 per cent) from stations 2, 3, 22, 24, 25, 26, 28, 35, 35-36, 40, 41, 42, 44, 45, 47, 48, 59, 62, 65, 69, 78, 80, 154; averages, 1.0 and 2.1 loricae in Atlantic and Pacific pump samples, and 2.8 and 4.1 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump samples 14°95–28°25 (23°46), net samples 13°37–27°88 (20°12); Pacific, 13°93–27°99 (21°23) and 14°33–27°52 (21°05), respectively. Salinity: Atlantic, pump samples 29.70–37.15 (35.33), net samples 35.61–36.81 (36.15); Pacific, 31.62–36.17 (34.86) and 31.62–36.44 (34.48), respectively. Density: Atlantic, pump samples 18.62–26.08 (23.89), net samples 23.26–27.01 (25.94); Pacific, 20.20–26.21 (24.37) and 20.34–26.17 (24.47), respectively. pH: Atlantic, pump samples 8.14–8.31 (8.21), net samples 7.93–8.30 (8.16); Pacific, 7.85–8.37 (8.17) and 7.87–8.38 (8.11), respectively.

#### *Dictyocysta speciosa* Jörgensen

*Dictyocysta speciosa*, Kofoid and Campbell, 1929, pp. 300–301, fig. 575.

The large lorica, with *elegans*-like fenestration and aborally constricted bowl, has a length of 1.63 oral diameters. The oral margin is mildly arched, with 8 flattened rims. The collar (1.0 oral diameter in length) is subcylindrical, the diameter at the lower end being 1.12 oral diameters. The collar has a double row of fenestrae. The upper row is made up of 8 rectangular windows with squarish corners, larger than the 9 subpentagonal to square ones of the lower row. The beams and mullions are hyaline and rounded, and enclose the open windows. The bowl has a considerably rounded shoulder, reaches 1.31 oral diameters a little below

the lower end of the collar, then rapidly contracts (53°), and becomes almost hemispherical (125°) within its lower fourth. The upper section is flat-sided. The aboral end is obtusely blunted.

The wall of the bowl has a postequatorial row of 8 rather small round fenestrae, and a lower row of 6 even smaller oval ones. The interfenestral area has many small circles of nearly uniform size.

Length, 66 to 80 $\mu$ .

*Dictyocysta speciosa* is larger than other species related to *D. elegans*, and has a bowl shaped unlike those in the remainder of that general group. Once seen, it is not hard to recognize.

Recorded from five stations (3, 4, 5-6, 6, 6-7) in the Atlantic drift and the North Sea.

Net samples only, of which 8 were taken at the surface, 2 at 50 meters, and 4 at 100 meters. Maximum frequency, 40 per cent between stations 5 and 6; all other records above minimum (2 to 36 per cent), except between stations 6 and 7, where only 1 lorica was found.

Temperature, 11°28–14°32 (12°80); salinity, 35.51–36.06 (35.77); density, 26.91–27.15 (27.00); pH, 7.90–8.15 (8.10).

#### *Dictyocysta spinosa* Kofoid and Campbell

*Dictyocysta spinosa* Kofoid and Campbell, 1929, p. 301, fig. 553.

The rather stout lorica, with *mitra*-like fenestration and distinct oral spines, has a length of 1.36 oral diameters. The oral rim has 8 flattened arches; from the middle of each arch arises an outspread needle-like spine. The collar is inverted subconical and flaring (8°); its length is 0.3 total length. The diameter at the throat equals that of the rim, and the sides are concave. There are 8 rounded, rectangular, closed windows. The bowl is broadly ovate, has no shoulder, and reaches 1.24 oral diameters near its middle. The aboral end is generally blunted.

There are 8 rows of more or less irregular rows of uneven fenestrae in the bowl. These increase in number but decrease in size toward the middle.

Length, 42 to 46 $\mu$ .

*Dictyocysta spinosa* and *D. extensa* are the only species with oral spines, and the latter species differs from *spinosa* in the altogether different wall structure, having fewer large fenestrae, and many small polygons on the longer, more acute bowl.

Recorded from four stations, two each in the Atlantic and the Pacific, as follows: one (19) in the Sargasso Sea, one (23) in the Atlantic equatorial region, one (75) in the Galápagos region, and one (135) in the California region.

There are 1 pump sample and 3 net samples, all taken at 100 meters. Frequency, minimum.

Temperature: Atlantic, net sample 22°42; Pacific, pump sample 18°95, net sample 18°40. Salinity: Atlantic, net samples 34.88–37.05 (35.85); Pacific, pump sample 34.88, net sample 35.47. Density: Atlantic, net sample 25.67; Pacific, pump sample 24.96, net sample 25.55. pH: Atlantic, net samples 8.18–8.25 (8.21); Pacific, pump sample 8.34, net sample 8.10.

*Dictyocysta tiara* Haeckel

*Dictyocysta tiara*, Kofoid and Campbell, 1929, p. 302, fig. 567.

The rather moderately tall, narrow lorica, with single row of fenestrae and elongated bowl, has a length of 2.0 oral diameters. The oral margin is undulating, with 8 very flat arches. The collar is cylindrical, 0.75 oral diameter in length, and has 8 rectangular, subequal open windows with rounded lower and angular upper corners. The bowl has a narrow shoulder, reaches a diameter of 1.25 oral diameters at the shoulder, which is a little lower than the lower end of the collar, then contracts (30°) for two-thirds of its length, and finally becomes subconical (98°). The aboral end is rounded.

The wall of the bowl has a single row of 8 elongated, narrow oval fenestrae in the equatorial region. More numerous tiny fenestrae occur in a double row below the major row. The remaining surface of the bowl and the supporting beams and mullions of the collar are studded with closely set, minute coccoliths. The collar windows are open.

Length, 80 $\mu$ .

This much misunderstood species is more elongated and narrower than any other.

Recorded from four stations in the Pacific, as follows: one (45) in the Galápagos region, one (64) in the South Pacific middle latitudes, and two (111, 112) in the North Pacific middle latitudes.

There are 5 pump samples, of which 1 was taken at the surface and 2 each at 50 and 100 meters. Frequency, 2 per cent at stations 45, 64, 111; average, 1.6 per cent.

Temperature, 15°90–22°43 (19°91); salinity, 34.54–35.26 (34.73); density, 24.02–25.43 (24.58); pH, 8.10–8.22 (8.16).

## COXLIELLIDAE Kofoid and Campbell emended

Coxliellidae, Kofoid and Campbell, 1929, p. 91.

The family includes four genera: *Coxliella*, *Climacocylis*, *Helicostomella*, and *Metacylis*. Only the last does not occur in the material of this expedition. All but *Helicostomella* are eupelagic, the latter being coastal; most of them are tropical.

## COXLIELLINAE Kofoid and Campbell

Coxliellinae Kofoid and Campbell, 1939, p. 90.

The Coxliellinae include those members of the family in which the spiral lamina extends the whole length of the lorica, except in some species in which it may be limited.

The genera included are *Coxliella* and *Climacocylis*.

## COXLIELLA Brandt emended

*Coxliella*, Kofoid and Campbell, 1929, pp. 95–96.

*Coxliella* has a spiral lamina which forms the bowl and horn. This spiraling is also found in the collar of *Codonellopsis* and in a few species of *Tintinnopsis*. It is not unlikely that *Coxliella* had its origin in the latter genus, and that the spiral collar of *Codonellopsis* is of a different source. The wall is rigid, the flaccidity of that of *Climacocylis* being derived. The aboral end of *Coxliella* is closed, that of

*Climacocylis* open; this is an additional suggestion of the derivation of the latter genus.

Species of *Coxliella* are common in warm and temperate seas. Only the subgenus *Protocoxliella* is from cool waters in both hemispheres, and is not found in the tropical ocean.

Six species are described here.

*Coxliella declivis* Kofoid and Campbell

*Coxliella declivis* Kofoid and Campbell, 1929, p. 97, fig. 192.

The tapering subconical lorica, with few turns and narrow aboral horn, has a length of 1.89 to 1.93 oral diameters. The oral margin is entire, thin, and smooth. The short, stout bowl is cylindrical in the upper fourth, and convex conical in the lower three-fourths; the upper section is 55° to 60°, whereas near the horn it is 95°. The short, conical aboral horn is somewhat under 0.3 oral diameter in length; it is twisted, and its end is minutely blunted.

The wall reaches as much as 0.09 oral diameter in thickness across the widest of the 9 to 10 left-turning spiral whorls. The fifth and sixth turns reach a width of 0.33 oral diameter; the uppermost and lowermost ones are only half that much, or less. There are thin laminae with three to five layers of tiny alveoles closely packed within their confines. The wall is dull, and lacunae are absent.

Length, 110 $\mu$ .

*Coxliella declivis* is more tapering and has a more symmetrical aboral horn than *C. laciniosa*. Its wide turns suggest *C. pseudannulata*, but its horn is decidedly different, and neither is it like that of *C. pelagica*. *Coxliella decipiens* is longer, with more and narrower spiral turns and somewhat similar aboral end. The remaining species are all so different that no difficulty in identification should arise.

Recorded from seven stations, two in the Atlantic and five in the Pacific, as follows: two (18, 19) in the Sargasso Sea, two (41, 85) in the Galápagos region, one (99) in the Pacific equatorial region, and two (133, 134) in the California region.

There are 2 pump and 6 net samples, of which 2 were taken at the surface, 2 at 50 meters, and 4 at 100 meters. Maximum frequency, 3 per cent at station 99; other records at 2 per cent from stations 19, 85.

Temperature: Atlantic, net samples 20°32–25°31 (22°68); Pacific, pump samples 18°18–22°68 (20°43), net samples 20°42–27°89 (25°38). Salinity: Atlantic, net samples 36.81–37.15 (37.00); Pacific, pump samples 34.63–34.70 (34.66), net samples 34.19–36.24 (35.15). Density: Atlantic, net samples 24.89–26.07 (25.48); Pacific, pump samples 23.82–24.96 (24.39), net samples 22.50–24.06 (23.31). pH: Atlantic, net samples 8.21–8.27 (8.24); Pacific, pump samples 8.34–8.47 (8.40), net samples 8.11–8.22 (8.18).

*Coxliella fasciata* (Kofoid) Brandt

(Figures 30, 34)

*Coxliella fasciata*, Kofoid and Campbell, 1929, pp. 97–98, fig. 205.

The greatly elongated conical lorica, with few spiral turns and slight flare, and with narrowed aboral end, has a length

of 3.62 oral diameters. The oral margin is thin-edged, entire, and rolled over. The upper end of the bowl flares as a cone ( $60^\circ$ ) and includes the uppermost of the spiral turns. Its sides are outwardly concave. The greater part of the remaining portion of the bowl is also conical ( $10^\circ$ ), except the aboral fifth, which contracts ( $16^\circ$ ) somewhat more. The aboral end is not prolonged or especially modified as a horn, save as it twists a bit.

The wall is made up of 10 left-wound spiral turns. The uppermost 5 are 0.25, 0.44, 0.53, 0.44, and 0.37 oral diameter, respectively, in width. The aboral 5 are more or less subuniformly about 0.44 oral diameter. Optically dark lines separate the turns, and they rest one against another without overlap. The wall is relatively thick, being 0.09 oral diameter in the thickest turn. There are thin laminae which enclose three to seven layers of rather tiny ovoid alveoles. The wall is almost transparent. The cavity follows the outer contour to the very tip; sometimes the aboral end is minutely open.

Length, 312 $\mu$ .

A peculiarly shaped, perhaps abnormal lorica is figured (fig. 30) in addition to the more usual type (fig. 34). This much shorter lorica has 19 almost horizontal turns, and a wavy, eccentric aboral third. It may be a young individual which for some reason did not finish out its lorica, or may be a representative of a rarer species not yet reported.

*Coxiella fasciata* is easily differentiated from the other species of the genus because of its elongated conical form with few turns. Its aboral end is pointed, unlike that of *C. minor*, which species is not tropical as is *fasciata*. Its contour and aboral end differ from those of *C. helix*; it is not so stout as *C. decipiens*, and lacks the solid horn which that species has.

Recorded from six stations, five in the Atlantic and one in the Pacific, as follows: one (14) in the Gulf Stream, one (20) in the Sargasso Sea, two (23, 24) in the Atlantic equatorial region, one (34) in the Caribbean Sea, and one (139) in the North Pacific trade region.

There are 1 pump and 5 net samples, of which 1 was taken at the surface, 2 at 50 meters, and 3 at 100 meters. The pump sample was taken in the Pacific and the net samples in the Atlantic. Frequency, 4 per cent at station 14; other records all minimum; average, 2 per cent.

Temperature: pump sample  $26^\circ 72$ , net samples  $14^\circ 02$ – $24^\circ 98$  ( $19^\circ 62$ ). Salinity: pump sample 34.82, net samples 35.59–36.73 (36.10). Density: pump sample 22.69, net samples 24.52–26.66 (25.45). pH: pump sample 8.34, net samples 7.96–8.21 (8.11).

*Coxiella helix* (Claparède and Lachmann) Brandt emended Kofoid and Campbell

*Coxiella helix*, Kofoid and Campbell, 1929, pp. 99–100, fig. 204.

The tall, tubular, vase-like lorica, with toothed oral margin, regular contour, and short, conical aboral horn, has a length of 3.72 oral diameters. The oral margin is regularly serrate, with about 36 short, evenly spaced, triangular, outspread

teeth. The long bowl contracts below the margin as a basal segment of an inverted concave cone ( $45^\circ$ ) with a width of about 0.1 total length. The tubelike part of the bowl occupies somewhat less than 0.6 total length; it is without local bulges or contractions. The posterior part is inverted, decidedly convex conical ( $22^\circ$  in the upper two-thirds and  $66^\circ$  in the lower third). The conical ( $22^\circ$ ) aboral horn has a length of only 0.5 oral diameter.

The spiral lamina which forms the wall has 18 left-turning spirals. These bands are widest across the mid-region of the bowl and subuniformly narrower in the upper and lower parts. At their widest they reach nearly 0.3 oral diameter. They tend to rest one on another in such fashion that the lateral contour presents a saw-toothed edge. An optically dark line marks their boundaries. The wall is subuniformly 0.02 oral diameter in thickness except near the suboral flare, where it gradually thins to the serrate margin. The wall has distinct, large, hexagonal secondary structures with enclosed minute alveoles. Toward the aboral end, adherent irregular blobs occur. The aboral horn is hollow and the lumen agrees with the outer contour exactly.

Length, 196 $\mu$ .

The *Carnegie* lorica is in so many ways different from that figured by Kofoid and Campbell that it might, with some justification, have been assigned to a new species. The regularity of facies, presence of teeth, length of bowl, and shortness of horn are all characters of note. Yet the two loricae seem to be essentially similar and to have definable characters in common.

*Coxiella helix* bears little resemblance to most of the species, being taller and more slender. It is somewhat like *C. fasciata*, but has a tubular bowl and definite contracted aboral horn, as well as suboral flare, and a toothed margin. *Coxiella minor* is also elongated, but its aboral horn is bulbous. *Coxiella decipiens* is relatively wider, and of altogether different appearance. *Coxiella helix* is not likely to be confused with others.

Recorded from three stations in the Atlantic, as follows: two (19, 20) in the Sargasso Sea and one (23) in the Atlantic equatorial region.

There are 3 net samples, of which 2 were taken at 50 meters and 1 at 100 meters. Frequency, 3 per cent at station 19.

Temperature,  $20^\circ 99$ – $25^\circ 31$  ( $22^\circ 95$ ); salinity, 36.04–37.15 (36.64); density, 24.89–25.38 (25.28); pH, 8.14–8.27 (8.20).

*Coxiella laciniosa* (Brandt) Brandt emended Kofoid and Campbell

(Figures 29, 31, 32, 33)

*Coxiella laciniosa*, Kofoid and Campbell, 1929, p. 100, fig. 193; Marshall, 1934, p. 642.

The generally short, stout, conical lorica, with entire rim and short, twisted, conical aboral horn, has a length of 1.21 oral diameters. The oral margin is thin-edged, erect, and smooth. The stout, generally conical bowl is subcylindrical in the anterior 0.59, and convex conical aborally (at first  $32^\circ$ , and  $105^\circ$  nearer the horn). The sides are full and the

spiral turns bulge somewhat. The aboral horn is short (0.17 oral diameter), conical ( $33^\circ$ ), and twisted.

The wall is thicker suborally than in the lower bowl and hollow horn; the thickness is 0.05 oral diameter at the maximum, and less than half as much elsewhere. Each of the spiral turns is enclosed by a thin inner and outer lamina, and these, in turn, enclose two to five layers of rounded alveoles. The left-turning spiral turns number 7 to 10. They usually are more or less subuniformly 0.21 oral diameter in width, save for the fourth and fifth ones, which reach 0.26. Optically dark lines separate the turns, and oval lacunae in 1 or 2 rows occur near the aboral end of the widest turn; sometimes a few odd ones are found on the turn just above this one. Very minute, or primary, alveoles may be found under the highest magnification of the microscope, but in general the wall is pallid.

Length, 75 to 140 $\mu$ .

Marshall (1934) finds loricae with but a single layer of alveoles, and with aboral swelling. The *Carnegie* loricae differ among themselves considerably, and a few extremes are figured (figs. 31, 32, 33); figure 29 shows a more common form. One of these specimens (fig. 32) has some likeness to *Coxliella declivis*, but differs in important respects.

*Coxliella laciniosa* is most like *C. declivis*, but its walls are different, the spiral turns are unlike, and the aboral horn is not blunted. *Coxliella decipiens* is longer and relatively narrower, with more turns and a different horn. The remaining species, in spite of the great variability of individual loricae of *laciniosa*, are quite unlike it and never lead to confusion.

Recorded from thirty-seven stations, twelve in the Atlantic and twenty-five in the Pacific, as follows: two (15, 16) in the Gulf Stream, four (17, 18, 19, 20) in the Sargasso Sea, five (23, 25, 27, 29, 30) in the Atlantic equatorial region, one (34) in the Caribbean Sea, six (43, 45, 46, 47, 71, 78) in the Galápagos region, six (48, 82, 84, 85, 95, 158) in the region of South Pacific island fields, six (100, 102, 105, 109, 140, 150) in the North Pacific trade region, three (136, 146, 148) in the California region, three (141, 144, 145) in the North Pacific middle latitudes, and one (155) in the Pacific equatorial region.

There are 19 pump and 24 net samples, of which 4 were taken at the surface, 22 at 50 meters, and 17 at 100 meters. Maximum frequency, 10 per cent at station 145; other records above minimum (2 to 4 per cent) from stations 15, 27, 34, 48, 84, 85, 145, 148, 155; average in Pacific net samples, 2.4 per cent.

Temperature: Atlantic, pump samples  $21^\circ 85$ – $27^\circ 11$  ( $24^\circ 20$ ), net samples  $14^\circ 60$ – $25^\circ 54$  ( $22^\circ 57$ ); Pacific,  $15^\circ 85$ – $27^\circ 52$  ( $21^\circ 63$ ) and  $18^\circ 87$ – $28^\circ 74$  ( $24^\circ 55$ ), respectively. Salinity: Atlantic, pump samples 36.22–36.60 (36.41), net samples 35.70–37.15 (36.42); Pacific, 34.32–36.46 (35.23) and 34.32–36.42 (35.08), respectively. Density: Atlantic, pump samples 23.62–25.49 (24.65), net samples 23.98–26.62 (25.10); Pacific, 22.71–25.60 (24.00) and 22.31–25.09 (23.63), respectively. pH: Atlantic, pump samples 8.23–8.29 (8.26), net samples 7.93–8.30 (8.17); Pacific, 7.83–8.34 (8.19) and 8.13–8.39 (8.25), respectively.

### *Coxliella longa* (Brandt) Laackmann

*Coxliella longa*, Kofoid and Campbell, 1929, p. 101, fig. 196.

The bullet-shaped lorica, with turns of moderate width, rounded aboral end, and short, curved aboral point, has a length of 2.1 oral diameters. The oral margin is irregularly toothed with larger and smaller scattered denticles. The bowl is subcylindrical in its upper three-fifths and becomes convex conical in the lower part ( $35^\circ$  in the anterior region and  $105^\circ$  near the horn). At the aboral end is a slightly curved, projecting point or horn; its free tip is minutely open.

The wall is only 0.03 oral diameter in thickness across the widest turn. There are relatively thick radial prisms or alveoles in two to four layers between the laminae. At the free tip of the aboral end the wall is somewhat swollen around the opening. Otherwise the cavity conforms to the outer contour. Optically dark lines separate adjacent spiral turns, of which there are 13. These become wider toward the aboral end, the widest one being 0.3 oral diameter, which is three times the width of the narrower anterior ones. Three or four small oval lacunae, with their long axes directed upward, are found on the widest turn.

Length, 130 to 135 $\mu$ .

*Coxliella longa* has more turns and a shorter aboral horn than *C. declivis*, *C. laciniosa*, and *C. pseudannulata*. It also has more turns than *C. intermedia* (an antarctic species), and an aboral horn. *Coxliella tubularis* is bigger, with more turns and a relatively better-developed horn.

Recorded from six stations in the Pacific, as follows: three (47, 69, 78) in the Galápagos region, one (65) in the South Pacific middle latitudes, and two (82, 83) in the region of South Pacific island fields.

There are 1 pump and 5 net samples, of which 2 were taken at the surface, 3 at 50 meters, and 1 at 100 meters. Maximum frequency, 3 per cent at station 69; average, 1.5 per cent.

Temperature: pump sample  $24^\circ 38$ , net samples  $15^\circ 03$ – $27^\circ 46$  ( $22^\circ 94$ ). Salinity: pump sample 36.03, net samples 34.30–36.49 (35.86). Density: pump sample 24.33, net samples 23.67–25.44 (24.18). pH: pump sample 8.14, net samples 8.10–8.24 (8.17).

### *Coxliella pseudannulata* (Jørgensen) Brandt

(Figure 28)

*Coxliella pseudannulata*, Kofoid and Campbell, 1929, p. 102, fig. 191.

The moderately stout lorica, with wide, bulging median spiral turns and thick, blunted aboral end, has a length of 2.6 oral diameters. The oral margin is minutely irregular and thin-edged. The bowl is asymmetrically subcylindrical in the anterior 0.45, conical ( $32^\circ$ ) in the submedian 0.4, and bluntly conical ( $26^\circ$ ) in the lowermost section. The aboral end is rounded off.

The wall is made up of 9 rather wide, right-wound spiral turns, the width of the median 2 being 0.46 and 0.37 oral diameter. The others are subuniformly about 0.23 or somewhat less. The turns commonly bulge in their middles,

those of the mid-section more than the others. The wall is rather thick, 0.06 oral diameter in places. There are thin laminae with one layer of distinct radial rectangular prisms. The wall is rather pallid.

Length, 153 $\mu$ .

The *Carnegie* lorica differs from that of Kofoid and Campbell in that the spiral turns are right- rather than left-turning; this is not due to error in drawing the reverse side. Perhaps, as in some snails, right-wound forms of normally left-turning shells may occur in Tintinnoina.

*Coxiella pseudannulata* differs from all the common species of that genus in the shape of the aboral end. From *C. calyptra* it differs in the lack of pores or lacunae. However, *calyptra* is more likely one of the Nassellaria and not a tintinnid. *Coxiella pelagica* lacks the contracted aboral horn and median wide bulging turns, otherwise the two are much alike. *Coxiella declivis* has a narrower horn and fewer spiral turns. *Coxiella laciniosa*, too, has a narrow horn, and posterior lacunae.

Recorded from one station (10) in the Atlantic drift, in a net sample taken at 50 meters. Frequency, 1 per cent.

Temperature, 9°86; salinity, 34.94; density, 27.96; pH, 8.04.

#### CLIMACOCYLIS Jörgensen

*Climacocylis*, Kofoid and Campbell, 1929, p. 92.

*Climacocylis*, with its flaccid walls, open aboral end, and distinctive form, is evidently specially adapted to life in the warm seas where it is common. The genus is probably derived from *Coxiella*.

*Climacocylis* is frequent in the warm waters near the equator in both the Atlantic and the Pacific, and does not venture far from this region to the north and south.

Three species are described here, and one new variety is named.

#### *Climacocylis scalaria* (Brandt) Jörgensen

*Climacocylis scalaria*, Kofoid and Campbell, 1929, p. 93, fig. 155; Marshall, 1934, p. 640.

In its usual form the lorica consists of a long tube with a spiral shelf and an expanded, flaring skirt; in length it is 6.9 to 10.0 oral diameters. The oral margin is entire and thin. The long tubular section occupies about 0.59 the total length, and on its upper two-thirds are 3 to 13 wide, plate-like, left-turning spiral shelves. These shelves increase gradually in diameter from oral to aboral end, ranging from 1.18 to 1.92 oral diameters. The shelves occupy the middles of wide spiral turns which number the same as the spiral shelves, and which are unequal in width, the widest, at the lower end, being 1.2 oral diameters. The shelves sometimes, although not always, are connected by a jelly-like substance recalling the outer sac of *Brandtiella palliata*. The lowermost third of the tube is free of spiral turns and shelves, and retains the same diameter as the oral end. At its aboral end the squarish, widely flaring, flounced skirt arises. This skirt has a length of about 2 oral diameters and is about as wide as long. Its lower edges are incoherent and ragged. The

aboral end is wide open; in life it may be saccular and closed off, but it is easily torn by the plankton net.

The wall is coarsely alveolar, with very large, subuniform hexagons faintly visible in the soft, flaccid, and almost transparent wall. There is but a single layer of prisms except in the spiral shelves, which have three to seven layers. The wall is subuniformly 0.01 oral diameter in thickness. Adherent coccoliths, diatoms, and debris are not uncommonly attached to the surface, sometimes extensively. The lumen does not enter into the solid shelves.

Length, 246 to 344 $\mu$ .

This peculiarly tropical species is exceedingly variable in almost every character. One of the loricae from station 21 had a shape like a bottle with a wide, long neck. The whole was spiraled and the shelves were not developed. The aboral end was introverted.

*Climacocylis scalaria* suggests *C. scalaroides*, but is longer, with hooplike skirt and wide, platelike shelves. A similar spiral shelf occurs on *Xystonella scandens*, but that species is altogether different; similar habits may have called forth virtually identical structures in distant genera.

Recorded from forty-six stations, thirteen in the Atlantic and thirty-three in the Pacific, as follows: two (2, 16) in the Gulf Stream, five (17, 18, 19, 20, 21) in the Sargasso Sea, four (22, 26, 27, 28) in the Atlantic equatorial region, two (31, 34) in the Caribbean Sea, ten (40, 45, 46, 68, 69, 71, 73, 77, 78, 80) in the Galápagos region, one (54) in the South Pacific middle latitudes, nine (82, 83, 84, 85, 87, 95, 157, 158, 159) in the region of South Pacific island fields, two (99, 152) in the Pacific equatorial region, six (100, 109, 110-111, 140, 150, 151) in the North Pacific trade region, three (112, 113, 145) in the North Pacific middle latitudes, and two (147, 149) in the California region. *Climacocylis scalaria* avoids the Atlantic drift, North Sea, American cold-water region, East Asiatic marginal sea, and Alaskan secondary region. All these are regions of cool water. Its preference for the warmer waters is also reflected in the temperature records.

There are 17 pump and 49 net samples, of which 17 were taken at the surface, 26 at 50 meters, and 23 at 100 meters. Maximum frequency, 64 per cent at station 73 at the surface; other records above minimum (2 to 51 per cent) from stations 2, 16, 17, 18, 19, 21, 34, 45, 46, 54, 71, 73, 77, 80, 82, 84, 85, 99, 109, 110-111, 112, 113, 145, 147, 149, 150, 151, 157, 159. Thus, at thirty stations (45 per cent) this species was one of the commoner Tintinnoina. It reached its maxima in the upper 50 meters, but did reach 2 per cent at 100 meters at station 54. Averages, 7.0 and 6.3 loricae in Atlantic and Pacific pump samples, and 3.2 and 8.7 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump samples 18°40-26°19 (23°89), net samples 17°50-26°57 (22°63); Pacific, 14°93-27°46 (23°64) and 15°33-28°74 (23°71), respectively. Salinity: Atlantic, pump samples 36.08-37.15 (36.45), net samples 36.24-37.15 (36.61); Pacific, 33.68-36.49 (35.30) and 34.02-36.92 (35.67), respectively. Density: Atlantic, pump samples 23.95-26.01 (24.77), net samples 23.84-26.07 (25.16); Pacific, 21.60-25.98 (23.93) and 22.31-25.83 (23.92), respectively.

pH: Atlantic, pump samples 8.11-8.29 (8.22), net samples 8.16-8.32 (8.23); Pacific, 7.80-8.42 (8.18) and 7.87-8.39 (8.20), respectively.

#### *Climacocylys scalaroides* Kofoid and Campbell

*Climacocylys scalaroides* Kofoid and Campbell, 1929, pp. 93-94, fig. 187; Marshall, 1934, pp. 641-642, fig. 14.

The short, fairly stocky lorica is finger-shaped and 2.6 to 6.0 oral diameters in length. The oral margin is smooth and entire. The bowl has a collar-like spiral band of 3 to 17 left-wound turns of unequal width. These bands form rounded ridges, and the collar-like section occupies 0.3 to 0.5 total length. The aboral five- to seven-tenths is devoid of bands, and the whole tubelike lorica approximates a cone ( $8^\circ$ ). The lateral contour is locally varied, especially in the undivided region. The aboral end is commonly closed off with some local thickening; sometimes it is open and ragged.

The soft, flaccid wall, easily deformed, has large hexagonal prisms, about 65 around the mouth and 10 vertically across the widest of the bands. The prisms are in a single layer everywhere save in the suboral bands, where there may be seven layers in the thickest parts. The wall is rather thick in places, reaching nearly 0.3 oral diameter near the blobby posterior part; mostly it is only a third as much.

Length, 90 to 271 $\mu$ .

There is considerable variation in dimensions and proportions, perhaps to be correlated with physical data. The number of spiral turns, their width, and the extent to which a real shelf is developed are also characters subject to difference. Marshall (1934) found caudal flaps or tongues at the aboral end; in the *Carnegie* material these tongues are lacking, the loricae conforming to the originals. Specimens with flaps may be distinctive in certain regions and should be specially designated. The name suggested for such variety is *marshallae*, n. var.

Close to *Climacocylys scalaria* in most characters, this species differs, however, in being smaller, in having fewer spiral turns in the collar, and in the lack of an aboral skirt, the spreading flounces of which give a peculiar character to *scalaria*. The spiral turns are never flat shelves as in *scalaria*, and the aboral masses or flaps are different in the two. The other species can hardly be confused with either of these, although the tubular *C. siphon* has the spiral turns in a restricted region; there is little else in common.

Recorded from seven stations, four in the Atlantic and three in the Pacific, as follows: two (19, 21) in the Sargasso Sea, one (22) in the Atlantic equatorial region, one (32) in the Caribbean Sea, one (38) in the Pacific equatorial region, and two (40, 73) in the Galápagos region.

There are 2 pump and 5 net samples, of which 3 were taken at the surface, 3 at 50 meters, and 1 at 100 meters. Frequency, 10 per cent at station 38; 2 per cent at station 40; other records minimum.

Temperature: Atlantic, pump sample  $19^\circ 21$ , net samples  $17^\circ 50$ - $26^\circ 57$  ( $23^\circ 12$ ); Pacific,  $28^\circ 01$  and  $15^\circ 33$ - $26^\circ 48$  ( $20^\circ 90$ ), respectively. Salinity: Atlantic, pump sample 35.41, net samples 36.28-37.15 (36.72); Pacific, 35.97 and 32.88-

34.89 (33.88), respectively. Density: Atlantic, pump sample 25.30, net samples 23.84-24.89 (24.36); Pacific, 23.14 and 21.31-25.83 (23.57), respectively. pH: Atlantic, pump sample 8.05, net samples 8.27-8.32 (8.29); Pacific, 8.23 and 7.87-8.33 (8.10), respectively.

#### *Climacocylys siphon* (Brandt) Kofoid and Campbell

*Climacocylys siphon*, Kofoid and Campbell, 1929, p. 94, fig. 184

The lorica is an elongated tube with numerous spiral turns, an open, ragged aboral end, and a length of 6.0 oral diameters. The oral margin is thin and entire. The spiral collar occupies the anterior 0.43 to 0.67 total length and is made up of 29 to 33 left-wound, low-angled ( $5^\circ$  to  $10^\circ$ ) turns. The turns are subequal, although with a general tendency to be wider in the lower part than in the upper. They are separated from one another by optically dark, wide lines. The lower 0.33 to 0.57 of the lorica, forming the bowl, is tubular. The aboral region is devoid of spiral lines or other special characters, the whole being really subconical ( $5^\circ$ ). The lateral contour is fairly regular. The wide-open aboral end is either squarely truncated or ragged. In the latter case it may be higher (as much as half the length of the aboral section) on one side.

The wall is rigid and easily fractured. It is minutely alveolar, with occasional lacunae in the spiral lamina.

There are 2 oval macronuclei and 18 membranelles.

Length, 260 to 290 $\mu$ .

*Climacocylys siphon* is not close to other members of the genus. Possibly it is closer to *C. digitula* or *C. elongata* than to others. These species are similar in shape, but the spiral is continuous from end to end. In this respect *siphon* is like *C. scalaria*, but it has no expanded skirt and the wall is not flaccid.

Recorded only from station 24 in the Atlantic equatorial region, in a net sample taken at 50 meters. Frequency, minimum.

Temperature,  $23^\circ 12$ ; salinity, 36.00; density, 24.67; pH, 8.14.

#### METACYLINAЕ Kofoid and Campbell

Metacylineae Kofoid and Campbell, 1929, p. 197.

The Metacylineae include those genera in which the spiral lamina is invariably limited to the anterior part of the lorica. The subfamily was formerly assigned to the Petalotrichidae, but is here transferred to the Coxiellidae, where it appears to be more naturally placed.

The genera included are *Metacylis* and *Helicostomella*. Only the latter was found in the material of this expedition.

#### HELICOSTOMELLA Jörgensen emended

*Helicostomella*, Kofoid and Campbell, 1929, p. 104.

*Helicostomella* is related on the one hand to *Coxiella* in having a spiral lamina, and on the other hand to *Climacocylys* in having the spiral region limited. The wall has typical secondary structure.

*Helicostomella* is often common in temperate waters, especially those of the north, although one species occurs as

far south as Patagonia. Most of the species are well known in northern Europe, and even to the north of Russia. Rarely do species of this genus go far to sea, nearly all being within coastal waters.

One species is described here.

#### *Helicostomella longa* (Brandt) Jörgensen

*Helicostomella longa*, Kofoid and Campbell, 1929, p. 106, fig. 206.

The small, short, rather plump lorica, with slightly swollen bowl and very short aboral spine, has a length of 2.24 oral diameters. The erect oral margin is formed by the uppermost of the whorls that form the collar. The collar is a spiral lamina of 4 whorls; its length is about 0.22 total length, and the laminae are subequal in width. A fine, dark line separates the turns one from another, and no overlap is developed. The turns are laterally slightly concave. The conical bowl is about 1.1 oral diameters in its greatest diameter, which is reached near the middle. The lower part narrows down ( $66^\circ$ ), and becomes more conical ( $90^\circ$ ) nearer the tip. The aboral horn is about 0.2 oral diameter in length, narrow conical ( $15^\circ$ ), and distally pointed.

The wall is finely alveolar, with tiny secondary *Favella*-like hexagons. Collar and bowl are alike in this respect. The wall is subuniformly 0.04 oral diameter in thickness, with thin laminae, and has rectangular prisms in a single layer. The lumen follows the contour exactly.

Length, 50 to 80 $\mu$ .

*Helicostomella longa* belies its name, being much the shortest and plumpest member of the genus. Its collar has fewer spiral turns than that of any other species, its bowl is much the widest, and its horn is the shortest. It bears some likeness to the antarctic *Laackmanniella naviculifera*, but the bowl is pointed instead of open and lacks adherent diatoms, and the collar has fewer turns.

Recorded from one station (130) in the California region, in a net sample taken at 100 meters. Frequency, 42 per cent. Temperature,  $8^\circ.96$ ; salinity, 33.72; density, 26.14; pH, 8.06.

#### FAVELLIDAE Kofoid and Campbell emended

Favellinae, Kofoid and Campbell, 1929, p. 116.

In this family are included four genera, namely, *Poroecus*, *Favella*, *Protocymatocyliis*, and *Cymatocyliis*. Only the first two occur in the material of this expedition, the latter two being antarctic. *Poroecus* is tropical, and *Favella* usually coastal.

#### POROECUS Cleve emended

*Poroecus*, Kofoid and Campbell, 1929, pp. 116-117.

*Poroecus* is evidently the simplest member of the Favellidae. Its thimble shape without much form differentiation, entire to irregular oral margin, and wall structure are indications of this fact. The genus is possibly related to *Tinnopsis*.

*Poroecus* is uncommon in the tropical sea, where coccoliths are abundant.

One species is described here.

#### *Poroecus apicatus* Kofoid and Campbell

*Poroecus apicatus* Kofoid and Campbell, 1929, p. 118, fig. 223.

The small lorica, with subcylindrical upper and conical lower bowl, has a length of 2.0 oral diameters. The oral margin is irregularly ragged and not differentiated. The bowl is cylindrical in the anterior half and is convex conical ( $55^\circ$ ) in the posterior section. The aboral end is broadly rounded.

The wall is thin and alveolar, and in each alveole there is a coccolith that completely fills it.

Length, 56 $\mu$ .

*Poroecus apicatus* is the shortest species of the genus. In the lack of aboral horn it differs from all others save *P. brandti*. From this species it differs in its shortness and contracted lower bowl. In *brandti* the aboral end is hemispherical and the lorica is more than twice as bulky, being 2.5 oral diameters and up to 275 $\mu$  in length.

Recorded from one station (71) in the Galápagos region, in a pump sample taken at 50 meters. Frequency, minimum. Temperature,  $18^\circ.85$ ; salinity, 35.09; density, 25.86; pH, 7.83.

#### FAVELLA Jörgensen emended

*Favella*, Kofoid and Campbell, 1929, p. 147.

*Favella* agrees with *Poroecus* in having laminae, and in similar wall structure and, in the simple species, similar form. *Favella* is more advanced in having better finish, larger size, and more highly developed form, and is also related to *Cymatocyliis* and *Protocymatocyliis*. These last two genera are exclusively antarctic in distribution, occurring under the ice in the marginal region of the Antarctic Continent, off Kaiser William II Land, where they are probably semineritic. No members of either of these genera are recorded in the Humboldt Current, Cape Horn Current, or Antarctic Current. The relation of these two genera to *Favella* is clear both in form and in wall structure. *Parafavella* is not related to any of these, but to the Xystonellidae.

*Favella* is almost exclusively found in neritic waters or in water of coastal origin, where there are many local species. A few species occur far out to sea, but these are generally very different from coastal forms. As a whole, it is most common in temperate water, but it does extend in range from northern waters beyond Iceland to southward of Australia. Some species cling to the coasts of tropical lands.

Five species are described here, of which two are new.

#### *Favella adriatica* (Imhof) Jörgensen emended Kofoid and Campbell

*Favella adriatica*, Kofoid and Campbell, 1929, pp. 149-150, fig. 277.

The rather short, stout lorica, with narrow oral cuff, cup-shaped bowl, and stout, conical aboral horn, has a length of 1.78 oral diameters. The oral margin is entire and a trifle

wavy. The erect oral cuff has a width of less than 0.04 oral diameter and is quite hyaline. The cuplike bowl, with more or less even upper margin, is narrow conical ( $4^\circ$ ) in the anterior 0.78 oral diameter below the oral margin, and wider ( $79^\circ$ ) in the posterior 0.5 oral diameter. The sides are full in the upper bowl and distinctly convex in the lower part. The aboral horn is a cone ( $15^\circ$ ) with a length of 0.5 oral diameter. Its sides are sinuous and there are 2 or 3 short pleats or folds near its upper end.

The wall is subuniformly thin, being not more than 0.02 oral diameter in thickness. The oral cuff is less than half as much. There are well developed thin laminae and radial prisms. The wall is everywhere finely meshed without lacunae, and the mesh continues over the horn. The cavity follows the outer contour.

Length, 200 to 400 $\mu$ .

*Favella adriatica* has a shorter, stouter bowl than *F. campanula*, as well as a wider horn. Its horn is shorter and less spinelike than that of *F. fistulicauda*, and it has an oral cuff lacking in that species. Its horn is better developed than that of *F. azorica*, and that species has a relatively longer bowl. *Favella arcuata* has a suboral ledge, a relatively longer bowl, and a shorter horn. *Favella infundibulum* has a conical instead of cuplike bowl and a handle-shaped horn. *Favella confessa* is of stouter facies, with a wider collar, a serrated oral rim, and scarcely developed horn. *Favella attingata* and *F. serrata* are very different species.

Recorded from one station (110) in the North Pacific trade region, in a pump sample taken at 100 meters. Frequency, minimum.

Temperature,  $17^\circ 96$ ; salinity, 34.73; density, 25.10; pH, 8.14.

#### *Favella azorica* (Cleve) Jørgensen

(Figure 56)

*Favella azorica*, Kofoed and Campbell, 1929, p. 151, fig. 284; Marshall, 1934, p. 642, fig. 15.

The small, cuplike lorica, with no teeth, generally convex-conical bowl, and aboral horn, has a length of 1.5 oral diameters. The oral rim is entire, thin, and erect. There is no differentiated collar, and the upper subcylindrical bowl continues with the same diameter as that of the oral opening for a distance of 0.64 oral diameter. Its sides are full and evenly contoured. The lower bowl contracts as a convex cone ( $60^\circ$ ) with a length of 0.57 oral diameter. The aboral horn is a barely concave cone ( $55^\circ$ ) with a length of 0.39 oral diameter, and it joins the lower bowl with gradual change in contour.

The wall has a subuniform thickness of 0.1 oral diameter across the bowl. It thins to the oral rim, and in the lower bowl and horn is a little less. There are clear inner and outer laminae, enclosing a single layer of radial, very faint prisms. The wall shows no trace of annuli. It is glass-clear.

The animal has 2 oval macronuclei.

Length, 82 $\mu$ .

Marshall (1934) figures a lorica with suboral rings, alveolar structure, and a length of 2 oral diameters. The length is stated to be 73 to 107 $\mu$  and the oral diameter 47 to 65 $\mu$ . The

*Carnegie* loricae, which were abundant, show little significant variation, all certainly lacking annuli.

*Favella azorica* most closely resembles *F. composita*, but the latter species has a number of fine suboral rings and is of somewhat different proportions. There is less difference between bowl and horn in *composita* than in *azorica*. *Favella minutissima* is tiny, with more sharply differentiated horn, but does bear some general relationship to *azorica*. The other species of *Favella* are unlike these species and can hardly be confused with them.

Recorded from off Easter Island, in a net sample taken at the surface. Frequency, 75 per cent; there were hundreds of loricae.

No physical data were taken at this station.

#### *Favella minutissima*, new species

(Plate 1, figure 8; figure 59)

The exceedingly small, cup-shaped lorica has a length of 1.5 oral diameters. The oral margin is erect and simple. There is no differentiated collar. The bowl continues below the rim for about 1 oral diameter with the same diameter throughout. Below this level it forms an inverted, rounded subhemisphere. The aboral horn has a length of approximately 0.5 oral diameter, and is a simple, solid, pointed spike.

The wall is relatively thick, about 0.1 oral diameter, sub-orally; toward the aboral end it becomes a little thinner. It is hyaline, without traces of laminae, prismatic structure, or surface markings of any sort. The cavity follows the outer contour strictly, save that the horn is solid.

Length, total 28 to 34 $\mu$ , pedicel 3.1 to 6.2 $\mu$ ; oral diameter, 18.8 to 19 $\mu$ .

*Favella minutissima* differs from all others of the genus in size, general proportions, and form. Its lack of collar and of prismatic structure sets it off from others. If it had coccoliths it would have been placed with *Porococcus*, perhaps near *Porococcus apiculatus*, but its size and shape are different. The presence of a collar would have suggested *Craterella*, but it lacks this essentially diagnostic organ. Its place in *Favella* is uncertain, and it awaits final disposition. *Favella azorica*, the species most like it in the genus, has no clear-cut horn.

Recorded from two stations (44, 75) in the Galápagos region, in 1 pump and 1 net sample taken at 50 and 100 meters, respectively. Frequency, minimum.

Temperature: pump sample  $20^\circ 52$ , net sample  $18^\circ 40$ . Salinity: pump sample 34.86, net sample 35.47. Density: pump sample 24.53, net sample 25.55. pH: pump sample 8.04, net sample 8.10.

Type locality, station 75, 100 meters; latitude  $14^\circ 15'$  south, longitude  $92^\circ 05'$  west.

#### *Favella septentrionalis*, new species

(Plate 1, figure 12)

The moderately large, trim lorica has a narrow collar, a long bowl, and a blunt, clumsy aboral horn; its length is 3.5 oral diameters. The narrow collar with median constriction is approximately 0.08 oral diameter in width. It is outwardly concave, and its margin is slightly recurved



toward the outside and inwardly convex. The collar is a thin, membrane-like, hyaline cuff or ring with no trace of spiral origin. Its upper margin is smooth, without irregularity. The collar rests squarely upon the regular, neat bowl below it. The bowl is long and thimble-shaped. The upper part occupies 0.62 the total length. Its anterior diameter is barely that of the oral opening, and it swells aborally to about 1.17 oral diameters. This section, thus, forms a segment of an inverted truncated cone (less than  $10^\circ$ ). Its sides are even and smooth, and have no trace of even the slightest irregularity. The aboral section of the bowl is somewhat greater than a hemisphere, or, perhaps more correctly, resembles half an oval. It occupies about 0.16 the total length; its length is 1.75 of its own diameter at the oral end. Its sides are full, even, regular arcs and like the upper section, with which it is continuous. The blunt, thick aboral horn has a length of about 0.22 total length. Its diameter at its flaring base, where it joins the bowl, is 0.36 oral diameter, and its free end is 0.42 basal diameter. It is, thus, also an inverted cone ( $12^\circ$ ). Its aboral end is almost squarely truncated; its sides are sinuous and irregular, unlike the trim lines of the upper parts.

The cavity of the lorica follows the outer contour closely in the collar and bowl, but in the horn it is reduced to a very narrow, slightly twisted, conical lumen which extends for about 0.7 the length of the horn itself. The cavity is widest orally and reaches a sharp point aborally. The wall is subuniformly about 0.07 oral diameter in thickness across the bowl, and 0.17 between the outer lamina and the wall of the lumen of the pedicel. There are an inner and an outer hyaline lamina, continuous about the oral end of the bowl. Between these laminae occur the secondary prisms in a single layer in the bowl. The outer lamina vanishes in the lower section of the bowl, but the inner one continues to the lumen of the pedicel, where it thins out and finally disappears. The secondary prisms are larger, about 75 in number from oral to lower end of the bowl. In the pedicel and also just beneath the collar the prisms occur in several layers, two or three across below the collar, and four or five aborally. They are less regular in shape in these regions. There are 3 to 45 prisms across the wall of the bowl. The aboral horn is without striations or other surface marks, like the bowl.

Length, total 269 $\mu$ , pedicel 57 $\mu$ ; oral diameter, 75 $\mu$ .

*Favella septentrionalis* resembles *F. franciscana* in general facies, but has a thicker, blunter, clumsy horn instead of a pointed one. The collar of *franciscana* is a spiral, whereas that of *septentrionalis* is a low ring. The wall of *franciscana* is roughened, unlike the trim one of *septentrionalis*. The present species lacks the suboral bulge of *F. arcuata* and has a different horn. It differs from *F. serrata* in having a smooth, recurved collar and, again, a different horn. In similar ways it differs from *F. attingata*. *Favella ehrenbergii* lacks the collar of *septentrionalis*, and its horn is different. *Favella septentrionalis* is more slender than *F. confessa* and of less square facies. It bears some resemblance to *F. panamensis*, but that species has a relatively longer and more pointed, regular horn and a taller collar, often with spiral structure. The horn of *septentrionalis* is not at all like that

of *F. campanula*, which is also a trim lorica. It is proportioned somewhat like *F. tarakaensis*, but the horn, again, differs widely in form. The collar of *tarakaensis* is a spiral and the margin is serrate.

Recorded from one station (116) in the North Pacific middle latitudes, in 2 net samples, 1 each taken at the surface and at 50 meters. Frequency, 4 per cent in both samples.

Temperature,  $11.18-16.07$  ( $13.62$ ); salinity,  $33.79-34.02$  ( $33.90$ ); density,  $24.99-25.83$  ( $25.41$ ); pH,  $8.11-8.17$  ( $8.14$ ).

Type locality, station 116, surface; latitude  $38^\circ 41'$  north, longitude  $147^\circ 41'$  east.

#### *Favella serrata* (Möbius) Jörgensen

*Favella serrata*, Kofoid and Campbell, 1929, p. 156, fig. 293.

The generally cylindrical-conical, rather stout lorica, with serrate oral rim, slight suboral bulge, and conical aboral horn, has a length of 3.51 oral diameters. The oral margin has about 70 minute, rounded triangular, subregular, slightly incurved teeth. There is a low, hyaline, suberect cuff with a width of less than 0.07 oral diameter immediately below the margin, and the bowl contracts below it to a diameter of 0.95 oral diameter at about 0.2 oral diameter below the rim. Below this level it again swells out evenly to a diameter of nearly 1.1 oral diameters at about 0.4 oral diameter below the rim. This suboral bulge has a width of approximately 0.32 oral diameter. At the lower end the bowl gradually and subregularly contracts as a cone ( $7^\circ$ ) for a length of nearly 1.6 oral diameters, and then as a wider one ( $42^\circ$ ) for 1.0 oral diameter. The upper section has more or less full sides, and the lower cone is slightly convex. The aboral horn is a narrow cone ( $10^\circ$ ) with a length of 0.86 oral diameter. Its sides are slightly sinuous and its tip is pointed.

The wall has a subuniform thickness of not over 0.04 oral diameter, and there are thin inner and outer laminae between which there are thin-walled, radial, single layers of prisms. The prisms are a little less wide suborally than in the lower bowl. The surface displays a fine alveolar structure with an occasional lacuna near the suboral part of the bowl. The cavity of the lorica follows the outer contour except that the horn is solid; the lumen enters into its upper end briefly.

The animal has 2 oval macronuclei.

Length, 320 $\mu$ .

The *Carnegie* loricae are much more trim and less bulky, with a relatively longer horn and with more pronounced suboral contraction, than is typical. The horn is solid rather than hollow.

*Favella serrata* differs from *F. septentrionalis* in having a serrate oral rim and a thinner, less blunt aboral horn. Its bowl is less conical than that of *F. attingata* and its horn is longer. It lacks the alae of *F. helgolandica*, and its bowl and collar are different. *Favella brevis* is squarish, with suboral rings and a thicker horn. *Favella confessa* has a gradual transition between horn and bowl, and a very short horn. *Favella ehrenbergii* lacks oral denticles, has no cuff and no bulge, and has a wide, conical horn.

Recorded from two stations, one each in the Atlantic and

the Pacific, as follows: one (9) in the Atlantic drift, and one (116) in the North Pacific middle latitudes.

There are 4 net samples, of which 2 were taken at the surface and 2 at 50 meters. Maximum frequency, 8 per cent at station 116; frequency at station 9, 2 per cent; averages, 1.5 and 5.5 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, 8°06–11°12 (9°59); Pacific, 11°18–16°07 (13°62). Salinity: Atlantic, 35.11–35.14 (35.12); Pacific, 33.79–34.02 (33.90). Density: Atlantic, 26.88–27.37 (27.12); Pacific, 24.99–25.83 (25.41). pH: Atlantic, 7.96–8.08 (8.02); Pacific, 8.11–8.17 (8.14).

PTYCHOCYLIDAE Kofoid and Campbell emended  
Ptychocylidae, Kofoid and Campbell (part), 1929, p. 172.

Only the single genus *Ptychocylis* occurs in the family.

PTYCHOCYLIS Brandt emended Jörgensen

*Ptychocylis*, Kofoid and Campbell, 1929, pp. 185–186.

*Ptychocylis* is related in form and in wall structure to *Favella*, *Protocymatocylis*, and *Cymatocylis*, and more remotely to *Poroecus*. *Ptychocylis* is the northern representative of these mostly southern and tropical genera.

*Ptychocylis* is distinctly a northern genus. Rarely does it extend as far south as latitude 40° north. Mostly it occurs in the Barents Sea, Davis Strait, Sea of Okhotsk, Bering Sea, and north of the West Wind Current, often in minus temperatures. Only washed and battered empty loricae enter San Francisco Bay.

Six species are described here.

*Ptychocylis acuta* Brandt emended Kofoid and Campbell

*Ptychocylis acuta*, Kofoid and Campbell, 1929, p. 187, fig. 353.

The generally cylindrical lorica, with acutely conical aboral end, has a length of 1.72 oral diameters. The oral margin is fairly regularly serrate, with about 70 triangular, erect teeth set upon a narrow, hyaline cuff with a width of only 0.03 oral diameter. The bowl swells concavely below the cuff to a diameter of 1.17 oral diameters at 0.13 oral diameter below the rim. This projecting ledge then rapidly narrows again and there is a cylinder below it. A second ledge, with a diameter of 1.17 oral diameters, is located at 0.45 oral diameter below the rim. The lower part of the bowl is a segment of an inverted truncated cone (25°) with a length of 0.77 oral diameter at its lower end, which is 1.22 oral diameters below the rim; the diameter at this level is 0.83 oral diameter. The aboral region forms a hollow-sided segment of an inverted truncated cone (80°) with a length of 0.25 oral diameter. Its lower end is 1.47 oral diameters below the rim. The diameter at this level reaches 0.38 oral diameter. The distally blunted aboral horn is an inverted cone (50°) with a length of nearly 0.27 oral diameter.

The wall has a uniformly thin inner and outer lamina, and clear interlamina substance fills the space between. The outer surface is irregularly reticulated with a scarcely raised network of secondary structure.

Length, 120 to 145 $\mu$ .

*Ptychocylis acuta* resembles *P. walesi* in having an acute aboral end, but the lower bowl is fuller and relatively shorter. *Ptychocylis glacialis* has a sharply pointed aboral end, and the remaining species are so different that they can hardly be confused with *acuta*.

Recorded from one station (119) in the East Asiatic marginal sea, in a pump sample taken at the surface. There were 2 loricae.

Temperature, 6°91; salinity, 32.96; density, 25.85; pH, 7.96.

*Ptychocylis arctica* Brandt emended Kofoid and Campbell

*Ptychocylis arctica*, Kofoid and Campbell, 1929, p. 187, fig. 351.

The large, stout, bullet-shaped lorica, with blunted, flattened aboral end, has a length of 1.48 oral diameters. The oral margin has about 50 large, triangular, erect teeth, evenly spaced and subequal. These denticles arise from a hyaline cuff with a width of only 0.03 oral diameter. Below the cuff the bowl extends as a narrow cylinder for a width of 0.05 oral diameter, and an angular ledge with a width of 0.06 oral diameter and a diameter of 1.12 oral diameters occurs below this cylinder. The bowl extends as a cylinder below the ledge once more, and is 0.25 oral diameter in width. At its lower end is a second ledge with a width somewhat less than that of the upper one, but with the same diameter. The lower part of the bowl contracts as an inverted truncated segment of a cone (22°) with a width of 0.78 oral diameter; its sides are plane to slightly full. The aboral region is an inverted convex cone (83°) with a width of 0.26 oral diameter. The aboral end is squarely truncated, and its diameter is 0.19 oral diameter.

The wall is thickened in the ledges to 0.05 oral diameter, and is less than half as thick in the lateral region. Laminae are difficult to detect, and the wall is homogeneous. The outer surface is reticulated with rather small prisms, the edges of which are weakly raised, giving the surface, especially at the aboral end, a pitted structure. The clear cuff rests upon the dense bowl. The lumen does not enter the ledges.

Length, 120 to 140 $\mu$ .

*Ptychocylis arctica* differs from *P. drygalskii* in the longer, lower bowl and general bullet shape. From *P. basicurvata* it differs in aboral truncation rather than simple aboral rounding. The remaining species have altogether different aboral ends.

Recorded from one station (10) in the Atlantic drift, in 2 net samples, 1 taken at the surface and 1 at 50 meters. Frequency, minimum.

Temperature, 9°86–10°94 (10°40); salinity, 34.94–34.95 (34.945); density, 26.77–27.96 (27.36); pH, 8.04–8.08 (8.06).

*Ptychocylis drygalskii* Brandt

*Ptychocylis drygalskii*, Kofoid and Campbell, 1929, p. 188, fig. 350; Hada, 1932b, p. 567, fig. 11.

The heavy-set lorica, with little-developed ledges and truncate conical, flattened aboral end, has a length of 1.4 oral diameters. The oral margin is regularly provided with

about 34 erect, triangular teeth. These teeth arise from a narrow (0.02 oral diameter) hyaline cuff. The bowl below the cuff expands concavely, giving rise to an angular ledge of nearly 1.15 oral diameters, close to 0.15 oral diameter below the rim. The bowl below the ledge is concave cylindrical. This cylindrical part is nearly 0.45 oral diameter in length, and at its lower end there is a ledgelike swollen zone of about 1.2 oral diameters with a width of approximately 0.22 oral diameter; sometimes this zone is more sharply marked and not so wide. The bowl contracts below this second ledge as an inverted basal segment of a hollow-sided truncate cone ( $27^\circ$ ) with a diameter, at its lower end, of 0.94 oral diameter. The aboral region again contracts as a concave cone ( $76^\circ$ ) with a width of 0.5 oral diameter, and the broadly rounded aboral end has a diameter of nearly 0.25 oral diameter.

The wall is homogeneous, and its structure is difficult to make out. Its thickness hardly exceeds 0.01 oral diameter, even in the ledges. The cavity partially enters the ledges and the horn. The surface shows hexagonal meshwork and is weakly pitted. It is denser aborally than elsewhere.

Length, 77 $\mu$ .

The *Carnegie* loricae are more like those of Hada (1932b) than those of Brandt in size, proportions, and other characters; perhaps there is some geographical difference.

*Ptychocyclus drygalskii* resembles *P. obtusa*, but it is stouter and its aboral end is not similar. It bears some likeness to *P. arctica*, but is shorter and stouter and has a less bullet-shaped bowl than that species; *arctica* has a narrower conical aboral region and pointed tip.

Recorded from one station (123) in the East Asiatic marginal sea, in a pump sample taken at the surface. Frequency, minimum.

Temperature,  $8^\circ 10$ ; salinity, 32.76; density, 25.52; pH, 8.03.

#### *Ptychocyclus minor* Jörgensen

*Ptychocyclus minor*, Kofoid and Campbell, 1929, p. 188, fig. 354.

The rather short, urn-shaped lorica, with conical aboral region and short horn, has a length of 1.7 oral diameters. The oral margin is regularly provided with about 56 short, erect, bluntly pointed, evenly spaced, triangular teeth resting on a narrow, hyaline cuff, the width of which is only 0.01 oral diameter. The bowl expands ( $80^\circ$ ) to a narrow, projecting shelf or ledge, the diameter of which is 1.18 oral diameters, and which is at 0.11 oral diameter below the rim. Below this shelf the bowl contracts with concave lateral contour to a swollen zone (1.08 oral diameter) with a width of 0.22 oral diameter, near 0.5 oral diameter below the rim. Below this swelling the bowl contracts as an inverted truncated, barely concave cone ( $16^\circ$ ) with a width of 0.39 oral diameter, and a diameter at its lower end of 0.92 oral diameter. The aboral region is an inverted hollow cone ( $90^\circ$ ), with a width equal to that of the region just above it, and a diameter of 0.21 oral diameter at the lower end. The aboral horn is a narrow cone ( $30^\circ$ ), with a length of 0.34 oral diameter. Its tip is minutely rounded.

The wall has thin laminae, and two to five layers of tiny,

hexagonal prisms are thus enclosed. The wall is thickest suborally and in the horn, where it reaches nearly 0.05 oral diameter; elsewhere it is about half as thick. The outer surface is rather coarsely reticulated with pitted hexagons; these pits are especially developed in the shelf and aboral cone.

Length, 90 to 135 $\mu$ .

Some of the *Carnegie* loricae contract with sharp angles suborally and have decided conical bowls and bluntly conical horns.

*Ptychocyclus minor* most resembles *P. urnula*, but is shorter, with less conical aboral region and more conical bowl. The horn is also shorter and more conical. *Ptychocyclus acuta* has a shorter horn; *P. repanda* and *P. ostensfeldi* are similar.

Recorded from seven stations in the Atlantic, as follows: one (7) in the North Sea, four (8, 9, 10, 11) in the Atlantic drift, one (12) in the American cold-water region, and one (14) at the margin of the Gulf Stream.

There are 2 pump and 14 net samples, of which 6 were taken at the surface, 6 at 50 meters, and 4 at 100 meters. Maximum frequency, 100 per cent at station 10 at the surface; other records above minimum (2 to 80 per cent) from stations 7, 8, 9, 11, 12, 14; averages, 5.5 loricae and 53.2 per cent in pump and net samples, respectively.

Temperature: pump samples  $7^\circ 01$ – $8^\circ 44$  ( $7^\circ 72$ ), net samples  $4^\circ 18$ – $14^\circ 02$  ( $8^\circ 96$ ). Salinity: pump samples 33.65–34.97 (34.31), net samples 34.51–35.59 (35.02). Density: pump samples 26.16–27.42 (26.79), net samples 26.66–27.96 (26.96). pH: pump samples 7.92–8.10 (8.01), net samples 7.92–8.08 (8.00).

#### *Ptychocyclus obtusa* Brandt emended Kofoid and Campbell

(Figures 57, 58)

*Ptychocyclus obtusa*, Kofoid and Campbell, 1929, pp. 188–189, fig. 349; Schulz and Wulff, 1929, pp. 336–338, figs. 105–109; Bernstein (part), 1931, pp. 13–14, fig. 2a, b (for fig. 2c–g see *P. glacialis* and *P. urnula*); Hada, 1932a, pp. 55–56, fig. 21; 1932b, p. 567.

The stout, squat lorica, with aboral cone and flattened end, has a length of 1.57 oral diameters. The oral margin is regularly serrate with minute, evenly spaced triangular points, and these rest on a very narrow, clear band the width of which is only 0.02 oral diameter. The bowl expands concavely and conically ( $60^\circ$ ) for a distance of 0.14 oral diameter and reaches 1.13 oral diameters at its lower end. It again contracts conically ( $50^\circ$ ) and reaches a diameter of 1.04 oral diameters at 0.26 oral diameter below the rim. Once again it expands conically ( $60^\circ$ ), reaching a diameter of 1.22 oral diameters near 0.43 oral diameter below the rim. Below this level the bowl contracts conically ( $65^\circ$ ), reaching, at 0.55 oral diameter below the rim, a diameter of 1.07 oral diameters. This last diameter is maintained for a distance of 1.12 oral diameters below the rim, giving the central region of the bowl a generally cylindrical contour. At the lower end of this cylinder the bowl contracts conically ( $80^\circ$ ) once more for 0.24 oral diameter, reaching a diameter of 0.68 oral diameter at the lower end of this zone. The pedicel-like region is a truncated cone ( $45^\circ$ ) with a length of 0.43

oral diameter. Its lower end is squarely truncated and its width is 0.4 oral diameter. The sides of this much contracted lorica are neatly rounded over the several shoulders, and the conical regions are generally full or convex.

The wall is usually thin, hardly exceeding 0.01 oral diameter, with some slight thickenings at the angles. Laminae and alveolar structure are not distinguished. The outer surface is reticulated, however, with elongate hexagons, and near the aboral end it is pitted, the walls of the reticulations being lifted above the general surface. The lorica is dark and heavy.

Length, 119 $\mu$ .

These extremely numerous loricae are decidedly variable. One extreme form is shown (fig. 58). Schulz and Wulff (1929) illustrate a long series taken in different temperatures and other physical conditions in the Barents Sea; these loricae all differ widely.

*Ptychocylis obtusa* resembles *P. cylindrica*, but the cylindrical part of the bowl is not so long and the lorica is much stockier. The character of the aboral end differentiates *obtusa* from the other species, for none of them has a wide, flat end; their ends are, for the most part, either acute or pointed.

Bernstein (1931) included *P. glacialis* and *P. urnula* in *obtusa*. Some of Schulz and Wulff's loricae (1929) belong elsewhere (especially in *P. cylindrica*), although not distinguished here. The genus needs special study.

Recorded from thirteen stations, three in the Atlantic and ten in the Pacific, as follows: one (7) in the North Sea, one (10) in the Atlantic drift, one (13) in the American cold-water region, two (116, 117) in the North Pacific middle latitudes, six (118, 119, 120, 121, 122, 123) in the East Asiatic marginal sea, and two (124, 125) in the Alaskan secondary region. The species is distinctly circumpolar.

There are 18 pump and 21 net samples, of which 10 were taken at the surface, 15 at 50 meters, and 14 at 100 meters. Maximum frequency, 91 per cent at station 125; other records above minimum (2 to 79 per cent) from stations 13, 116, 117, 120, 121, 122, 123, 124. Records of 2 to 300 loricae occur in pump samples; average frequencies in net samples, 15 and 44.2 per cent in Atlantic and Pacific, respectively.

Temperature: Atlantic, pump sample 11°27', net samples 1°64'–11°27' (7°72'); Pacific, 1°72'–10°50' (5°09') and 2°01'–18°18' (5°80'), respectively. Salinity: Atlantic, pump sample 32.68, net samples 32.68–35.24 (34.06); Pacific, 32.73–33.72 (33.00) and 32.73–34.06 (33.12), respectively. Density: Atlantic, pump sample 24.94, net samples 24.94–27.96 (26.81); Pacific, 25.13–26.52 (25.48) and 25.52–26.76 (26.16), respectively. pH: Atlantic, net samples 8.04; Pacific, pump samples 7.86–8.21 (7.95), net samples 7.64–8.11 (7.97). Records of pH were not available for the Atlantic pump sample, but were available for 2 of the net samples, each 8.04.

#### *Ptychocylis urnula* (Claparède and Lachmann) Brandt

*Ptychocylis urnula*, Kofoid and Campbell, 1929, pp. 189–190, fig. 355; Schulz and Wulff, 1929, pp. 336–338, figs. 111–114. *Ptychocylis obtusa*, Bernstein (part), 1931, pp. 13–14, fig. 2f, g (for fig. 2a–e see *P. obtusa* and *P. glacialis*).

The generally cylindrical lorica, with conical aboral end

and elongated, pointed horn, has a length of 1.93 oral diameters. The oral margin is regularly set with about 60 sharp, erect, evenly spaced, triangular teeth, which arise from a hyaline cuff with a width of less than 0.02 oral diameter. The bowl swells concavely to a suboral ledge of 1.17 oral diameters at 0.1 oral diameter below the rim. Below the ledge it assumes a barely concave cylindrical shape for a distance of 0.37 oral diameter below the rim, at which level a second, less pronounced and distinctly rounded, ledge occurs. This ledge has a diameter of 1.06 oral diameters and occupies a zone with a width of approximately 0.14 oral diameter. The bowl below this zone becomes subcylindrical for 1.0 oral diameter and again swells slightly, reaching a diameter a little greater than that of the oral margin. Below this level the bowl contracts as a plane or barely concave cone (62°) with a length of 0.68 oral diameter. At its lower end is the aboral horn, which is a narrow, sharp, pointed cone (26°) with a length of nearly 0.26 oral diameter.

The wall is thick, being 0.06 oral diameter across the upper ledge, where it is thickest; elsewhere it is only about a third as much. The cavity follows the outer contour, entering into the upper bulge and extending to the tip of the horn. The wall is denser aborally and its surface is finely reticulated with irregularly formed hexagonal prisms, the walls of which are raised so that the bowl appears pitted.

Length, 123 to 192 $\mu$ .

Variations in length are probably correlated with temperature. Some loricae have longer horns than others, but the general shape is retained.

*Ptychocylis urnula* resembles *P. minor*, but is longer and has a more conical aboral region and a thinner and longer horn. Its bowl is also more cylindrical. Its horn is not so long as that of *P. repanda* or *P. ostensfeldi*, and the bowls of these two species are very different. *Ptychocylis wailesi* has a concave-conical lower bowl and lacks a prolonged horn. Other species have rounded aboral ends and are not closely related.

Bernstein (1931) unites *urnula* and *obtusa* in his figures, but distinguishes one lorica in his text as *urnula* (fig. 2g).

Recorded from one station (10) in the Atlantic drift, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 6°56'; salinity, 35.02; density, 27.52; pH, 7.95.

#### PETALOTRICHIDAE Kofoid and Campbell emended

Petalotrichidae, Kofoid and Campbell, 1929, p. 190.

Included in this family are three genera: *Craterella*, *Acanthostomella*, and *Petalotricha*. All three genera occur in the material of this expedition. *Petalotricha* is exclusively a warm-water genus, the others being more widely spread, often into very cold waters.

#### CRATERELLINAE Kofoid and Campbell

Craterellinae Kofoid and Campbell, 1929, p. 190.

Two genera belong to this subfamily: *Acanthostomella* and *Craterella*.

**CRATERELLA** Kofoid and Campbell

*Craterella* Kofoid and Campbell, 1929, p. 194.

*Craterella* includes a few small tropical species as well as one or two from cooler waters. Owing to the small dimensions, the actual distribution is inadequately known, as are the species.

Two species are described here.

***Craterella armilla*** Kofoid and Campbell

(Figure 19)

*Craterella armilla* Kofoid and Campbell, 1929, p. 195, fig. 371.

The tiny, saccular lorica, with low inner collar, repeated outer collars, thimble-like bowl, and pointed aboral end, has a length of 1.53 oral diameters. The oral margin is thin, erect, and entire, and the inner collar spreads to the upper end of the anteriormost of the two outer collars as a segment of a cone ( $62^\circ$ ) with a length of hardly 0.08 oral diameter. The upper outer collar has a diameter of 1.15 oral diameters, and flares ( $45^\circ$ ). It is separated by a trough from the inner collar. The second outer collar has a diameter of 1.3 oral diameters, and flares ( $90^\circ$ ). It is separated from the first outer collar by a trough. The pointed bowl has a length of 1.38 oral diameters. Its upper two-thirds is a truncated segment of an inverted cone ( $10^\circ$ ), and it has plane sides. The aboral third of the bowl is conical ( $80^\circ$ ), with convex sides and a simple pointed aboral end.

The wall is thick, with distinct laminae and interlaminar prisms, and the surface shows rugosity.

Length, 29 $\mu$ .

The lorica figured (fig. 19) has a pointed rather than rounded aboral end.

*Craterella armilla* differs from the other species in having repeated collars and a rough surface. It is stouter than *C. protuberans* and less contracted below. In general shape it is like *C. torulata*, but the collar duplication differentiates it. The collars flare instead of contracting as in *C. urceolata*. *Craterella aperta* from Australia is not at all like *armilla*, or, indeed, any of the others; it may not belong to *Craterella*.

Recorded from two stations, one in the Atlantic and one in the Pacific, as follows: one (23) in the Atlantic equatorial region, and one (69) in the Galápagos region.

There are 1 pump and 1 net sample, taken at the surface and at 50 meters, respectively. Frequency, minimum. The pump sample was taken in the Atlantic and the net sample in the Pacific.

Temperature: pump sample  $21^\circ.13$ , net sample  $20^\circ.99$ . Salinity: pump sample 35.24, net sample 36.04. Density: pump sample 24.66, net sample 25.30. pH: pump sample 8.12, net sample 8.14.

***Craterella urceolata*** (Ostenfeld) Kofoid and Campbell

(Figure 20)

*Craterella urceolata*, Kofoid and Campbell, 1929, p. 196, fig. 368.

The tiny lorica has a contracted aperture, flaring outer collar, and wide, conical, pointed bowl, and its length is 1.24

oral diameters. The oral margin is thin, sharp-edged, and entire. The inner collar is a basal segment of a truncated cone ( $80^\circ$ ) with concave sides and a trough separating it from the outer collar below. The outer collar has a diameter of 1.2 oral diameters and a width of 0.16 oral diameter. It flares ( $54^\circ$ ) from the bowl below, the upper diameter of which is 1.11 oral diameters. The upper two-thirds of the bowl is a segment of an inverted truncated cone ( $30^\circ$ ), and the lower section is a wider cone ( $82^\circ$ ). The sides of both sections are convex, those of the upper section less so than those of the lower. The aboral end is pointed but not prolonged or sharp.

The wall is hyaline and thin, and the cavity neatly follows the outer contour.

Length, 48 $\mu$ .

The lorica figured (fig. 20) has a more conical bowl, more flare in the outer collar, and a narrower aperture than usual.

*Craterella urceolata* differs from other species in having a high inner collar, and in its stouter proportions. It is somewhat like *C. obscura*, but the bowl is not so long, and its upper section is less cylindrical. It bears some likeness to *C. acuta*, but that species has a higher, more flaring inner collar, and a pointed, prolonged aboral end. *Craterella protuberans* has a blunt aboral horn.

Recorded from one station (41) in the Galápagos region, in a net sample taken at the surface. Frequency, minimum.

Temperature,  $20^\circ.42$ ; salinity, 34.19; density, 24.06; pH, 8.11.

**ACANTHOSTOMELLA** Jörgensen

*Acanthostomella*, Kofoid and Campbell, 1929, p. 191.

*Acanthostomella* adds a number of teeth to the outer collar of *Craterella*. The genus is, however, remarkable in that there are two sharp divisions in distribution. One group of species is distinctly tropical, and the other group is of cold-water facies. The latter mostly have distinct prismatic structure, whereas the former are glass-clear. The tropical species usually have fewer and stronger teeth than the others. As yet the genus is not so well known as it will be on further examination of microplankton.

Six species are described here.

***Acanthostomella elongata*** Kofoid and Campbell

*Acanthostomella elongata* Kofoid and Campbell, 1929, p. 192, fig. 359.

The tall lorica is shaped like a finger cot and has a sub-hemispherical aboral end and a short spine; the length is 3.0 oral diameters. The oral margin is thin and entire, and the inner collar is erect and rather wide. The outer collar has 24 outward-directed, low clawlike teeth, and hardly flares. The upper bowl is cylindrical and about 2.6 oral diameters in length. The lower bowl is about 0.4 oral diameter in length, or less, and is an inverted convex cone ( $62^\circ$ ). Its lower end is drawn out into a tiny aboral spinule.

The wall is thin; alveoles and laminae are present.

Length, 70 $\mu$ .

*Acanthostomella elongata* has a long cylindrical bowl, at

least twice as long as that of any other species. It resembles a small replica of *Parafavella digitalis*, but that species not only is larger and longer, but also lacks teeth and inner and outer collars. It is not at all like the common *A. norvegica*, its frequent neighbor.

Recorded from one station (125) in the Alaskan secondary region, in a pump sample taken at 50 meters. There were 2 loricae.

Temperature, 5°68; salinity, 32.79; density, 25.88; pH, 7.98.

*Acanthostomella gracilis* (Brandt) Kofoid and Campbell

*Acanthostomella gracilis*, Kofoid and Campbell, 1929, p. 192, fig. 360.

The rather short, stout lorica, with cylindrical upper bowl and conical, pointed aboral end, has a length of 1.7 oral diameters. The oral margin is thin and erect; the inner collar is cufflike and its width is nearly 0.07 oral diameter. It is separated by an angular trough from the outer collar. The outer collar flares (35°) and from its free edge arise 36 narrow, outward-projecting, subequal, subequidistant, triangular teeth. The upper bowl is cylindrical and about 1.11 oral diameters in length. The bowl is conical (80°) with distinctly convex sides, and its lower end is drawn out bluntly.

The wall is rather thick, about 0.03 oral diameter in thickness, and there are thin laminae with rectangular, radial secondary prisms enclosed between them. The wall thins down a bit at the oral end.

The large animal has 2 macronuclei and rather long membranelles.

Length, 45 to 60μ.

*Acanthostomella gracilis* has a cylindrical upper bowl and a bluntly pointed aboral end, whereas *A. norvegica*, its closest relative, has a laterally concave and aborally swollen bowl with a distinct horn. *Acanthostomella obtusa* has a blunted, distinct, and longer horn, and *A. elongata* has a much taller bowl.

Recorded from one station (119) in the East Asiatic marginal sea, in 2 pump samples taken at 50 and 100 meters. Frequency, 2 and 4 loricae.

Temperature, 3°42 at 50 meters; salinity, 33.05-33.13 (33.09); density, 26.31-26.52 (26.41); pH, 7.85-7.93 (7.89).

*Acanthostomella lata* Kofoid and Campbell

*Acanthostomella lata* Kofoid and Campbell, 1929, pp. 192-193, fig. 364.

The stout, goblet-shaped lorica, with low teeth, high inner collar, conical bowl, and sharp, pointed aboral spine, has a length of 1.25 oral diameters. The oral margin is thin, erect, and entire. The inner collar is cufflike and about 0.1 oral diameter in width. The outer collar, which is separated from the inner by a deep trough, flares (20°) and its rim has 22 short, stout, outward-spread triangular teeth whose free tips are rotated to the left. The bowl is conical (about 15°) suborally, and wider conical (90°) toward the lower end. It is full and distinctly convex. The aboral horn is a

spine (20°) with a length of approximately 0.25 oral diameter.

The subuniformly thin wall has clearly marked laminae and distinct prismatic structure. The spine is hollow.

Length, 37μ.

The *Carnegie* loricae agree closely with that of Kofoid and Campbell, save that the wall is unusually glassy.

*Acanthostomella lata* is larger than most species, and relatively wider, with shorter teeth and higher inner collar. It has more teeth than *A. conicoides*, a distinctly convex instead of concave lower bowl, and a distinct spine. Its bowl is less saccular than that of the northern *A. norvegica*, its spine is longer, and its teeth are shorter, fewer, and rotated.

Recorded from five stations, one in the Atlantic and four in the Pacific, as follows: one (33) in the Caribbean Sea, one (40) in the Galápagos region, one (65) in the South Pacific middle latitudes, one (137) in the California region, and one (159) in the region of South Pacific island fields.

There are 1 pump and 4 net samples, of which 1 (137) was taken at the surface and 2 each at 50 and 100 meters. Frequencies did not exceed 1 per cent.

Temperature: Atlantic, net sample 23°17; Pacific, net samples 15°03-27°90 (19°42), pump sample 25°48. Salinity: Atlantic, net sample 36.49; Pacific, net samples 34.30-35.75 (34.98), pump sample 34.97. Density: Atlantic, net sample 25.03; Pacific, net samples 23.01-25.83 (24.75), pump sample 23.19. pH: Atlantic, net sample 8.18; Pacific, net samples 7.83-8.37 (8.10), pump sample 8.39.

*Acanthostomella minutissima* Kofoid and Campbell

*Acanthostomella minutissima* Kofoid and Campbell, 1929, p. 193, fig. 358.

The rather plump, short, cuplike lorica, with numerous teeth and round aboral end, has a length of 1.30 to 1.64 oral diameters. The oral margin is thin and erect. The inner collar is narrow, cufflike, and thin. The outer collar flares sharply (50°) and carries about 25 slender, narrow triangular, outward-curved teeth which are about as long as the width of the inner collar. The bowl is subcylindrical in the anterior 0.55 and contracts as a cone (90°) in the lower section. This aboral region is subhemispherical, with convex sides. The aboral end is not especially differentiated.

The rather thick wall has thin laminae and is pronouncedly alveolar. Kofoid and Campbell (1929) found coccoliths studding the whole exterior of some loricae. The cavity conforms to the outer contour.

Length, 29 to 36μ.

The shape of the aboral end is hemispheroidal to paraboloidal, and the wall may have coccoliths.

This small tropical species generally resembles the northern *Acanthostomella norvegica*, but differs in being smaller, and in having a distinct, flaring collar. Its upper bowl is typically not so long and the aboral end never has the emergent point of *norvegica*. It is unlike any of the other tropical species. Had it no teeth it would have been considered something like *Craterella urceolata*.

Recorded from four stations, one in the Atlantic and three in the Pacific, as follows: one (18) in the Sargasso Sea, two

(41, 69) in the Galápagos region, and one (65) in the South Pacific middle latitudes.

There are 4 net samples, of which 2 were taken at the surface and 2 at 100 meters. Frequency, 2 per cent at station 69.

Temperature: Atlantic, 20°32'; Pacific, 15°00'–21°13' (18°86'). Salinity: Atlantic, 36.81; Pacific, 34.19–35.24 (34.57). Density: Atlantic, 26.01; Pacific, 24.06–25.44 (24.72). pH: Atlantic, 8.21; Pacific, 8.10–8.12 (8.11).

### *Acanthostomella norvegica* (Daday) Jörgensen

(Figures 21, 22, 23)

*Acanthostomella norvegica*, Kofoid and Campbell, 1929, p. 193, fig. 363; Bernstein, 1931, p. 14; Hada, 1932a, pp. 56–57, fig. 22; 1932b, p. 567, fig. 20.

The short, stout, cuplike lorica, with short, incurved, clawlike teeth, wide, swollen bowl, and aboral end with tiny nipple, has a length of 1.14 to 1.71 oral diameters. The oral margin is thin. The inner collar is less than 0.1 oral diameter in width, and has a spreading base. There is a trough between it and the outer collar. The outer collar flares (40° to 50°) and has outwardly convex sides. On its free edge are 20 to 36 incurved, clawlike, sharply pointed, narrow triangular, subequal, and subequidistant teeth. The upper section of the short, wide bowl is an inverted basal segment of a full truncated cone (4°) with a length of 0.73 to 1.0 oral diameter. The lower section is at first 42° to 63°, and later 90° to 145°, thus forming a rounded cone, or subhemisphere, with pronouncedly convex sides. The aboral end has a nipple-like horn with a length of not more than 0.1 oral diameter.

The wall is uniformly thin (hardly 0.02 oral diameter). There are laminae with rectangular, subequal prisms in a single layer. The inner collar is glass-clear. The horn is solid. The aboral half of the bowl is mostly plastered with adherent fecal matter.

There are 2 oval macronuclei.

Length, 45 to 50 $\mu$ t.

Three extreme variants are shown (figs. 21–23). Of these, one (fig. 23) is hollow-sided in the upper bowl, and swollen at about 1 oral diameter below the rim. Its bowl is longer than usual. The others figured are more nearly of the usual type. Hada (1932a, 1932b) figures 2 loricae, one with a longer horn than the other. The horns on these specimens are longer and more sharply pointed than those on the *Carnegie* specimens. The bowls are not so long as that of the extreme specimen of this collection, nor so short as those of others. In other characters, however, all these agree.

*Acanthostomella norvegica* is, perhaps, closest to *A. gracilis*, which has the same general habitat. It is aborally expanded, however, and has a nipple. Its lower bowl is conical rather than cylindrical, and the aboral region is less angular. Its bowl is not so long as that of *A. elongata*, and it is altogether unlike the tropical species of the genus in most characters.

Recorded from fifteen stations, eight in the Atlantic and seven in the Pacific, as follows: one (7) in the North Sea,

three (8, 10, 11) in the Atlantic drift, two (12, 13) in the American cold-water region, one (14) in the Gulf Stream, two (117, 126) in the North Pacific middle latitudes, four (120, 121, 122, 123) in the East Asiatic marginal sea, one (124) in the Alaskan secondary region, and one (130) in the California region. *Acanthostomella norvegica* has a pronounced northern and temperate distribution and appears elsewhere either accidentally in water of warmer origin, as in the Gulf Stream (station 14), or as a subsurface dweller.

There are 14 pump and 16 net samples, of which 9 were taken at the surface, 13 at 50 meters, and 8 at 100 meters. Maximum frequency, 68 per cent at station 13; other records above minimum (2 to 56 per cent) from stations 7, 11, 14, 117, 120, 121, 123, the greatest frequencies being in surface catches; averages, 19.0 and 1.8 loricae in Atlantic and Pacific pump samples, and 14.8 and 7.5 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, net samples 4°18'–14°02' (8°55'), pump samples 7°01'–14°05' (11°07'); Pacific, 2°17'–12°01' (9°10') and 2°05'–12°56' (7°18'), respectively. One record of 14°02' was in the Gulf Stream, where 3 empty loricae were recorded in 2 samples. Salinity: Atlantic, net samples 32.68–35.95 (34.73), pump samples 32.68–35.10 (34.25); Pacific, 33.06–34.22 (33.60) and 32.66–34.22 (33.07), respectively. Density: Atlantic, net samples 24.94–27.96 (27.04), pump samples 24.94–27.42 (26.14); Pacific, 25.19–26.41 (26.00) and 25.26–26.48 (25.84), respectively. pH: Atlantic, net samples 7.93–8.08 (8.01), pump samples 7.92–8.18 (8.05); Pacific, 7.72–8.26 (7.99) and 7.84–8.06 (7.98), respectively.

### *Acanthostomella obtusa* Kofoid and Campbell

*Acanthostomella obtusa* Kofoid and Campbell, 1929, p. 194, fig. 361.

The short, stout, cuplike lorica, with tall, thickened inner collar, heavy outer collar, few teeth, and short, blunt aboral horn, has a length of 1.6 to 1.7 oral diameters. The oral margin is thin, erect, and entire, and the wider outer collar has 20 short, stout, outward-projecting, triangular teeth. The outer collar is less than 1.1 oral diameters in diameter and barely flares. The upper bowl is a full truncated cone (20°), and the lower three-tenths widens out as a hollow cone (68°). The lower part of the aboral three-tenths widens yet more. The aboral horn is about rectangular in section, being 0.25 oral diameter in length. Its free tip is squarely truncated.

The thin, hyaline wall of the bowl is slightly thickened in the collar.

Length, 26 to 36 $\mu$ t.

*Acanthostomella obtusa* differs from the other species in having a stout, squarish aboral horn. The remaining species have either no developed horn, or else a sharply pointed one. *Acanthostomella conicoides* has fewer teeth (6 to 8) and is more slender. *Acanthostomella gracilis* is alveolar, and has a relatively longer, more cylindrical bowl, and no horn.

Recorded from two stations (45, 80) in the Galápagos region, in a net and a pump sample taken at the surface and at 50 meters, respectively. Frequency, 2 per cent at station 80.

Temperature, 22.37–26.04 (24.20); salinity, 35.23–35.94 (35.35); density, 23.75–24.30 (24.02); pH, 8.13–8.20 (8.16).

#### PETALOTRICHINAE Kofoid and Campbell

Petalotrichinae, Kofoid and Campbell, 1929, p. 202.

Only the single genus *Petalotricha* belongs to this subfamily.

#### PETALOTRICHIA Kent emended

*Petalotricha*, Kofoid and Campbell, 1929, p. 202.

Large, smooth-walled, well finished loricae are characteristic of *Petalotricha*. These are among the more complex Tintinnoina of the warmest parts of the ocean. One species, *Petalotricha foli*, is limited to the eastern Pacific, but *P. major* is circumtropical.

Five species are described here.

#### *Petalotricha ampulla* (Fol) Kent

(Figure 26)

*Petalotricha ampulla*, Kofoid and Campbell, 1929, p. 203, fig. 389; Entz, 1935, pp. 15–26, figs. 1–15.

The stout lorica, with pointed aboral end, has a length of 1.06 oral diameters. The oral margin is irregularly serrate with minute points. The upper collar is a horizontal shelf, and the oral aperture has a diameter of but 0.87 the diameter of the outer edge of this shelf. The lower collar is a basal segment of a low inverted cone (28°) with full sides; its width is 0.22 oral diameter. Optically dark lines separate the two collars and the bowl. The bowl rounds away from the throat at 58° and at the shoulder reaches a diameter of 0.85 oral diameter. The bowl is 0.89 oral diameter at its maximum, which lies at 0.4 oral diameter below the margin. Below this level it contracts (at 32° for a distance of 0.52 oral diameter below the level of the maximum diameter, and then at 100° for the remaining distance). The aboral end is broadly pointed but not prolonged.

The thin, uniform wall is not over 0.01 oral diameter in thickness, and is grayish; there is a row of small oval lacunae at the upper end of the lower collar. A double row of lacunae also occurs below the shoulder.

The animal has about 100 small macronuclei, and 5 chromosomes are reported in the micronuclei. If this last be confirmed, the vegetative individual must be haploid, because the chromosome number is odd, and the reduction in conjugation must be postzygotic, a condition unique in the ciliates, although common in algae, mastigophorans, and certain, if not all, sporozoans.

Length, 110 $\mu$ .

Entz (1935) discusses the cytology of the animal in a special paper.

*Petalotricha ampulla* is pointed aborally, unlike *P. major*, which is rounded. Its bowl is short in contrast with that of *P. foli*, in which the bowl is conical and elongated. It differs from *P. serrata* in its shallower, less regular, and less distinct serrations and deeper throat. It lacks the curtain of *P. entzi*. On the whole it is not likely to be confused with other common species, especially *major* and *foli*.

Recorded from eight stations, four each in the Atlantic and the Pacific, as follows: two (4, 5) in the Atlantic drift, two (14, 16) in the Gulf Stream, two (65, 66) in the South Pacific middle latitudes, one (68) in the Galápagos region, and one (113) in the North Pacific middle latitudes.

There are 1 pump and 8 net samples, of which 2 were taken at 50 meters and 7 at 100 meters. Maximum frequency, 30 per cent at station 68; other records above minimum (2 to 10 per cent) from stations 4, 5, 14, 16, 65, 113; averages in net samples, 5 and 12 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, net samples 13.51–23.64 (15.77); Pacific, pump sample 17.94, net samples 15.03–21.74 (17.77). Salinity: Atlantic, net samples 35.88–36.41 (35.95); Pacific, pump sample 34.94, net samples 34.30–34.85 (34.60). Density: Atlantic, net samples 24.84–27.01 (26.48); Pacific, pump sample 25.26, net samples 24.06–25.52 (25.00). pH: Atlantic, net samples 8.06–8.23 (8.14); Pacific, pump sample 8.12, net samples 8.10–8.23 (8.15).

#### *Petalotricha capsa* Brandt

*Petalotricha capsa*, Kofoid and Campbell, 1929, p. 203, fig. 387.

The saccular lorica, with flaring collars, goblet-shaped bowl, and rounded aboral end, has a length of 0.93 oral diameter. The oral margin is smooth, thin-edged, and nearly erect. The upper and lower collars flare concurrently as basal segments of inverted truncated cones (62°), and each is laterally sigmoid. On the inside, the boundary between the lower edge of the upper collar and the upper edge of the lower collar is marked off by an erect, short ledge, and there is a similar ledge at the lower edge of the lower collar where it joins the bowl. On the outside, tiny oval lacunae occur along the boundary lines of the two collars. The diameter of the throat is 0.77 oral diameter. The bowl below rounds over a slightly developed shoulder and then becomes conical (10°) for about two-thirds the length of the bowl, again increasing below this to 62°, and finally to 125° near the aboral end. The aboral end is hemispheroidal.

The wall is 0.02 oral diameter in thickness, and there are thin, distinct inner and outer laminae between which are enclosed two or three layers of rounded alveoles. These alveoles are clearly visible externally, and the whole lorica distinctly shows them. Large lacunae, of oval shape with the axes directed vertically, occur in 2 or 3 rows in the upper three-tenths of the bowl; they are 16 in number across one face.

Length, 125 $\mu$ .

*Petalotricha capsa* resembles *P. indica* in having alveoles in the wall in several layers. It differs from *indica* in its lesser elongation, narrower aboral region, and more constricted throat. From *P. pacifica* it may be distinguished by its longer, less hemispherical bowl, and by the several layers of alveoles. The remaining species have different wall structure.

Recorded from two stations (158, 159) in the region of South Pacific island fields.



There are 5 net samples, of which 1 was taken at the surface, and 2 each at 50 and 100 meters. Maximum frequency, 82 per cent at station 158 at 100 meters; average, 44 per cent.

Temperature, 27°81–28°60 (28°19); salinity, 35.58–35.89 (35.74); density, 22.71–23.11 (22.90); pH, 8.37–8.39 (8.38).

#### *Petalotricha foli* Kofoid and Campbell

(Figure 27)

*Petalotricha foli* Kofoid and Campbell, 1929, p. 204, fig. 390.

The elongated conical lorica has a length of 2.34 oral diameters. The oral margin is roughly serrate, with minute points. The upper collar or shelf is a low basal segment of a full cone (90°) with a width of less than 0.2 oral diameter and with a lower diameter of nearly 0.87 oral diameter. The lower collar is also a basal segment of a low, convex cone (50°) with a width of about 0.2 oral diameter and a lower diameter of 0.77 oral diameter. There are sharp, optically dark lines separating these two collars from each other and from the bowl. The long bowl is a full cone (32°). The upper 0.16 of the bowl rounds with some suggestion of shoulder which is about 0.82 oral diameter in diameter and reaches 0.8 oral diameter near 0.2 total length below the rim. Below this level the bowl contracts evenly, with some minor local contractions and bulges, to the sharply pointed but otherwise unmodified aboral end.

The wall is subuniformly about 0.02 oral diameter in thickness, and has laminae and subrectangular prisms between the laminae. The lower end of the bowl (about 0.4 total length) has irregular vertical creases or folds, and near the shoulder there are circular to narrow oval lacunae in two or three rows. The remaining part of the lorica is almost transparent, for the small prisms do not show an external meshwork.

Length, 264 to 377 $\mu$ .

There are dwarf loricae of 1.75 oral diameters scattered among the larger ones, and most of the loricae tend to be stouter than the figured specimen (fig. 27).

*Petalotricha foli* is unlike the other species of the genus in having a long, conical bowl, and in its heavy-set facies. Apparently it spreads from off Mexico to the mid-Pacific.

Recorded from one station (151) in the North Pacific trade region, in a net sample taken at 50 meters. Frequency, 11 per cent.

Temperature, 18°28; salinity, 34.42; density, 24.77; pH, not recorded.

#### *Petalotricha major* Jörgensen

(Figures 24, 25)

*Petalotricha major*, Kofoid and Campbell, 1929, pp. 204–205, fig. 384.

The rather short lorica has a globose bowl and a length of only 0.9 oral diameter. The oral margin is serrate, with minute points. The upper collar is a low, almost flat shelf and flares 100°. The oral aperture has a diameter of 0.86 that of the outer rim of the shelf. The lower collar is a basal

segment of an inverted truncated full cone (65°) with a diameter at its lower end of 0.7 oral diameter. The bowl is globose. Its upper end is truncated where it joins the lower collar, and it is 0.86 oral diameter in diameter at the maximum. The aboral end is smoothly rounded and without differentiation.

The thin wall is uniformly about 0.01 oral diameter in thickness, and there are thin laminae with a single layer of rectangular prisms enclosed. The wall is glossy gray. There is a single row of tiny oval lacunae at the upper end of the lower collar where it joins the upper collar, and a belt of several rows of scattered similar ones in the equatorial region of the bowl.

Length, 95 to 110 $\mu$ .

An extreme form is figured (fig. 25) in which a minute point is present. This lorica also has a very plump bowl which is considerably shorter than wide. In the same collection were other loricae much longer than wide. The common form in this collection conforms to type in every detail. Some loricae have a suboral curtain comparable to that of *P. entzi*.

*Petalotricha major* has a spherical bowl unlike that of any of the other species. It is quite unlike *P. ampulla*, in which the aboral end is pointed, and it differs from *P. entzi*, which also has a globose bowl, in that *entzi* has an outer hyaline envelope developed around the collar. *Petalotricha capsula* has a saccular bowl and alveoles in the wall in several layers.

There is a possibility that *P. entzi* belongs to this species, since specimens with the diagnostic curtain occur. If this should be proved, then *major* becomes a synonym of *entzi*, since Kofoid's description of the latter was much earlier than Jörgensen's of *major*.

Recorded from fifty-five stations, twenty-four in the Atlantic and thirty-one in the Pacific, as follows: three (2, 14, 16) in the Gulf Stream, three (3, 4, 5) in the Atlantic drift, six (17, 18, 19, 20, 20–21, 21) in the Sargasso Sea, eight (22, 23, 24, 25, 27, 28, 29, 30) in the Atlantic equatorial region, four (31, 32, 33, 34) in the Caribbean Sea, three (46, 68, 69) in the Galápagos region, four (63, 64, 65, 67) in the South Pacific middle latitudes, eight (81, 82, 85, 94, 95, 96, 157, 160) in the region of South Pacific island fields, four (99, 152, 155, 156) in the Pacific equatorial region, three (100, 150, 151) in the North Pacific trade region, two (112, 113) in the North Pacific middle latitudes, and seven (131, 135, 136, 137, 147, 148, 149) in the California region.

There are 15 pump and 58 net samples, of which 4 were taken at the surface, 18 at 50 meters, 50 at 100 meters, and 1 at 150 meters. The preference of this species for subsurface waters appears clear from the data. Maximum frequency, 86 per cent at station 30 at 100 meters; other records above minimum (2 to 42 per cent) from stations 2, 3, 5, 16, 17, 18, 19, 20, 22, 23, 24, 27, 28, 31, 32, 33, 34, 46, 63, 65, 67, 68, 69, 82, 85, 95, 96, 99, 100, 112, 113, 131, 136, 147, 148, 149, 150, 151, 152, 155, 156, 157, 160; averages in net samples, 16 and 12.3 per cent for the Atlantic and Pacific, respectively.

Temperature: Atlantic, pump samples 14°95–20°93 (17°40), net samples 13°79–27°88 (21°00); Pacific, 15°03–28°74 (21°47) and 11°48–28°74 (21°81), respectively. Salinity:

Atlantic, pump samples 35.10–36.75 (35.82), net samples 35.88–37.05 (36.20); Pacific, 34.30–36.46 (35.01) and 33.36–36.24 (35.11), respectively. Density: Atlantic, pump samples 25.86–26.34 (26.09), net samples 23.26–27.01 (25.42); Pacific, 22.43–25.48 (24.29) and 22.31–26.50 (24.69), respectively. pH: Atlantic, pump samples 7.96–8.20 (8.11), net samples 7.93–8.28 (8.23); Pacific, 8.08–8.34 (8.20) and 7.76–8.39 (8.21), respectively.

#### *Petalotricha serrata* Kofoid and Campbell

*Petalotricha serrata* Kofoid and Campbell, 1929, p. 205, fig. 386.

The lorica, with definitely serrated oral margin and a saccular aborally pointed end, has a length of 1.1 oral diameters. The oral margin has 48 short, sharp, erect, triangular teeth. The upper collar flares (80°) and its width is 0.09 oral diameter. Its lower edge is marked by a single row of small, ovoid lacunae with horizontal axes. The lower collar has a width of 0.12 oral diameter and is a band or cuff with plane sides; it is differentiated only by being optically less dense than the bowl. There is scarcely any nuchal constriction, and the bowl below reaches 0.9 oral diameter at a similar distance below the margin. It contracts (26°) below the level of maximum diameter for a distance of two-thirds its own length, and again more so (100°) below this to the aboral end. The aboral end is distinctly pointed, with a tiny nipple.

The gray wall is thin and has but a single layer of prisms between the laminae. There are 17 large equatorial lacunae.

Length, 105 to 120 $\mu$ .

*Petalotricha serrata* resembles *P. ampulla*, but the oral teeth are regular and pronounced. It has a cylindrical lower collar, and unlike *ampulla* has scarcely any nuchal contraction. Its bowl is pointed, unlike that of *P. major*, and is longer than that of *P. pacifica*, but not so long as that of *P. indica*. *Petalotricha capsula* has definite many-layered alveolar walls, lacking in *serrata*.

Recorded from two stations, one each in the Atlantic and the Pacific, as follows: one (30) in the Atlantic equatorial region, and one (46) in the Galápagos region.

There are 2 net samples, one each from 50 and 100 meters. Frequency, minimum.

Temperature: Atlantic, 25°54; Pacific, 23°26. Salinity: Atlantic, 36.40; Pacific, 35.33. Density: Atlantic, 24.25; Pacific, 24.13. pH: Atlantic, 8.28; Pacific, 8.16.

#### RHABDONELLIDAE Kofoid and Campbell

Rhabdonellidae Kofoid and Campbell, 1929, p. 206.

Included in this family are four genera: *Protorhabdonella*, *Epirhabdonella*, *Rhabdonella*, and *Rhabdonellopsis*. Three are found in the material of this expedition, and all are tropical to subtropical.

#### PROTORHABDONELLA Jörgensen

*Protorhabdonella*, Kofoid and Campbell, 1929, p. 206.

*Protorhabdonella* is clearly the simplest genus of the Rhabdonellidae in size and form. Kofoid and Campbell (1939,

p. 158) erected a new genus, *Epirhabdonella*, with two new species, also related but with finlike ribs.

*Protorhabdonella* is almost exclusively tropical and oceanic, being most common in southern waters.

Three species are described here.

#### *Protorhabdonella curta* (Cleve) Jörgensen

*Protorhabdonella curta*, Kofoid and Campbell, 1929, p. 207, fig. 393; Marshall, 1934, p. 646.

The tiny conical lorica, with numerous twisted ribs and pointed aboral end, has a length of 1.8 oral diameters. The oral margin is thin-edged and narrow, and an exceedingly low cuff surrounds it. The conical bowl is 12° in the upper half and increases to 68° in the lower part. There is a low, rounded shoulder a little below the oral margin, the diameter of which is 1.2 oral diameters; at its middle the bowl is slightly less than 1.0 oral diameter. The upper bowl is barely convex, but the lower is distinctly concave. The aboral end is pointed, and conical (16°) but not especially prolonged. There are about 24 strongly left-turned (15°), very low, linelike ribs. These ribs are rarely or never branched, and die away some distance below the suboral shoulder; they converge at the aboral end. Fenestrae are lacking.

The exceedingly thin wall is transparent.

Length, 39 to 52 $\mu$ .

*Protorhabdonella curta* differs from *P. simplex* chiefly in having more ribs that are strongly twisted, in contrast with the fewer vertical ones of the other species. Differences in shape are less marked, but some are of importance. Although it has numerous ribs, it is not like *Rhabdonella exilis*, *R. indica*, or *R. amor*, all forms with longer, narrower bowls and emergent horns.

Recorded from four stations, one in the Atlantic and three in the Pacific, as follows: one (31) in the Caribbean Sea, two (54, 60) in the South Pacific middle latitudes, and one (113) in the North Pacific middle latitudes.

There are 4 net samples, of which 1 was taken at the surface and 3 at 100 meters. Frequency, 4 per cent at station 113, and 2 per cent at station 54; other records minimum; average in the Pacific, 2.3 per cent.

Temperature: Atlantic, 22°56; Pacific, 14°97–21°74 (18°48). Salinity: Atlantic, 36.51; Pacific, 33.91–35.35 (34.64). Density: Atlantic, 25.22; Pacific, 24.06–25.37 (24.86). pH: Atlantic, 8.19; Pacific, 8.07–8.23 (8.15).

#### *Protorhabdonella simplex* (Cleve) Jörgensen

(Figures 83, 84)

*Protorhabdonella simplex*, Kofoid and Campbell, 1929, p. 208, fig. 395; Marshall, 1934, p. 646.

The short, conical lorica, with low, hyaline collar, few bladelike fins, and pointed aboral end, has a length of 2.18 oral diameters. The oral rim is simple, thin, and erect. The low collar is a cuff with a length of little more than 0.01 oral diameter. The conical bowl is about 9° within the upper 0.9 oral diameter, and increases to 42° in the lower 1.32 oral diameters. Just below the collar is a barely evident rounded shoulder, the diameter of which is 1.18 oral diameters; at the

level at which the cone widens it is 1.04. At the aboral end is a narrower ( $23^\circ$ ), scarcely prolonged point which is the homologue of the aboral horn of other species. There are 6 narrow (0.02 oral diameter), equidistant, decurrent blade-like ribs which extend from the aboral end to the lower edge of the collar. These ribs do not branch and are strictly vertical.

The wall is hyaline and without fenestrae, and is thickest just below the collar, where it reaches twice the width of the cuff that rests on it; it gradually thins and is only three-tenths as thick in the lower bowl. There are thin laminae, but prisms were not evident between them.

Length, 52 to 98 $\mu$ .

There is considerable variation in length and proportions, probably correlated significantly with temperature. The number of ribs (6 to 10) is interesting.

*Protorhabdonella simplex* resembles *P. curta*, but its ribs are considerably fewer, and vertical. The bowl is longer and narrows less quickly. It resembles *P. ventricosa* in having few ribs, but that species is widely expanded toward the aboral three-tenths (almost 1.4 oral diameters). It is unlike *Rhabdonella amor*, in which the ribs are lower, twisted, branched, and numerous, and which has a higher collar.

Recorded from eighteen stations, four in the Atlantic and fourteen in the Pacific, as follows: two (20-21, 21) in the Sargasso Sea, two (23, 24) in the Atlantic equatorial region, six (41, 45, 46, 69, 77, 78) in the Galápagos region, four (61, 63, 64, 66) in the South Pacific middle latitudes, two (102, 109) in the North Pacific trade region, one (131) in the California region, and one (143) in the North Pacific middle latitudes.

There are 9 pump and 18 net samples, of which 10 were taken at the surface, 7 at 50 meters, and 10 at 100 meters. Maximum frequency, 8 per cent at station 61; other records above minimum (2 to 5 per cent) from stations 21, 41, 45, 46, 69, 77, 78; averages in net samples, 1.3 and 3.1 per cent for the Atlantic and Pacific, respectively; average in pump samples, 1.5 loricae.

Temperature: Atlantic, net samples  $15^\circ 55-26^\circ 57$  ( $21^\circ 88$ ); Pacific, pump samples  $14^\circ 55-25^\circ 73$  ( $20^\circ 72$ ), net samples  $12^\circ 12-23^\circ 72$  ( $20^\circ 65$ ). Salinity: Atlantic, net samples 35.61-36.28 (36.03); Pacific, pump samples 34.39-36.17 (35.14), net samples 33.36-36.04 (34.89). Density: Atlantic, net samples 23.84-26.34 (24.98); Pacific, pump samples 23.65-26.11 (24.63), net samples 24.06-25.31 (24.52). pH: Atlantic, net samples 7.96-8.32 (8.17); Pacific, pump samples 7.92-8.30 (8.24), net samples 8.05-8.32 (8.15).

#### *Protorhabdonella striatura* Kofoid and Campbell

*Protorhabdonella striatura* Kofoid and Campbell, 1929, p. 208, fig. 392.

The elongated, conical, chalice-shaped lorica, with numerous ribs and narrow conical aboral horn, has a length of 4.88 oral diameters. The oral margin is thin and erect. The collar is a basal segment of a cone ( $21^\circ$ ) and has a length of about 0.5 oral diameter; its diameter at the lower end is 0.91 oral diameter. The elongated bowl gradually expands

from the throat to nearly 1.2 oral diameters near 1.65 oral diameters below the rim. Below this level the bowl steadily contracts ( $22^\circ$ ) within less than 2.2 oral diameters, forming an inverted segment of a cone. The pedicel is an inverted asymmetrical cone ( $18^\circ$ ) with a length of 1.46 oral diameters.

The rather transparent wall has 24 vertical ribs, a few of which branch in the upper three-tenths of the bowl. There are a few (6 to 8) small circular fenestrae scattered in a zone within the posterior part of the bowl above the pedicel. The wall is thin (about 0.02 oral diameter), with slight thickening at the throat.

Length, 125 to 165 $\mu$ .

*Protorhabdonella striatura* differs from *P. mira* in having a shorter pedicel and more ribs, and in contraction at the throat. The other species of the genus have weaker development of the pedicel.

Recorded from one station (27) in the Atlantic equatorial region, in a pump sample taken at 50 meters. Frequency, 2 loricae.

Temperature,  $26^\circ 04$ ; salinity, 36.25; density, 23.98; pH, 8.30.

#### RHABDONELLA Brandt emended

*Rhabdonella*, Kofoid and Campbell, 1929, pp. 209-211.

*Rhabdonella* is related to the much smaller, simpler *Protorhabdonella*, and to the more complex *Rhabdonellopsis*. The dominant structure in this genus is the vertical ribs. These suggest the possible origin of the genus in some member of the Favellidae or the Ptychocyliidae, in which there are many short surface pleats, and also suggest relationship to the more advanced genera of the Epiplocyliidae.

*Rhabdonella* occurs in tropical seas, there being little or no limitation of species to any of the oceans save, perhaps, in a few rare and little understood species, such as *Rhabdonella aberrans*.

Eighteen species are described here.

#### *Rhabdonella amor* (Cleve) Brandt

(Figure 85)

*Rhabdonella amor*, Kofoid and Campbell, 1929, p. 212, fig. 398; Marshall, 1934, pp. 649-650, fig. 26.

The small lorica has a high suboral rim, conical bowl, and pointed aboral end; its length is 1.9 oral diameters. The oral rim is ringlike, sharp, and high. The suboral trough is deep and concave, and the diameter of its outer margin is 1.15 oral diameters. There is little suboral flare. The bowl is distinctly conical ( $14^\circ$  in the upper two-fifths, then  $46^\circ$ , and finally  $40^\circ$  in the lowermost fifth). The aboral end is pointed, sharp, and not prolonged.

The wall has a thickness of 0.1 oral diameter suborally, and progressively thins in the bowl. There are thin laminae which enclose several layers of exceedingly minute alveoles. There are 32 to 44 left-deflected (as much as  $12^\circ$ ), commonly branched and anastomosed ribs. The intercostae have 15 to 20 single or double rows of large oval fenestrae which pass across the laminae and enclosed alveoles.

Length, 77 to 98 $\mu$ .

Marshall's 2 figured loricae are unusual in shape and in

faintness of fenestrae. They may, however, not be *Rhabdonella amor*, but rather a new species peculiar to the Barrier Reef.

*Rhabdonella amor* averages fewer ribs than *R. indica*, is longer, and lacks pronounced suboral flare. It lacks the peg of the somewhat longer *R. cornucopia* and the distinct horn of the shorter *R. exilis*. It is easy to distinguish it from other species.

Recorded from thirty-four stations, sixteen in the Atlantic and eighteen in the Pacific, as follows: one (15) in the Gulf Stream, two (19, 21) in the Sargasso Sea, nine (21-22, 22, 23, 24, 25, 27, 28, 29, 30) in the Atlantic equatorial region, four (31, 32, 33, 34) in the Caribbean Sea, four (35, 35-36, 36, 39) in the Pacific equatorial region, two (60, 62-63) in the South Pacific middle latitudes, two (73, 80) in the Galápagos region, six (81, 82, 85, 93, 96, 160) in the region of South Pacific island fields, one (144) in the North Pacific middle latitudes, one (146) in the California region, and two (150, 151) in the North Pacific trade region.

There are 19 pump and 41 net samples, of which 25 were taken at the surface, 18 at 50 meters, and 17 at 100 meters. In general this species has a pronounced surface preference. Maximum frequency, 30 per cent at station 30; other records above minimum (2 to 12 per cent) from stations 21-22, 22, 24, 25, 27, 29, 31, 32, 33, 34, 35, 35-36, 60, 80, 82, 85, 151, 160; averages in net samples, 2.0 and 3.8 per cent for the Atlantic and Pacific, respectively; the pump samples include from 1 to 15 loricae, with averages of 1.7 and 5.0 in the Atlantic and Pacific, respectively.

Temperature: Atlantic, pump samples 14°60-28°51 (23°59), net samples 14°60-27°88 (22°82); Pacific, 17°46-29°30 (24°39) and 14°97-28°58 (24°39), respectively. Salinity: Atlantic, pump samples 35.22-36.99 (35.99), net samples 35.61-37.15 (36.29); Pacific, 34.59-35.42 (35.07) and 31.62-36.33 (34.83), respectively. Density: Atlantic, pump samples 22.73-26.62 (23.77), net samples 23.26-26.34 (24.84); Pacific, 21.95-25.11 (23.58) and 20.34-25.60 (23.33), respectively. pH: Atlantic, pump samples 7.93-8.34 (8.31), net samples 7.93-8.31 (8.23); Pacific, 8.12-8.37 (8.22) and 7.92-8.44 (8.23), respectively.

#### *Rhabdonella brandti* Kofoid and Campbell

(Figure 89)

*Rhabdonella brandti* Kofoid and Campbell, 1929, p. 213, fig. 400; Marshall, 1934, p. 649, fig. 24.

The short, chalice-shaped lorica, with tapering conical bowl and fairly long horn, has a length of 3.42 oral diameters. The oral rim is thin and erect, and its outer edge is the concave upper margin of the inner face of the suboral trough. The suboral trough is flattened toward the periphery, and the diameter of its outer margin is 1.23 oral diameters. There is some suboral flare (28°) within the anterior 0.3 oral diameter. The bowl tapers (10°) for about 0.4 total length, then becomes inverted subconical (33°) for approximately another 0.4. The aboral horn is narrow conical (13°), about 1 oral diameter in length, and with a basal diameter of 0.23 oral diameter. The free tip is sharply pointed.

The wall is thickest suborally (nearly 0.16 oral diameter) and becomes gradually thinner lower down. There are thin laminae which enclose minute alveoles. There are 48 long, vertical, sometimes anastomosed ribs with 26 to 34 minute, distinct fenestrae in each intercostal space. Minute alveoles are externally evident in the generally brownish wall.

Length, 95 to 198 $\mu$ .

This distinctive species has less suboral flare, less wide bowl, and more irregular ribs than *R. elegans*. Its horn is not so long or so narrow as that of *R. quantula* or *R. inflata*.

Recorded from four stations in the Atlantic, as follows: two (15, 16) in the Gulf Stream, and two (19, 20) in the Sargasso Sea.

There are 1 pump and 5 net samples, of which 2 were taken at the surface, 2 at 50 meters, and 2 at 100 meters. Frequency, 2 per cent at station 19; 15 loricae in pump sample at station 16; average for net samples, 1.6 per cent.

Temperature: pump sample 25°92, net samples 22°42-24°81 (23°28). Salinity: pump sample 36.16, net samples 36.39-37.07 (36.73). Density: pump sample 23.93, net samples 24.47-25.67 (25.17). pH: pump sample 8.24, net samples 8.19-8.26 (8.22).

#### *Rhabdonella conica* Kofoid and Campbell

*Rhabdonella conica* Kofoid and Campbell, 1929, pp. 214-215, fig. 418.

The very tall, lanky lorica, with conical bowl, greatly elongated horn, and little transition between bowl and horn, has a length of 6.5 oral diameters. The oral rim is submerged and recurved. The suboral trough is asymmetrically concave; the diameter of its outer margin is 1.1 oral diameters. The narrow bowl tapers (8°), but has a more or less ringlike suboral swelling, its length being approximately 0.5 total length. The long aboral horn continues with the same taper, although this is gradually reduced to less than 6° near the tip.

The wall is only 0.03 oral diameter in thickness at the thickest part. There is a suboral jelly-like curtain in some individuals, in the anterior three-tenths or less. The laminae are very thin and enclose extremely minute alveoles. There are 48 left-deflected, often branched, and sometimes anastomosed ribs. The intercostae have a dozen or more rather large, oval, subequidistant fenestrae and a fine meshwork of tiny hexagons.

Length, 290 to 480 $\mu$ .

Some loricae reach 8.0 oral diameters in length, and the aboral horn is often nearly transparent; mostly the loricae are brown.

Because of its length and thinness, *Rhabdonella conica* is easy to distinguish. In form it resembles *R. aberrans*, but that species is shorter, with an irregular oral region and defective ribs. *Rhabdonella cuspidata* is inflated in the lower bowl and of stouter facies although about as long as *conica*. The horn is always relatively longer in *R. conica* than in *R. spiralis*, and there is almost no transition between bowl and horn in *conica*; this character is rather distinct in *spiralis*.

Recorded from seventeen stations, one in the Atlantic and

sixteen in the Pacific; it was also found off Easter Island. The stations are as follows: one (19) in the Sargasso Sea, three (47, 78, 80) in the Galápagos region, eight (48, 81, 82, 83, 84, 85, 95, 96) in the region of South Pacific island fields, two (61, 65) in the South Pacific middle latitudes, and three (107, 139, 140) in the North Pacific trade region.

There are 16 pump and 16 net samples, of which 9 were taken at the surface, 16 at 50 meters, and 7 at 100 meters. Maximum frequency, 31 per cent at station 78; other records above minimum (2 to 14 per cent) from stations 47, 48, 61, 80, 81, 82, 85, 95, 139; average in Pacific net samples, 7.7 per cent.

Temperature: Atlantic, net sample 22.42; Pacific, pump samples 23.88–29.34 (26.33), net samples 10.92–28.74 (24.49). Salinity: Atlantic, net sample 37.05; Pacific, pump samples 34.39–36.49 (35.74), net samples 34.05–36.49 (35.74). Density: Atlantic, net sample 25.67; Pacific, pump samples 21.90–25.11 (23.49), net samples 22.43–26.06 (23.91). pH: Atlantic, net sample 8.25; Pacific, pump samples 8.14–8.39 (8.21), net samples 8.03–8.39 (8.21).

#### *Rhabdonella cornucopia* Kofoid and Campbell

*Rhabdonella cornucopia* Kofoid and Campbell, 1929, p. 215, fig. 399.

The short lorica, with high oral rim, conical bowl, feeble ribs, and conical aboral horn, has a length of 2.22 oral diameters. The oral rim is erect, high, and ringlike, and the suboral trough is flat; the diameter of the outer margin of the latter is 1.22 oral diameters. There is almost no suboral flare. The bowl is conical (18° increasing to 30° in the lower part) and at its lower end gives rise to the aboral horn. The horn is 0.55 oral diameter in length, conical (12°), truncated at the tip, and minutely open.

The wall is subuniformly 0.15 oral diameter in thickness. There are thin laminae and enclosed faint alveoles. The ribs number 26, and are very faint and difficult to follow, and left-twisted (hardly 10°); there are no fenestrae. The horn is lemon yellow.

Length, 97 to 146 $\mu$ .

*Rhabdonella cornucopia* is longer than *R. exilis*, and has faint ribs and a longer conical horn. *Rhabdonella amor* lacks a horn and has distinct ribs. The remaining species are altogether different.

Recorded from two stations in the Pacific, as follows: one (60–61) in the South Pacific middle latitudes, and one (144) in the North Pacific middle latitudes.

There are 1 pump and 1 net sample, both taken at the surface. Frequency, minimum.

Temperature, net sample, 23.26; salinity, 34.97; density, 23.86; pH, 8.37; all records at station 144.

#### *Rhabdonella cuspidata* (Zacharias) Brandt

*Rhabdonella cuspidata*, Kofoid and Campbell, 1929, p. 215, fig. 417.

The greatly elongated lorica, with contraction and later inflation and conical horn, has a length of 7.0 oral diameters. The oral rim is low, ringlike, and submerged by the higher

outer margin of the concave suboral trough; the diameter of this margin is 1.17 oral diameters. The bowl contracts (10°) for 1.33 oral diameters, having at the lower end a diameter of 0.9 oral diameter, and then expands, reaching 1.0 oral diameter at 0.46 total length below the rim. The lower bowl is convex conical (30°) within 1.5 oral diameters. At its lower end is the narrow conical (8°) aboral horn, the length of which is nearly 0.36 total length; its free tip is sharp.

The wall has a thickness of 0.1 oral diameter across the suboral trough and becomes reduced to a third of that in the bowl. There are thin laminae which enclose several layers of small alveoles, and the fenestrae cut across from lamina to lamina. There are approximately 30 subvertical, sometimes branched ribs. The intercostae have 12 to 30 very minute, oval, faint fenestrae.

Length, 421 $\mu$ .

Many loricae are much shorter (down to 250 $\mu$ ) than usual.

*Rhabdonella cuspidata*, with its lateral concavity and swelling and its great length, is easily distinguished from other species. In elongation and proportions it approaches *R. conica*, but it is otherwise only remotely like that species.

Recorded from one station (65) in the South Pacific middle latitudes, in a net sample taken at the surface. Frequency, 8 per cent.

Temperature, 20.22; salinity, 34.53; density, 24.37; pH, 8.10.

#### *Rhabdonella elegans* Jörgensen emended Kofoid and Campbell

*Rhabdonella elegans*, Kofoid and Campbell, 1929, p. 215, fig. 401.

The rather short lorica, with wide, generally conical bowl and tapering horn, has a length of 2.81 oral diameters. The oral rim is relatively high, with outward-sloping sides. The suboral trough is deep and subangular; the diameter of its outer margin is 1.17 oral diameters. There is a distinct flare (62°) well within the anterior 0.5 oral diameter. The diameter of the bowl at the lower end of the flare is 1.0 oral diameter. Below this level the bowl is decidedly convex conical (10° increasing to 42° in the lower half). The aboral horn is narrow conical (12°), and 0.82 oral diameter in length; it has a sharply pointed free tip.

The wall has a thickness of 0.06 oral diameter in the bowl and has very little suboral thickening. There are thin laminae which enclose fine primary alveoles in several layers. There are approximately 24 vertical, unbranched ribs running from end to end. Fenestrae are lacking.

Length, 110 to 122 $\mu$ .

*Rhabdonella elegans* differs from *R. cornucopia* in its longer horn and more convex bowl. It has a horn, which is lacking in *R. amor*, and the horn is longer than that of *R. indica*. It is much longer and more convex than *R. exilis*.

Recorded from one station (14) in the Gulf Stream, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 14.02; salinity, 35.59; density, 26.66; pH, 8.06.

*Rhabdonella exilis* Kofoid and Campbell

*Rhabdonella exilis* Kofoid and Campbell, 1929, p. 216, fig. 396.

The very short lorica, with high oral rim, narrow conical bowl, and pointed, prolonged peg-shaped horn, has a length of 2.52 oral diameters. The oral rim is high and ringlike; the suboral trough is plane, and angled out to the low outer margin of the trough, the diameter of which is 1.09 oral diameters. There is no suboral flare. The conical bowl ( $10^{\circ}$  to  $15^{\circ}$  in the upper part, increasing to as much as  $45^{\circ}$  in the lower part) contracts evenly to the aboral end. The aboral horn is nearly 0.5 oral diameter in length, peg-shaped, and distally pointed.

The wall is thickest suborally, gradually thinning in the lower bowl. Laminae are evident only in the upper bowl, those of the lower bowl being apparently fused. There are 46 left-directed ( $18^{\circ}$ ), weak, unbranched ribs which continue from end to end. Fenestrae are lacking.

Length, 60 to 70 $\mu$ .

*Rhabdonella exilis* is shorter than *R. cornucopia*, and has more ribs and also stouter proportions. The horn is better developed than in *R. indica*.

Recorded from twelve stations, three in the Atlantic and nine in the Pacific, as follows: one (20) in the Sargasso Sea, two (33, 34) in the Caribbean Sea, one (36) in the Pacific equatorial region, three (63, 64, 65) in the South Pacific middle latitudes, one (78) in the Galápagos region, two (91, 159) in the region of South Pacific island fields, one (140) in the North Pacific trade region, and one (146) in the California region.

There are 10 pump and 3 net samples, of which 6 were taken at the surface, 5 at 50 meters, and 2 at 100 meters. Frequency, 3 per cent at station 65; 2 per cent at stations 36, 140, 146; average for Atlantic net samples, 1.6 per cent.

Temperature: Atlantic, pump samples  $26^{\circ}05-28^{\circ}51$  ( $27^{\circ}28$ ), net samples  $23^{\circ}17-24^{\circ}98$  ( $24^{\circ}07$ ); Pacific,  $15^{\circ}90-28^{\circ}65$  ( $22^{\circ}64$ ) and  $28^{\circ}60$ , respectively. Salinity: Atlantic, pump samples  $35.87-36.55$  (36.21), net samples  $36.49-36.53$  (36.51); Pacific,  $31.62-36.03$  (34.54) and  $35.74$ , respectively. Density: Atlantic, pump samples  $22.91-24.21$  ( $23.56$ ), net samples  $24.52-25.03$  ( $24.77$ ); Pacific,  $20.34-25.43$  ( $23.60$ ) and  $22.77$ , respectively. pH: Atlantic, pump samples  $8.28-8.37$  (8.32), net samples  $8.18-8.21$  (8.19); Pacific,  $8.10-8.39$  (8.19) and  $8.37$ , respectively.

*Rhabdonella hebe* (Cleve) Brandt

*Rhabdonella hebe*, Kofoid and Campbell, 1929, p. 216, fig. 409.

The moderately tall lorica, with moderate number of ribs, conical bowl, and spindle-like swelling on the horn, has a length of 4.15 oral diameters. The oral rim is very low, erect, and ringlike, and the suboral trough which surrounds it is concave; the outer margin has a diameter of 1.26 oral diameters. The suboral flare ( $58^{\circ}$ ) is within 0.1 oral diameter and forms a thickened suboral lip around the upper end of the conical bowl. The bowl is subconical ( $20^{\circ}$  in the anterior 0.37 total length and  $36^{\circ}$  in the lower 0.19). The aboral horn is conical ( $8^{\circ}$ ), 0.44 total length in length, with a ten-

dency toward the formation of a spindle near the distal end, and with a minute, truncated, open (?) free tip.

The wall is thickest across the suboral shelf, where it reaches nearly 0.16 oral diameter; it becomes less than three-tenths as much in the bowl. There are thin laminae which enclose several layers of small, hexagonal prisms. Fenestrae connect the laminae across the wall at intervals. There is a curtain of jelly-like material enclosing the upper 0.24 of the lorica. There are 11 to 28 left-deflected ( $5^{\circ}$  to  $7^{\circ}$ ), branched ribs which die away on the suboral flare. Fenestrae are scattered in 1 or 2 rows up and down each intercosta. The horn is denser than the nearly transparent bowl.

Length, 200 to 330 $\mu$ .

*Rhabdonella hebe* may be at once distinguished from *R. spiralis* by shorter length, fewer ribs, proportions, and bowl shape. Its horn is more distinctly set off from the bowl than in *R. valdestriata*; it has fenestrae, lacking in *R. chavesi*, and its oral region is narrower than in *R. striata*. It is not likely to be confused with other species.

Recorded from seven stations, three in the Atlantic and four in the Pacific, as follows: one (15) in the Gulf Stream, one (30) in the Atlantic equatorial region, one (31) in the Caribbean Sea, one (45) in the Galápagos region, one (57) in the South Pacific middle latitudes, one (145) in the North Pacific middle latitudes, and one (146) in the California region.

There are 6 pump and 4 net samples, of which 3 were taken at the surface, 3 at 50 meters, and 4 at 100 meters. Maximum frequency, 72 per cent at station 15; other records above minimum (6 to 12 per cent) from stations 145, 146 in pump samples; average in Pacific pump samples, 24.6 loricae.

Temperature: Atlantic, pump samples  $18^{\circ}56-19^{\circ}27$  ( $18^{\circ}91$ ), net samples  $22^{\circ}56-27^{\circ}88$  ( $25^{\circ}08$ ); Pacific,  $16^{\circ}58-22^{\circ}37$  ( $20^{\circ}05$ ) and  $22^{\circ}37$ , respectively. Salinity: Atlantic, pump samples  $36.08-36.51$  (36.32), net samples  $36.45-36.47$  (36.46); Pacific,  $34.32-34.91$  (34.61) and  $35.23$ , respectively. Density: Atlantic, pump samples  $26.12-26.26$  (26.19), net samples  $23.26-25.22$  (24.31); Pacific,  $23.88-24.66$  (24.37) and  $24.30$ , respectively. pH: Atlantic, pump samples  $8.19-8.21$  (8.20), net samples  $8.19-8.30$  (8.25); Pacific,  $8.14-8.31$  (8.26) and  $8.13$ , respectively.

*Rhabdonella henseni* (Brandt) Brandt

(Figure 90)

*Rhabdonella henseni*, Kofoid and Campbell, 1929, p. 216, fig. 408.

The moderately elongated lorica, with wide, chalice-shaped bowl, rather long, thick aboral horn, and vertical ribs, has a length of 5.1 oral diameters. The oral rim is hyaline, higher than the margin of the suboral trough, thin, ringlike, and erect. The suboral trough is shallow, and its outer margin has a diameter of 1.13 oral diameters. There is scarcely any suboral flare. The bowl is subcylindrical for nearly 0.46 total length, and convex conical ( $40^{\circ}$ ) for about 1.1 oral diameters. The elongated, conical ( $8^{\circ}$ ) aboral horn has a basal diameter of 0.3 oral diameter, and a length of almost 0.33 total length; its junction with the bowl is often asymmetrical.

The wall is thickest across the ridgelike suboral flare, where it reaches 0.05 oral diameter; elsewhere it is decidedly thinner. There are exceedingly thin, dark laminae with numerous minute alveoles enclosed. A curtain-like film of transparent jelly encloses the upper bowl. There are 18 vertical, frequently anastomosing, branching, rarely discontinuous and short ribs, which run the whole length of the lorica save suborally. There are 12 to 18 small fenestrae (the sites of coccoliths), and fine alveoles form an external meshwork in the intercostae. The whole lorica is a deep brown color.

Length, 303 $\mu$ .

The aboral horn of the figured specimen (fig. 90) is not so thick as usual.

*Rhabdonella henseni* is stouter and plumper than any species of the *R. spiralis* group. It is closest to *R. torta* and *R. lohmanni*. It may be distinguished from *lohmanni* by the vertical rather than oblique ribs, the smaller size, and the more slender horn. From *torta* it may be distinguished by the larger size and the vertical rather than right-spiral ribs.

Recorded from three stations, one in the Atlantic and two in the Pacific, as follows: one (17) in the Sargasso Sea, one (96) in the region of South Pacific island fields, and one (135) in the California region.

There are 2 pump samples and 1 net sample, of which 2 were taken at the surface and 1 at 50 meters. Frequency, minimum.

Temperature: Atlantic, net sample 21°85; Pacific, pump samples 23°76–29°30 (26°53). Salinity: Atlantic, net sample 36.60; Pacific, pump samples 35.12–35.27 (35.19). Density: Atlantic, net sample 25.49; Pacific, pump samples 22.19–23.83 (23.01). pH: Atlantic, net sample 8.27; Pacific, pump samples 8.23–8.37 (8.30).

#### *Rhabdonella indica* Laackmann

*Rhabdonella indica*, Kofoid and Campbell, 1929, p. 217, fig. 397.

The short lorica, with conical bowl, short, peglike aboral horn, and numerous ribs, has a length of 2.15 oral diameters. The oral rim is high, erect, ringlike, and sharp-edged. The suboral trough is concave; the diameter of its outer margin is 1.17 oral diameters. There is a distinct suboral flare (35°) within the upper 0.1 oral diameter. The bowl is convex conical (15° in the anterior half, increasing to 45° in the posterior section, and then 20°). The aboral end has a prolonged, peglike horn with distal sharp point.

The wall reaches 0.09 oral diameter in thickness suborally, but thins rapidly in the middle. There are thin laminae which enclose several layers of minute alveoles. There are 36 to 42 delicate, left-twisted (15°), sometimes branched ribs, which die away on the swollen suboral flare. Fenestrae are lacking.

Length, 56 to 63 $\mu$ .

*Rhabdonella indica* differs from *R. amor* in size, lack of fenestrae, twist of the ribs, and more numerous ribs. It is somewhat shorter than *R. exilis*, with fewer ribs and greater density. It can scarcely be confused with other species.

Recorded from twenty stations in the Pacific, as follows:

three (36, 37, 39) in the Pacific equatorial region, four (46, 47, 78, 80) in the Galápagos region, three (48, 82, 90) in the region of South Pacific island fields, one (58) in the South Pacific middle latitudes, three (107, 109, 150) in the North Pacific trade region, four (135, 136, 146, 147) in the California region, and two (142, 145) in the North Pacific middle latitudes.

There are 24 pump and 6 net samples, of which 16 were taken at the surface, 9 at 50 meters, and 5 at 100 meters. Maximum frequency, 6 per cent at station 46; other records above minimum (2 to 5 per cent) from stations 48, 78; average in net samples, 42 per cent; 2 to 15 loricae in pump samples.

Temperature: pump samples 14°49–27°12 (23°27), net samples 16°98–24°38 (22°57). Salinity: pump samples 31.62–36.44 (35.34), net samples 33.97–36.44 (35.50). Density: pump samples 20.20–26.07 (23.35), net samples 24.11–24.86 (24.45). pH: pump samples 7.85–8.32 (8.28), net samples 8.12–8.23 (8.17).

#### *Rhabdonella inflata* Kofoid and Campbell

*Rhabdonella inflata* Kofoid and Campbell, 1929, p. 217, fig. 403.

The short, rather stout lorica, with chalice-shaped bowl and wide aboral region, with little transition, has a length of 3.66 oral diameters. The oral rim is low, ringlike, and erect. The suboral trough is flat and the diameter of its outer margin is 1.22 oral diameters. There is very little suboral flare. The bowl tapers (5°) for nearly 0.4 total length and then becomes subconical (33°) within 1.2 oral diameters. The transition between lower bowl and horn is gradual. The aboral horn has a length equal to that of the lower bowl, is subconical (14°), and is sharply pointed at the free tip.

The wall thickness reaches not over 0.06 oral diameter suborally and thins down in the bowl. There are thin laminae which enclose small alveoles in several layers. There are upwards of 60 subvertical, mostly unbranched ribs, and the intercostae have many small, faint fenestrae.

Length, 124 to 200 $\mu$ .

*Rhabdonella inflata* is shorter than *R. spiralis*, with gradually differentiated horn and with more ribs. In similar characters it differs from *R. hebe*, which last has a spindle-like knob lacking in *inflata*. It is stouter than *R. striata* and has fainter fenestrae.

Recorded from two stations (131, 147) in the California region, in net samples taken at 100 meters. Frequency, 2 per cent at station 131.

Temperature, 12°12–19°27 (15°69); salinity, 33.36–35.04 (34.20); density, 25.00–25.31 (25.15); pH, 8.29–8.32 (8.30).

#### *Rhabdonella lohmanni* Kofoid and Campbell

*Rhabdonella lohmanni* Kofoid and Campbell, 1929, p. 218, fig. 416.

The tall lorica, with chalice-shaped bowl, oblique ribs, and stout horn, has a length of 5.5 oral diameters. The oral rim is low, ringlike, and slanted outward. There is almost no suboral trough or suboral flare; the diameter of the bowl at the upper end is, however, 1.11 oral diameters. The upper two-thirds of the bowl is subcylindrical, and the lower bowl

is subconical (up to  $35^\circ$ ). The aboral horn reaches 0.38 total length and is relatively stout subconical ( $9^\circ$ ). Its free tip is pointed.

The wall reaches a maximum thickness of only about 0.05 oral diameter. There are thin laminae which enclose small alveoles. There are 48 definitely right-turning ( $10^\circ$ ), branched, often anastomosed, heavy ribs, which fade away near the distal tip of the horn and just below the suboral rim; there are no fenestrae.

Length, 317 to 377 $\mu$ .

*Rhabdonella lohmanni* resembles *R. henseni* in general, but has oblique ribs and a stout horn, and is longer. *Rhabdonella torta* is shorter (210 to 228 $\mu$ ) but otherwise rather similar.

Recorded from two stations (138, 140) in the North Pacific trade region, in 2 pump samples, 1 taken at the surface and 1 at 50 meters. Frequency, minimum.

Temperature,  $26^\circ 14$ – $26^\circ 87$  ( $26^\circ 50$ ); salinity, 34.85–35.02 (34.93); density, 22.80–22.90 (22.85); pH, 8.35–8.39 (8.37).

#### *Rhabdonella poculum* (Ostenfeld and Schmidt) Brandt

(Figure 92)

*Rhabdonella poculum*, Kofoid and Campbell, 1929, p. 218, fig. 405.

The short, wide lorica, with nearly cylindrical upper and conical lower bowl, and wide conical horn, has a length of 1.93 oral diameters. The oral rim is entire, and is a cuff which rises above the suboral trough which surrounds it. The suboral trough is shallow and concave; the diameter of its outer margin is 1.1 oral diameters. The bowl flares ( $10^\circ$ ) within the anterior 0.1 oral diameter, then becomes cylindrical for 0.85 oral diameter, and finally convex conical ( $60^\circ$ ) for nearly 0.54 oral diameter. The aboral horn is inverted and concave conical ( $40^\circ$ ), with a basal diameter of 0.32 oral diameter, and with a sharply pointed free tip.

The wall is subuniformly about 0.09 oral diameter in thickness. There are 24 deflected ( $15^\circ$ ) ribs, which arise on the horn or near it, and die away just below the suboral flare. The ribs are often branched and sometimes anastomosed, and the intercostal regions have 8 to 12 scattered, oval fenestrae. The lorica is commonly dark brown.

Length, 85 $\mu$ .

The *Carnegie* loricae show much more transition between lower bowl and horn than is shown in the single figure of Kofoid and Campbell; they have fewer ribs (left, rather than right, deflection), and have fenestrae.

*Rhabdonella poculum* may be distinguished at once from other species by the general form. In some ways it is like *R. amor*, but it has a distinctly conical, well differentiated horn. The shortness, and the basal width of the horn are characters which are especially distinct.

Recorded from three stations in the Pacific, as follows: two (40, 41) in the Galápagos region, and one (93) in the region of South Pacific island fields.

There are 3 pump and 3 net samples, of which 4 were taken at the surface, 1 at 50 meters, and 1 at 100 meters. Maximum frequency, 13 per cent at station 41; average in net samples, 5.3 per cent.

Temperature: pump samples  $20^\circ 42$ – $28^\circ 74$  ( $24^\circ 45$ ), net samples  $14^\circ 55$ – $20^\circ 42$  ( $16^\circ 76$ ). Salinity: pump samples 33.70–34.71 (34.20), net samples 34.19–35.02 (34.40). Density: pump samples 21.95–24.06 (23.07), net samples 24.06–26.11 (25.33). pH: pump samples 8.11–8.30 (8.14), net samples 7.87–8.11 (7.96).

#### *Rhabdonella quantula* Kofoid and Campbell

*Rhabdonella quantula* Kofoid and Campbell, 1929, p. 218, fig. 402.

The rather short lorica, with narrow, chalice-like bowl and elongated horn, has a length of 3.66 oral diameters. The oral rim is low and ringlike, and extends only slightly above the suboral trough. The suboral trough is concave and the diameter of its outer margin is 1.22 oral diameters. There is some suboral flare ( $35^\circ$ ) within the upper 0.05 oral diameter. The bowl tapers ( $16^\circ$ ) in the anterior 0.37 total length and then becomes subconical ( $30^\circ$ ) within the posterior 0.35 total length. The aboral horn (0.29 total length in length) is narrow conical ( $5^\circ$ ) and sharply pointed at the free tip.

The wall is thickest across the suboral flare, where it reaches 0.1 oral diameter; at other levels it is reduced by one-half. There are thin laminae which enclose fine alveoles. There are upwards of 54 subvertical, continuous, distinct, unbranched ribs, and in each intercostal area are 6 to 8 small circular fenestrae.

Length, 138 to 172 $\mu$ .

*Rhabdonella quantula* differs from *R. spiralis* mainly in shortness and in greater number of ribs. *Rhabdonella inflata* is of about the same size, but has a longer, less tapering bowl; *R. cornucopia* has a stubby aboral horn. The lower bowl of *R. brandti* is wider, and its horn is shorter than in *quantula*.

Recorded from ten stations in the Pacific, as follows: three (35, 35-36, 99) in the Pacific equatorial region, two (78, 80) in the Galápagos region, four (81, 82, 84, 85) in the region of South Pacific island fields, and one (140) in the North Pacific trade region.

There are 3 pump and 10 net samples, of which 3 were taken at the surface, 7 at 50 meters, and 3 at 100 meters. Maximum frequency, 75 per cent at station 35-36; other records above minimum (2 to 8 per cent) from stations 35, 82, 85, 99; average in net samples, 10.6 per cent.

Temperature: pump samples  $25^\circ 94$ – $28^\circ 32$  ( $26^\circ 77$ ), net samples  $14^\circ 33$ – $27^\circ 89$  ( $23^\circ 48$ ). Salinity: pump samples 35.02–35.95 (35.58), net samples 34.88–36.42 (35.71). Density: pump samples 22.45–23.75 (23.09), net samples 22.50–26.06 (24.09). pH: pump samples 8.16–8.34 (8.23), net samples 7.88–8.22 (8.13).

#### *Rhabdonella spiralis* (Fol) Brandt emended Kofoid and Campbell

*Rhabdonella spiralis*, Kofoid and Campbell, 1929, p. 219, fig. 414; Hofker (part), 1931, pp. 378–381, figs. 68–72 (for fig. 67 see *Rhabdonellopsis triton*); Marshall, 1934, pp. 646–648, figs. 23, 27(?).

The moderately tall, elongated lorica, with tapering bowl



and horn, subequal in length, has a length of 5.5 oral diameters. The oral rim is erect, ringlike, and about as high as the outer rim of the suboral trough. The suboral trough is concave and the diameter of its outer margin is 1.2 oral diameters. The bowl flares ( $38^\circ$ ) within the upper 0.1 oral diameter. It then tapers ( $14^\circ$ ) for 0.42 total length, then becomes subconical ( $28^\circ$ ) for 0.18. From its lower end arises the aboral horn. The horn tapers ( $7^\circ$ ) and has a length of 0.4 total length, and its free tip is sharp.

The wall has a thickness of not over 0.1 oral diameter across the trough, and thins regularly below. There are thin laminae which enclose several layers of minute alveoles. There are 42 sometimes branched, anastomosed, subvertical ribs, which continue from end to end. Between the ribs are 12 to 20 small, scattered circular fenestrae, mostly gathered in the upper bowl and more rare below.

Length, 260 $\mu$ .

That part of Hofker's material which has distal knobs is assigned in this report to *Rhabdonellopsis triton*. Marshall does not distinguish *spiralis* from related species, but since only one figure is clearly of this species, this Barrier Reef material is all included as *spiralis*. One of Marshall's figures (fig. 27) strongly suggests *Rhabdonella anadyomene*, save that the ribs are reversed and the oral rim more developed; this lorica may, however, be only an incomplete (abnormal or defective?) specimen. It is not at all like the imperfect *R. hydria*, which is probably only a defective *spiralis*. Defective loricae were not encountered in the Carnegie material save at station 1, where at 70 meters one specimen somewhat like Marshall's was found. On the whole it is rather remarkable that so few defective loricae of these ciliates are found, considering their abundance in the ocean. Perhaps this is because they are quickly formed.

*Rhabdonella spiralis* is closest to *R. valdestriata*, *R. striata*, and *R. hebe*. It is usually longer than these, with more slender proportions, with distinct suboral flare, and with subequal upper bowl and horn. There is more transition between lower bowl and horn than in *hebe* or *valdestriata*, but not so much as in *striata*. It never has the length, narrowness, or facies of *R. conica*. The remaining species are clearly unlike it and occasion no opportunity for confusion.

Recorded from forty-four stations, sixteen in the Atlantic and twenty-eight in the Pacific, as follows: three (1, 15, 16) in the Gulf Stream, four (17, 18, 19, 21) in the Sargasso Sea, five (24, 26, 27, 29, 30) in the Atlantic equatorial region, four (31, 32, 33, 34) in the Caribbean Sea, two (35, 37) in the Pacific equatorial region, eight (45, 46, 47, 68, 69, 78, 79, 80) in the Galápagos region, six (48, 87, 89, 90, 95, 97) in the region of South Pacific island fields, nine (50, 51, 53, 54, 61, 62, 62-63, 64, 65) in the South Pacific middle latitudes, two (131, 146) in the California region, and one (145) in the North Pacific middle latitudes.

There are 46 pump and 27 net samples, of which 31 were taken at the surface, 24 at 50 meters, 1 at 70 meters, and 17 at 100 meters. The preference of this species for surface water is evident. Maximum frequency, 90 per cent at station 64; other records above minimum (2 to 88 per cent) from stations 18, 30, 31, 54, 61, 62-63, 65, 145; average in net

samples, Atlantic 1.6 per cent, Pacific 37.5 per cent; in pump samples, 300 loricae counted at station 15; other pump records 1 to 43, average in the Pacific 6.0.

Temperature: Atlantic, pump samples  $18.40-28.51$  ( $25.76$ ), net samples  $15.55-28.05$  ( $22.28$ ); Pacific,  $13.28-28.74$  ( $22.70$ ) and  $10.92-24.38$  ( $18.50$ ), respectively. Salinity: Atlantic, pump samples 29.70-36.58 (35.80), net samples 35.61-37.15 (36.45); Pacific, 31.68-36.44 (35.27) and 33.36-36.03 (34.59), respectively. Density: Atlantic, pump samples 18.62-26.01 (23.69), net samples 23.20-26.34 (25.00); Pacific, 20.20-25.40 (24.15) and 24.24-26.06 (24.58), respectively. pH: Atlantic, pump samples 8.11-8.31 (8.26), net samples 7.96-8.37 (8.29); Pacific, 8.05-8.28 (8.17) and 8.03-8.34 (8.17), respectively.

#### *Rhabdonella striata* (Biedermann) Brandt emended Kofoid and Campbell

*Rhabdonella striata*, Kofoid and Campbell, 1929, p. 219, fig. 411.

The moderately tall lorica, with stout conical bowl and elongate conical horn, has a length of 3.71 oral diameters. The oral rim is a low, outward-recurved rim, which projects a little above the outer margin of the suboral trough. The suboral trough is flattened concave; the diameter of its outer margin is 1.09 oral diameters. There is a wide suboral flare ( $60^\circ$ ) within the upper 0.1 oral diameter. The upper bowl tapers ( $16^\circ$ ) for 0.42 total length, and then becomes subconical ( $44^\circ$ ) for 0.19 total length. The aboral horn is narrow concave conical ( $5^\circ$ ), with a length of 0.39 total length and with a truncated free tip.

The wall has a maximum thickness of approximately 0.1 oral diameter. There are thin laminae which enclose fine alveoles in several layers. There are 42 commonly branched, anastomosed, subvertical, low ribs which continue from end to end. Fenestrae are numerous, but small and not especially conspicuous.

Length, 225 $\mu$ .

*Rhabdonella striata* has a more sharply differentiated lower bowl and more ribs than *R. valdestriata*. It is stouter and shorter, and has more ribs than *R. spiralis*. *Rhabdonella brandti* is shorter.

Recorded from fifty-five stations, sixteen in the Atlantic and thirty-nine in the Pacific, as follows: three (20, 20-21, 21) in the Sargasso Sea, nine (22, 23, 24, 25, 26, 27, 28, 29, 30) in the Atlantic equatorial region, four (31, 32, 33, 34) in the Caribbean Sea, six (52, 56, 63, 65, 66, 67) in the South Pacific middle latitudes, three (68, 69, 80) in the Galápagos region, seven (89, 90, 93, 95, 96, 97, 159) in the region of South Pacific island fields, four (99, 152, 153, 154) in the Pacific equatorial region, six (100, 107, 108, 109, 110, 138) in the North Pacific trade region, eight (132, 133, 135, 136, 137, 146, 148, 149) in the California region, and five (141, 142, 143, 144, 145) in the North Pacific middle latitudes. *Rhabdonella striata* is the most common *Rhabdonella* in the ocean and is most widely distributed in warmer seas.

There are 54 pump and 45 net samples, of which 37 were taken at the surface, 24 at 50 meters, and 38 at 100 meters.

Maximum frequency, 78 per cent at station 20-21; other records above minimum (2 to 60 per cent) from stations 21, 22, 23, 24, 25, 27, 28, 29, 30, 32, 33, 34, 68, 69, 80, 99, 136, 137, 145, 152, 153, 154, 159; averages in net samples, 17.9 and 4.8 per cent for the Atlantic and Pacific, respectively; in pump samples, 150 loricae at station 96; average in Pacific pump samples, 10.3.

Temperature: Atlantic, pump samples  $14^{\circ}60-27^{\circ}61$  ( $23^{\circ}11$ ), net samples  $14^{\circ}60-28^{\circ}54$  ( $23^{\circ}54$ ); Pacific,  $15^{\circ}84-29^{\circ}43$  ( $23^{\circ}68$ ) and  $11^{\circ}48-28^{\circ}60$  ( $21^{\circ}47$ ), respectively. Salinity: Atlantic, pump samples 35.22-36.75 (35.96), net samples 35.61-36.65 (36.13); Pacific, 33.68-35.39 (35.08) and 34.30-35.95 (34.96), respectively. Density: Atlantic, pump samples 22.84-26.62 (24.43), net samples 21.78-26.02 (23.49); Pacific, 21.70-25.48 (23.45) and 22.31-26.50 (24.31), respectively. pH: Atlantic, pump samples 7.93-8.32 (8.20), net samples 7.93-8.32 (8.19); Pacific, 8.08-8.47 (8.29) and 7.76-8.39 (8.16), respectively.

#### *Rhabdonella torta* Kofoid and Campbell

*Rhabdonella torta* Kofoid and Campbell, 1929, p. 220, fig. 404.

The fairly long lorica, with stout, chalice-shaped bowl, oblique ribs, and wide conical horn, has a length of 4.0 oral diameters. The oral rim is submerged and low. The suboral trough is flat and the diameter of its outer rim is 1.18 oral diameters. The bowl tapers ( $15^{\circ}$ ) in the anterior two-thirds and becomes subconical ( $30^{\circ}$ ) in the lower section. The aboral horn is conical ( $22^{\circ}$ ), little differentiated, and about 0.3 total length in length, and has a blunted, free tip.

The wall reaches 0.11 oral diameter in thickness suborally and thins regularly in the bowl. There are thin laminae and enclosed alveoles in several layers. There are 56 right-twisted (upwards of  $40^{\circ}$ ), feebly anastomosed and branched ribs; the tips of the ribs are left-turned near the suboral margin. There are 4 to 8 distinct fenestrae in the intercostae. The lorica, as in *Rhabdonella lohmanni* and *R. henseni*, is deep brown.

Length, 210 to 228 $\mu$ .

*Rhabdonella torta* is related to *R. henseni* and *R. lohmanni*, but is much shorter than either and has a much less clearly differentiated horn. The ribs are also different.

Recorded from station 61 in the South Pacific middle latitudes, in a net sample taken at the surface. Frequency, 4 per cent.

Temperature,  $16^{\circ}90$ ; salinity, 34.05; density, 24.83; pH, 8.05.

#### *Rhabdonella valdestriata* Brandt

(Figure 91)

*Rhabdonella valdestriata*, Kofoid and Campbell, 1929, p. 220, fig. 410.

The moderately tall, chalice-shaped lorica, with almost no suboral flare, slight transition between bowl and horn, and long bowl, has a length of 4.25 oral diameters. The oral rim is ringlike and submerged by the higher rim of the suboral trough. The suboral trough is very shallow and the diameter of its outer edge is 1.2 oral diameters. The bowl tapers

( $12^{\circ}$ ) for 0.34 total length, then becomes inverted subconical ( $28^{\circ}$ ) for 0.29. The transition between lower bowl and aboral horn is gradual. The horn is conical ( $15^{\circ}$ ), is 0.37 total length in length, and has a sharp, pointed free tip.

The wall is thickest suborally (0.12 oral diameter) and thins evenly below. There are thin laminae with enclosed minute alveoles in several layers. There are 24 vertical, continuous, rarely branched and anastomosed ribs with scattered, irregularly placed fenestrae.

Length, 150 to 225 $\mu$ .

*Rhabdonella valdestriata* differs from *R. cuspidata* in its longer bowl, lack of aboral swelling, and shortness. It is less widely conical than *R. striata* and lacks the distinct suboral flare of *R. spiralis*.

Recorded from three stations in the Pacific, as follows: one (35) in the Pacific equatorial region, one (49) in the region of South Pacific island fields, and one (63) in the South Pacific middle latitudes.

There are 3 pump samples and 1 net sample, of which 2 were taken at the surface and 2 at 50 meters. Frequency, 4 per cent in the net sample; 4 to 60 (35.0) loricae in pump samples.

Temperature: pump samples  $17^{\circ}01-23^{\circ}38$  ( $19^{\circ}92$ ), net sample  $16^{\circ}30$ . Salinity: pump samples 34.59-36.17 (35.13), net sample 34.88. Density: pump samples 24.36-25.22 (24.76), net sample 25.60. pH: pump samples 8.07-8.27 (8.14), net sample 7.92.

#### RHABDONELLOPSIS Kofoid and Campbell

*Rhabdonellopsis* Kofoid and Campbell, 1929, p. 221.

*Rhabdonellopsis* probably arose from *Rhabdonella* by the addition of a knob and lance.

*Rhabdonellopsis* is a genus of the circumtropical region, although some species range southward of New Zealand and northward of Hawaii. Loricae are carried by the Gulf Stream to considerable latitudes.

Six species are described here.

#### *Rhabdonellopsis apophysata* (Cleve) Kofoid and Campbell

*Rhabdonellopsis apophysata*, Kofoid and Campbell, 1929, p. 221, fig. 420.

The relatively elongated lorica, with stout skirt, ribbed pedicel, and no fenestrae, has a length of 6.4 oral diameters. The oral rim is high, ringlike, and erect, and forms the inner boundary of the suboral trough. The trough is flat, and its outer rim has a diameter of 1.3 oral diameters. The long bowl flares ( $54^{\circ}$ ) within the upper 0.4 oral diameter. Below the flaring region the bowl is subconical ( $15^{\circ}$  in the upper 0.35 total length and  $32^{\circ}$  in the lower section). At its lower end is the narrow (0.21 oral diameter), cylindrical pedicel, the length of which is 0.41 total length. At its aboral end is the expanded skirt, the lower edge of which is irregular, and from its middle arises the conical ( $10^{\circ}$ ) pointed lance.

The wall is thickest just below the suboral trough, where it reaches 0.12 oral diameter. It becomes much thinner below. There are thin laminae with enclosed radial, single-

layered, secondary rectangles, and within these are minute alveoles in several layers. On the surface are 20 to 28 sub-vertical ribs, which continue down the pedicel and over the skirt. The areas between the ribs are free of fenestrae. The suboral ring and the lance are hyaline, but the pedicel is brownish.

Length, 297 $\mu$ .

The ribs are less deflected and the lorica is shorter than in specimens from other sources.

*Rhabdonellopsis apophysata* has more ribs than *R. longicaulis*, which species not only is longer, but also is fenestrate and has a heavier knob. *Rhabdonellopsis composita* lacks ribs on the knob, and has fewer ribs on the bowl. *Rhabdonellopsis intermedia* is shorter, is fenestrate, and has fewer ribs. In the remaining species the knob is spindle-like.

Recorded from nine stations, seven in the Atlantic and two in the Pacific, as follows: two (19, 20) in the Sargasso Sea, two (27, 29) in the Atlantic equatorial region, three (31, 32, 34) in the Caribbean Sea, and two (35-36, 37) in the Pacific equatorial region.

There are 12 net samples, of which 3 were taken at the surface, 3 at 50 meters, and 6 at 100 meters. Maximum frequency, 10 per cent at station 32; other records above minimum (2 to 8 per cent) from stations 27, 32, 34, 35-36; averages, Atlantic 4.3 per cent, Pacific 3.8 per cent.

Temperature: Atlantic, 18°08–26°04 (24°81); Pacific, 1 record only, 27°12. Salinity: Atlantic, 36.03–37.15 (36.57); Pacific, 31.68. Density: Atlantic, 23.98–26.06 (25.52); Pacific, 20.20. pH: Atlantic, 8.09–8.30 (8.20); Pacific, 8.28.

#### *Rhabdonellopsis composita* (Brandt) Kofoid and Campbell

(Figure 87)

*Rhabdonellopsis composita*, Kofoid and Campbell, 1929, pp. 222–223, fig. 421.

The rather tall lorica, without ribs on the pedicel, and with few ribs, stout knob, and thick lance, has a length of 6.05 oral diameters. The oral margin is erect, thin, ringlike, and higher than the outer edge of the suboral trough. The suboral trough is concave and the diameter of its rounded-over outer rim is 1.17 oral diameters. The bowl flares (73°) within the anterior fifth. Below the flare it tapers (8°) for 0.28 total length, and then becomes subconical (26°) for nearly 0.23 total length. The long pedicel is a cylinder (0.25 oral diameter in diameter) with a length of almost 0.42 total length. At its lower end is the thickened, skirtlike knob. From the middle of the knob arises the thick lance (0.6 oral diameter in length).

The wall reaches a maximum thickness of 0.14 oral diameter at the flare and thins down to a tenth that much in the bowl. There are thin laminae which enclose minute alveoles. There are 12 vertical, unbranched ribs, which die out below the middle of the bowl, so that the lower half is nonstriate. A few (2 to 6) minute fenestrae are found scattered along each intercosta. The lance has vertical fins. The whole lorica is colorless, save the knob.

Length, 280 to 353 $\mu$ .

*Rhabdonellopsis composita* has fewer ribs of shorter length

than *R. apophysata*; it is also fenestrated, and the lance is fluted.

Recorded from sixteen stations in the Atlantic, as follows: two (15, 16) in the Gulf Stream, six (17, 18, 19, 20, 20-21, 21) in the Sargasso Sea, seven (22, 23, 24, 26, 27, 28, 29) in the Atlantic equatorial region, and one (34) in the Caribbean Sea.

There are 17 pump and 17 net samples, of which 14 were taken at the surface, 11 at 50 meters, and 9 at 100 meters. Maximum frequency, 16 per cent at stations 15, 24; other records above minimum (2 to 5 per cent) from stations 18, 19, 21; average in net samples, 5.1 per cent; pump samples, 140 loricae taken at station 15, 33 at station 21, 12 at station 34, and 13 at station 24.

Temperature: pump samples 17°50–28°51 (24°62), net samples 15°55–26°98 (22°65). Salinity: pump samples 35.22–37.15 (35.54), net samples 35.61–37.15 (36.44). Density: pump samples 22.84–26.26 (24.20), net samples 23.79–26.34 (24.92). pH: pump samples 8.14–8.37 (8.26), net samples 7.96–8.32 (8.27).

#### *Rhabdonellopsis intermedia* Kofoid and Campbell

*Rhabdonellopsis intermedia* Kofoid and Campbell, 1929, p. 223, fig. 424; Marshall, 1934, pp. 650–651, fig. 28.

The short lorica, with flaring conical bowl, tapering shaft, and deflected ribs, has a length of 4.9 oral diameters. The oral rim is low and ringlike, and forms the inner boundary of the concave suboral trough. The diameter of the trough is 1.14 oral diameters. The bowl flares (63°) within the upper 0.1 oral diameter, then tapers (12°) for 0.31 total length, and finally becomes inverted subconical (38°) for 0.8 oral diameter. The pedicel also tapers (8°), the transition between the lowermost section of the bowl and the pedicel being gradual. The pedicel also expands a bit above the knob, so that it is distinctly concave in lateral contour; it has a length of nearly 0.33 total length. At its lower end is the modestly expanded knob, from the middle of which arises the lance (0.5 oral diameter in length), the free tip of which is sometimes open.

The wall has a thickness of 0.15 oral diameter suborally and thins down evenly in the lower bowl. There are thin laminae which enclose radial, rectangular secondary prisms, which in their turn enclose minute alveoles in several layers. The ribs number 16 (24); they are deflected (up to 10°) to the left, and sometimes they branch. They continue on the pedicel, knob, and lance. The intercostae have 7 to 16 small fenestrae and strongly developed, though small, prisms.

Length, 222 to 298 $\mu$ .

*Rhabdonellopsis intermedia* is shorter than *R. apophysata*, with fenestrae and fewer ribs. The ribs are continued the whole length, whereas in *R. composita* they die out on the bowl. The pedicel is relatively shorter, as is the whole lorica actually, than in *R. longicaulis*.

Recorded from six stations in the Pacific, as follows: two (45, 46) in the Galápagos region, two (83, 84) in the region of South Pacific island fields, and two (100, 150) in the North Pacific trade region.

There are 2 pump and 7 net samples, of which 1 was taken at the surface, 6 at 50 meters, and 1 each at 100 and 150 meters. Maximum frequency, 11 per cent at station 84; other records above minimum (2 to 7 per cent) from stations 45, 83, 84; averages, 4.4 per cent and 1.5 loricae in net and pump samples, respectively.

Temperature: pump samples  $14^{\circ}73-27^{\circ}46$  ( $21^{\circ}09$ ), net samples  $21^{\circ}69-27^{\circ}89$  ( $24^{\circ}70$ ). Salinity: pump samples  $34.27-36.49$  (35.38), net samples  $34.71-36.42$  (35.48). Density: pump samples  $23.11-25.48$  (24.59), net samples  $22.31-24.48$  (23.79). pH: pump samples  $8.12-8.24$  (8.18), net samples  $8.12-8.22$  (8.16).

#### *Rhabdonellopsis longicaulis* Kofoid and Campbell

(Figure 88)

*Rhabdonellopsis longicaulis* Kofoid and Campbell, 1929, p. 223, fig. 419.

The greatly elongated lorica, with heavy knob, minute, sparse fenestrae, and very long pedicel, has a length of 8.0 oral diameters. The oral margin is fairly high, ringlike, and erect, and is the inner boundary of the concave suboral trough. The outer margin of the trough is serrate, and its diameter is 1.24 oral diameters. The bowl flares ( $52^{\circ}$ ) within the anterior 0.32 oral diameter, and then tapers ( $13^{\circ}$ ) for 0.42 total length before becoming subconical ( $33^{\circ}$ ) for 0.72 oral diameter. From the lower end of this section arises the tapering pedicel ( $5^{\circ}$ ), the length of which is 0.42 total length, and the diameter of which is 0.16 oral diameter. At the aboral end of the pedicel is the thickened, expanded knob (0.25 oral diameter in width). From the end of the knob arises the thin lance, the length of which is 0.6 oral diameter.

The wall reaches nearly 0.1 oral diameter in thickness suborally and lessens to a fraction in the lower bowl and pedicel. There are thin laminae which enclose minute prisms. The ribs are few (16), rarely branched within the upper fourth, continued down to the knob, nearly vertical, decurrent suborally, and not equally spaced. There are 2 to 5 minute fenestrae scattered in the intercostal spaces; these are the sites of tiny coccoliths. The knob is brownish, but the rest of the lorica is translucent.

Length, 350 to 468 $\mu$ .

This large, stately species is easy to distinguish from the others. The length, few fenestrae, long pedicel, heavy knob, and few ribs are all characters that separate it.

Recorded from nineteen stations in the Pacific, as follows: five (45, 46, 75, 76, 77) in the Galápagos region, two (63, 65) in the South Pacific middle latitudes, two (82, 84) in the region of South Pacific island fields, six (103, 107, 108, 109, 140, 151) in the North Pacific trade region, one (135) in the California region, one (141) in the North Pacific middle latitudes, and two (152, 153) in the Pacific equatorial region.

There are 21 pump and 12 net samples, of which 16 were taken at the surface, 11 at 50 meters, and 6 at 100 meters. Maximum frequency, 40 per cent at station 151; other records above minimum (2 to 19 per cent) from stations 45, 75, 76, 77, 84, 152; average in net samples, 8.4 per cent; in pump samples, maximum, 6 loricae at station 45; average, 1.7.

Temperature: pump samples  $15^{\circ}03-28^{\circ}08$  ( $23^{\circ}43$ ), net samples  $11^{\circ}48-27^{\circ}52$  ( $22^{\circ}56$ ). Salinity: pump samples  $34.02-35.86$  (34.87), net samples  $34.02-36.42$  (35.43). Density: pump samples  $21.78-25.48$  (23.20), net samples  $22.34-26.50$  (24.34). pH: pump samples  $8.08-8.47$  (8.24), net samples  $7.76-8.21$  (8.11).

#### *Rhabdonellopsis minima* Kofoid and Campbell

*Rhabdonellopsis minima* Kofoid and Campbell, 1929, p. 224, fig. 423.

The rather short lorica, with cornucopia-shaped bowl, long, tapering pedicel, and spindle-shaped knob, has a length of 5.0 oral diameters. The oral rim is submerged by the higher outer edge of the suboral trough, and its diameter is 1.09 oral diameters. The bowl contracts as a cone ( $13^{\circ}$ ) in the anterior 0.27 total length, and then ( $25^{\circ}$ ) in similar form and length. The long (0.49 total length), tapering pedicel ( $15^{\circ}$ ) has a thickened spindle-like knob (0.11 oral diameter in length), below which is a short lance the length of which is about equal to that of the knob.

The wall reaches a thickness of 0.1 oral diameter suborally and progressively lessens lower in the bowl and pedicel. There are thin laminae which enclose minute alveoles. The ribs arise a little below the suboral trough, are commonly bifurcate in the upper part, are decidedly left-turning (as much as  $20^{\circ}$ ), continue to the knob and lance, and number about 16. Fenestrae (6 to 18) are found in the intercostae, as are also minute prisms.

Length, 177 to 254 $\mu$ .

*Rhabdonellopsis minima* has a conical bowl, more twisted striae, and spindle-shaped knob, unlike *R. intermedia*. *Rhabdonellopsis triton* is much narrower, with a different number of ribs and different bowl. The remaining species have skirted knobs.

Recorded from eight stations in the Pacific, as follows: one (37) in the Pacific equatorial region, five (52, 54, 61, 62-63, 64) in the South Pacific middle latitudes, and two (48, 81) in the region of South Pacific island fields.

There are 2 pump and 11 net samples, of which 11 were taken at the surface and 2 at 100 meters. Maximum frequency, 98 per cent at station 48, minimum at station 52; average in net samples, 25 per cent; only 3 loricae were in pump samples.

Temperature: pump samples  $26^{\circ}53-27^{\circ}12$  ( $26^{\circ}82$ ), net samples  $10^{\circ}92-23^{\circ}63$  ( $19^{\circ}53$ ). Salinity: pump samples  $31.68-35.82$  (33.75), net samples  $34.05-36.44$  (35.15). Density: pump samples  $20.20-23.50$  (21.85), net samples  $24.33-26.06$  (24.65). pH: pump samples  $8.19-8.28$  (8.23), net samples  $8.03-8.27$  (8.15).

#### *Rhabdonellopsis triton* (Zacharias) Kofoid and Campbell

(Figure 86)

*Rhabdonellopsis triton*, Kofoid and Campbell, 1929, p. 224, fig. 422.

*Rhabdonella spiralis*, Hofker (part), 1931, pp. 378-381, fig. 67 (for figs. 68-73 see *Rhabdonella spiralis*).

The relatively short lorica, with conical bowl, swollen,

spindle-shaped knob, long lance, and few ribs and fenestrae, has a length of 5.6 oral diameters. The oral rim is a ring-like cuff which rises above the suboral trough. The suboral trough is flattened concave, and its outer margin has a diameter of 1.35 oral diameters. The bowl flares ( $58^\circ$ ) within the suboral 0.28, and then becomes inverted, slightly convex conical ( $25^\circ$ ); its length is 0.52 total length. The pedicel is tubular, with a diameter of only 0.18 oral diameter, and at 0.84 total length from the oral margin gives rise to a swollen, spindle-like knob (0.43 oral diameter in length). From the lower end arises the lance, the length of which is 0.4 oral diameter.

The wall reaches a thickness of almost 0.15 oral diameter across the suboral trough and gradually thins to a tenth as much in the pedicel. There are thin laminae and enclosed minute alveoles in several layers. The ribs number 12; they are subequidistant and unbranched, and die away before they reach the knob. There are 2 to 4 minute fenestrae in each intercostal area. The knob region is brownish, and on its surface are a number of right-turning striae.

There are 2 macronuclei.

Length, 312 $\mu$ .

The *Carnegie* loricae have unbranched ribs, few fenestrae, nonstriate pedicels, and higher oral rims than is usual for the species from other sources.

Hofker's photograph (fig. 67) shows a spindle-like knob unlike that of any others of his loricae. This specimen, and others, are assigned by us to *triton*.

*Rhabdonellopsis triton* has a spindle-shaped knob unlike the other species, save *R. composita*. In *composita* the bowl is wider, and the ribs are more numerous, are deflected, and have many fenestrae.

Recorded from three stations, one in the Atlantic and two in the Pacific, as follows: one (21) in the Sargasso Sea, one (45) in the Galápagos region, and one (131) in the California region.

There are 4 net samples, of which 2 were taken at the surface, 1 at 50 meters, and 1 at 100 meters. Frequency, 3 per cent at station 45; average in the Pacific, 3 per cent.

Temperature: Atlantic,  $26^\circ 57$ ; Pacific,  $12^\circ 12$ – $22^\circ 43$  ( $18^\circ 97$ ). Salinity: Atlantic, 36.28; Pacific, 33.36–35.26 (34.61). Density: Atlantic, 23.84; Pacific, 24.30–25.31 (24.64). pH: Atlantic, 8.32; Pacific, 8.12–8.32 (8.19).

#### EPIPLOCYLIDAE Kofoid and Campbell

Epiplocylidae Kofoid and Campbell, 1939, p. 125.

Three genera are included in the family: *Epiplocylis*, *Epiorrella*, and *Epicanella*. All three are mainly tropical and occur in the material of this expedition.

#### EPIPLOCYLIS Jörgensen emended

*Epiplocylis*, Kofoid and Campbell (part), 1929, pp. 172–173.

*Epiplocylis* is one of the more advanced genera. The vertical lines suggest derivation from some stem near the Rhabdonellidae. The cuplike shape remotely resembles that found in the Petalotrichidae.

*Epiplocylis* is common in the warm regions of the ocean. Some species, such as *E. undella*, are among the most frequent in those areas. Others extend north and south of the equator into temperate regions, but never reach really cool waters. Most of the species are circumtropical, with very little limitation to any of the oceans. Some species occur in such abundance as to constitute swarms, as do also some species of *Rhabdonella*. These swarms in the sea are not infrequent in some tintinnids, although, as a whole, the Tintinnoina are more usually found in small percentages. Areas of abundance usually extend over a wide number of stations and represent relatively large areas in the ocean.

Seventeen species are described here, one of which is new.

#### *Epiplocylis atlantica* Kofoid and Campbell

(Figure 72)

*Epiplocylis atlantica* Kofoid and Campbell, 1929, p. 176, fig. 340.

The short, heavy-set lorica, with wide conical aboral end, short horn, and low reticulated area, has a length of 1.62 oral diameters. The oral margin is thinly rounded. The bowl expands from the rim for 0.55 total length, and has a diameter at the lower level of 1.07 oral diameters. The lower bowl is inverted conical ( $93^\circ$ ), and joins the upper bowl with a rounded angle, the lateral contour of the whole being distinctly convex. The short (0.22 oral diameter) aboral horn is conical ( $28^\circ$ ) and its free tip is blunted.

The wall has a thickness of 0.067 oral diameter in the suboral thickened region which extends 0.31 oral diameter below the rim, and is elsewhere about one-third as thick. There are relatively thick inner and outer laminae which enclose rather small alveoles. The reticulated aboral region occupies 0.32 oral diameter, and comparatively few branched and anastomosing free lines extend above it for 0.15 oral diameter. The reticulations are deep pits of more or less subcircular form.

Length, 88 $\mu$ .

The *Carnegie* loricae are shorter than those from other sources.

*Epiplocylis atlantica* is shorter, wider, and more conical than *E. blanda*. In some characters it resembles *E. undella*, but it has lateral convexity rather than cylindrical upper bowl, a full aboral cone, and much finer reticulations.

Recorded from five stations in the Atlantic, as follows: one (19) in the Sargasso Sea, and four (23, 25, 28, 29) in the Atlantic equatorial region.

There are 5 net samples, of which 2 were taken at 50 meters and 3 at 100 meters. Frequency, 3 per cent at stations 19, 23; 2 per cent at stations 28, 29; average, 2.5 per cent.

Temperature,  $14^\circ 60$ – $27^\circ 11$  ( $22^\circ 73$ ); salinity, 35.70–37.05 (36.26); density, 23.62–26.62 (24.92); pH, 7.93–8.29 (8.18).

#### *Epiplocylis blanda* Jörgensen emended Kofoid and Campbell

(Figure 73)

*Epiplocylis blanda*, Kofoid and Campbell, 1929, p. 176, fig. 341; Marshall, 1934, p. 644, fig. 19.

The tall, cup-shaped lorica, with short free lines and long,

tapering suboral section, has a length of 2.03 oral diameters. The oral margin is thinly rounded, and there is some suboral flare ( $30^\circ$ ). The long bowl below the flare tapers ( $2^\circ$ ) for 0.5 total length and then becomes inverted conical ( $50^\circ$ ); this section is almost 0.38 total length in length. Its truncated lower end has a diameter of about 0.15 oral diameter. The aboral horn (0.12 total length in length) is concave conical ( $29^\circ$ ), and the free tip is blunt.

The wall is thickest within the flaring section, where it is 0.07 oral diameter; in other parts it is half as much. There are thin laminae which enclose hyaline material. The reticulated region occupies the aboral 0.56 total length, the upper third of which has minute circles and short, curved free lines, the lowermost part having large, more or less circular, sunken pitlike areas.

Length, 120 to 158 $\mu$ .

The loricae of this expedition are longer and have fewer free lines and often shorter aboral horns than usual, and are much more trim than the one figured by Marshall (1934).

*Epiplocylys blanda* has free lines and a less blunt horn than *E. obtusa*. *Epiplocylys impensa* has different proportions, a wider aboral cone, and relatively longer horn. *Epiplocylys mucronata* is taller and of different proportions, and has a much longer horn. *Epiplocylys acuminata* has a very long horn, and a wide suboral band lacking in *blanda*. *Epiplocylys sargassensis* has a conical bowl, and the transition between horn and bowl is more gradual. Once seen, *blanda* is scarcely to be confused with the other species.

Recorded from thirty-eight stations, seventeen in the Atlantic and twenty-one in the Pacific, as follows: one (16) in the Gulf Stream, five (17, 18, 19, 20-21, 21) in the Sargasso Sea, seven (22, 23, 25, 27, 28, 29, 30) in the Atlantic equatorial region, four (31, 32, 33, 34) in the Caribbean Sea, five (47, 68, 71, 78, 80) in the Galápagos region, two (66, 67) in the South Pacific middle latitudes, three (81, 82, 83) in the region of South Pacific island fields, three (100, 150, 151) in the North Pacific trade region, four (131, 136, 146, 149) in the California region, one (145) in the North Pacific middle latitudes, and three (152, 153, 154) in the Pacific equatorial region.

There are 3 pump and 51 net samples, of which 8 were taken at the surface, 21 at 50 meters, and 25 at 100 meters. Maximum frequency, 99 per cent at station 131; other records above minimum (2 to 52 per cent) from stations 16, 17, 19, 20-21, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33, 34, 71, 78, 80, 81, 82, 100, 136, 145, 146, 150, 151, 152, 153, 154; averages, 9.2 and 13.0 per cent in Atlantic and Pacific net samples.

Temperature: Atlantic, net samples  $14^\circ 60-27^\circ 88$  ( $23^\circ 29$ ); Pacific, net samples  $11^\circ 48-27^\circ 67$  ( $21^\circ 07$ ), pump samples  $13^\circ 98-23^\circ 88$  ( $18^\circ 83$ ). Salinity: Atlantic, net samples 35.70-37.05 (36.19); Pacific, net samples 33.24-36.33 (34.61), pump samples 33.24-35.96 (34.55). Density: Atlantic, net samples 23.84-26.62 (24.80); Pacific, net samples 22.31-26.50 (24.30), pump samples 24.42-25.03 (24.71). pH: Atlantic, net samples 7.93-8.32 (8.23); Pacific, net samples 7.76-8.38 (8.20), pump samples 8.23-8.39 (8.31).

### *Epiplocylys calyx* (Brandt) Jörgensen

*Epiplocylys calyx*, Kofoid and Campbell, 1929, p. 177, fig. 328.

The short, conical lorica, with thickened suboral wall, heavy surface reticulation, and sharp aboral horn, has a length of 1.24 oral diameters. The oral margin is thin and sharp. The bowl generally has a conical contour ( $25^\circ$  increasing to  $57^\circ$  and then to  $93^\circ$ ), the angle being least in the anterior 0.54 total length and gradually greater in the lower bowl, and quite without sudden changes. The suboral thickened region (0.28 oral diameter in width) bulges a trifle beyond the general contour. The aboral horn tapers ( $20^\circ$ ), has a length of 0.3 oral diameter, and is sharply pointed at its free tip.

The wall thickness is 0.06 oral diameter in the wide suboral region and less than a third that much in the remaining parts of the bowl. The upper 0.24 oral diameter is entirely free of surface lines or reticulations. There are only a few very short free lines, the greater part of the surface being heavily reticulated with large subcircular, moderately pitted areas.

Length, 75 $\mu$ .

*Epiplocylys calyx* resembles *E. labiosa*, but is shorter and wider, with a thinner swollen suboral region, and generally more conical bowl. Its lower bowl and horn are less abruptly differentiated than in *E. lata*, and it has a shorter, wider bowl and narrower free region than *E. exigua*.

Recorded from six stations in the Atlantic, as follows: two (18, 21) in the Sargasso Sea, and four (23, 24, 25, 30) in the Atlantic equatorial region.

There are 8 net samples, of which 4 each were taken at 50 and 100 meters. Frequency, 5 per cent at station 18; 2 per cent at stations 24, 30; average, 2 per cent.

Temperature,  $14^\circ 60-27^\circ 88$  ( $20^\circ 84$ ); salinity, 35.61-37.70 (36.41); density, 23.26-26.62 (25.37); pH, 7.93-8.30 (8.02).

### *Epiplocylys carnegiei*, new species

(Plate 1, figure 11)

The stout, squat, squarish acorn-shaped lorica has a length of 2.5 oral diameters. The oral margin is rounded over, thin, erect, and even. The bowl below is subdivided into three sections. Of these, the first is a basal segment of an inverted cone ( $53^\circ$ ), with a length of 0.54 oral diameter. Its basal diameter is the widest level of the bowl, 1.53 oral diameters. Its sides are regular with a bare tendency toward lateral concavity. The second section is a basal segment of an inverted truncated cone ( $25^\circ$ ) with a length of 0.72 oral diameter. Its aboral diameter is 1.11 oral diameters. Its sides are somewhat flattened and regular. Between the above two conical sections is a broad band with a width of 0.42 oral diameter. Its upper boundary is about 0.26 oral diameter below the oral margin. Its lower boundary contracts more quickly and assumes the contour of the bowl below. This band produces a swollen appearance, and its upper edge separates the bowl into two regions differentiated by wall characters. The lowermost of the three sections of the bowl is a wide, inverted cone ( $80^\circ$ ); its length is 0.42 oral diameter, and is the same as that of the band nearer the oral end

of the bowl. This section has full, convex sides formed by low arcs. It forms an angular junction with the lowest level of the conical subdivision of the bowl above it. The aboral horn is a short, conical peg ( $30^\circ$ ), the length of which is only 0.16 oral diameter.

The wall is thickened in the suboral region and the band. Its greatest thickness in these places is 0.14 oral diameter. In the bowl it is much thinner, being less than 0.04, more or less subuniformly at all levels. The wall is filled with small, irregularly arranged secondary prisms which crowd upon one another so that no two are shaped alike. In the thinner region of the bowl there are fewer layers of prisms than in the superstructure. The outer wall is differentiated into two zones by the patterning. Of these, the anterior one is the narrower band. This begins at the upper edge of the suboral band and continues to the oral margin. It is made up of faint, roughly hexagonal prisms, about 10 in number in a vertical line and approximately 60 in number across the face of the bowl. They increase in size and prominence as they reach the suboral ledge, and an exact plane of division between them and the coarse reticulum below becomes difficult. The coarse surface reticulum which incrusts the posterior 0.85 of the bowl is made up of a prevailing pentagonal to hexagonal meshwork. The nearly uniform framework which surrounds the depressed areas is heavy and thick, and gives the lorica a clumsy appearance. There are 12 to 16 meshes in a vertical line and about 20 to 26 across the bowl. The mesh continues over the basal part of the aboral horn, but the free end is devoid of extra structure. The lumen of the upper bowl is a cylinder with a length of about 0.26 oral diameter. Below this level it is a basal segment of a cone (about  $60^\circ$ ) with a length of nearly 0.26 oral diameter. It then follows the outer contour reasonably closely to the lower end of the bowl. The horn is solid.

Length, bowl 100 $\mu$ , horn 12.5 $\mu$ ; diameter, oral 56.2 $\mu$ , maximum 81 $\mu$ , lower bowl 63 $\mu$ ; wall thickness, 8 $\mu$ .

The shape of the lower bowl varies. Though having a general tendency to be squarish, it may narrow and be more or less conical. Such loricae recall *Epiplocylys semireticulata*. The thickened zone is wider in some loricae than in others, and the inner side of the throat, though typically vertical, may flare outward. The surface reticulations are thicker-walled and coarser in some individuals than in the general run.

*Epiplocylys carnegiei* is close to *E. semireticulata*, but differs from that species in more contracted oral aperture, relatively shorter aboral horn, and less coarse reticulum. Loricae from this collection have greater suboral contraction than the loricae figured by Brandt (1906, pl. 58, fig. 9) and their lower ends are squarish in form; otherwise they are similar. This species differs from *E. acuminata* in its more definitely oblong shape and short horn as well as in its finer and heavier reticulum. The aboral horn of *acuminata* is nearly 0.33 total length in length.

*Epiplocylys semireticulata* was described by Biedermann (1893) and has had a checkered career, which has been summed up by Kofoid and Campbell (1929). In the present report it is considered as distinct from *E. acuminata*, with

which the latest authors have put it. Perhaps Brandt's lorica belongs to *carnegiei* and not to *semireticulata*; the differences may be only minor ones within the limits of a single species.

Recorded from five stations in the Atlantic, as follows: two (3, 4) in the Atlantic drift, and three (14, 15, 16) in the Gulf Stream.

There are 4 pump and 5 net samples, of which 2 were taken at the surface, 3 at 50 meters, and 4 at 100 meters. Maximum frequency, 7 per cent at station 3; other records above minimum (2 to 3 per cent) from station 16; average in net samples, 3.6 per cent.

Temperature: pump samples  $14^\circ 02-24^\circ 81$  ( $20^\circ 52$ ), net samples  $13^\circ 37-23^\circ 64$  ( $16^\circ 35$ ). Salinity: pump samples 35.59-36.48 (36.21), net samples 35.88-36.41 (36.02). Density: pump samples 24.47-26.66 (25.49), net samples 24.84-27.01 (26.40). pH: pump samples 8.06-8.23 (8.16), net samples 8.10-8.23 (8.15).

Type locality, station 3, at 50 meters; latitude  $44^\circ 00'$  north, longitude  $36^\circ 10'$  west.

#### *Epiplocylys constricta* Kofoid and Campbell

*Epiplocylys constricta* Kofoid and Campbell, 1929, p. 177, fig. 333; Marshall, 1934, p. 643.

The fairly short, rotund lorica, with short free lines and narrow aboral horn, has a length of 1.72 oral diameters. The oral margin is thin and rounded. The bowl is distinctly rotund, expanding from the rim ( $12^\circ$ ) for 0.64 total length and reaching 1.09 oral diameters at that level. The aboral part contracts convexly ( $33^\circ$  increasing to  $80^\circ$  posteriorly) and the aboral horn arises from its lowermost end. The horn is conical ( $18^\circ$ ) and nearly 0.55 oral diameter in length, and has a sharp free tip.

The wall has a maximum thickness of 0.07 oral diameter in the suboral region and thins to less than a third as much aborally. There are thin, homogeneous laminae with enclosed tiny alveoles. The reticulated region occupies the aboral half of the bowl, and above that level the free lines arise. The short free lines are deflected ( $15^\circ$  to  $50^\circ$ ) toward the left; the reticulations are thick-walled, subcircular, and often overlapping, and on the upper horn are heavy vertical lines.

Length, 93 to 112 $\mu$ .

*Epiplocylys constricta* has shorter free lines than *E. deflexa*, and no oral flare. In *E. inconspicua* the deflected free lines extend much farther on the wider bowl. Other related species have subvertical free lines.

Recorded from twenty-six stations in the Pacific, as follows: one (54) in the South Pacific middle latitudes, eight (82, 83, 84, 85, 157, 158, 159, 160) in the region of South Pacific island fields, four (100, 109, 140, 150) in the North Pacific trade region, three (113, 142, 145) in the North Pacific middle latitudes, five (137, 146, 147, 148, 149) in the California region, and five (152, 153, 154, 155, 156) in the Pacific equatorial region.

There are 15 pump and 25 net samples, of which 8 were taken at the surface, 16 at 50 meters, and 16 at 100 meters.

Maximum frequency, 64 per cent at station 155; other records above minimum (2 to 44 per cent) from all stations except 54; average in net samples, 15.3 per cent; in pump samples there were 1 to 6 loricae, average 1.7.

Temperature: pump samples  $14^{\circ}32-27^{\circ}73$  ( $24^{\circ}15$ ), net samples  $18^{\circ}74-28^{\circ}60$  ( $25^{\circ}16$ ). Salinity: pump samples 34.50-35.04 (34.77), net samples 34.18-36.49 (34.93). Density: pump samples 22.29-25.75 (23.45), net samples 22.65-25.37 (23.54). pH: pump samples 7.87-8.47 (8.34), net samples 7.93-8.44 (8.28).

#### *Epiplocylix deflexa* Kofoid and Campbell

*Epiplocylix deflexa* Kofoid and Campbell, 1929, p. 178, fig. 334; Marshall, 1934, p. 645, fig. 20.

The moderately large lorica, with convex bowl, conical aboral horn, and strongly deflected free lines, has a length of 1.67 oral diameters. The oral margin is thick, but sharp and erect. The wide bowl increases regularly from the rim to 1.17 oral diameters at 0.5 oral diameter below the rim. The lower bowl is convex conical ( $20^{\circ}$  increasing to  $74^{\circ}$  and then to  $93^{\circ}$ ), being least in its anterior half and gradually wider below. The aboral horn is narrow conical ( $23^{\circ}$ ) with a length of 0.28 oral diameter, and is sharply pointed at its free tip.

The wall is angular in section. Its thickness (maximum 0.14 oral diameter) reduces the cavity to 0.89 oral diameter near 0.17 below the rim, and is gradually reduced by thinning lower down. There are relatively thick laminae with large, rectangular secondary areas; these last, in turn, enclose minute primary alveoles. The reticulated aboral region occupies the lowermost 0.67 oral diameter. The reticulations are large, subcircular, deeply pitted areas. The free lines are strongly deflected to the left (up to  $60^{\circ}$ ) and then extend upward to within the anterior 0.25 of the bowl. On the upper end of the horn there are strong vertical ridges.

Length, 88 to 113 $\mu$ .

The Carnegie material agrees closely with Marshall's.

*Epiplocylix deflexa* resembles *E. constricta*, but the free lines are more strongly deflected and longer, the wall is thicker, with secondary areas, and the horn is not so long. *Epiplocylix pacifica* is longer and more trim, with shorter free lines which are vertical rather than deflected. *Epiplocylix inconspicuata* has a wider (not flattened) bowl with subcylindrical upper section.

Recorded from eleven stations in the Pacific, as follows: four (45, 46, 47, 80) in the Galápagos region, four (48, 82, 85, 95) in the region of South Pacific island fields, two (99, 153) in the Pacific equatorial region, and one (113) in the North Pacific middle latitudes.

There are 2 pump and 12 net samples, of which 3 were taken at the surface, 5 at 50 meters, and 6 at 100 meters. Maximum frequency, 21 per cent at station 47; other records above minimum (2 to 18 per cent) from stations 45, 46, 48, 82, 95, 99, 113, 153; average in net samples, 6.6 per cent.

Temperature: pump samples  $23^{\circ}58-28^{\circ}05$  ( $25^{\circ}81$ ), net samples  $21^{\circ}69-28^{\circ}74$  ( $24^{\circ}45$ ). Salinity: pump samples 34.40-36.21 (35.30), net samples 34.66-36.44 (35.49). Den-

sity: pump samples 21.95-24.70 (23.32), net samples 22.43-24.48 (23.86). pH: pump samples 8.18-8.39 (8.28), net samples 8.12-8.28 (8.19).

#### *Epiplocylix exigua* Kofoid and Campbell

*Epiplocylix exigua* Kofoid and Campbell, 1929, p. 178, fig. 337; Marshall, 1934, p. 643, fig. 17.

The rather small lorica, with subcylindrical upper and conical lower bowl, thickened suboral wall, well reticulated surface, and gradually differentiated aboral horn, has a length of 1.83 oral diameters. The oral margin is thick. The bowl is convex subcylindrical in the anterior 0.65 oral diameter, and conical below ( $53^{\circ}$  in the upper two-thirds and  $80^{\circ}$  in the lower part). The aboral horn is gradually formed, being conical ( $16^{\circ}$ ), with a length of 0.38 oral diameter, and blunt at its free tip.

The wall has a thickness of 0.1 oral diameter in the thickened zone, which occupies the anterior 0.41 oral diameter; its thickness is reduced to a third as much in the remaining part of the bowl. There are rather thick laminae which enclose hyaline material. The reticulated region occupies about 0.75 of the length of the bowl; the reticulations are large, squarish, pitted areas. A few vertical free lines occur, and on the upper end of the horn are upright lines.

Length, 74 to 88 $\mu$ .

This species intergrades in some characters with *Epiplocylix labiosa*, as Marshall (1934) points out, but it may be distinguished by the fuller lower bowl, the more gradually differentiated horn, and the higher level of the reticulated area. Its horn is not so long as that of *E. lata*, and the bowl and horn are less distinct; the reticulated region is typically higher in *lata*.

Recorded from four stations in the Pacific, as follows: one (78) in the Galápagos region, one (83) in the region of South Pacific island fields, one (113) in the North Pacific middle latitudes, and one (136) in the California region.

There are 3 pump samples and 1 net sample, of which 1 was taken at 50 meters and 3 at 100 meters. Frequency, 12 per cent at station 113; other records minimum.

Temperature: pump samples  $18^{\circ}87-27^{\circ}46$  ( $22^{\circ}46$ ), net sample  $21^{\circ}74$ . Salinity: pump samples 35.02-36.49 (35.56), net sample 34.66. Density: pump samples 23.71-25.11 (24.63), net sample 24.06. pH: pump samples 8.14-8.39 (8.25), net sample 8.23.

#### *Epiplocylix exquisita* Kofoid and Campbell

*Epiplocylix exquisita* Kofoid and Campbell, 1929, p. 179, fig. 342.

The moderately tall, wide lorica, with convex subconical bowl, has a length of 1.25 oral diameters. The oral margin is thin and fairly sharp. The bowl is very wide, and convex subconical ( $18^{\circ}$  increasing to  $48^{\circ}$  and then to  $90^{\circ}$ ), the angle being least in the anterior 0.46 oral diameter and greatest in the aboral 0.3 oral diameter. The aboral horn is narrow conical ( $18^{\circ}$ ), and 0.33 oral diameter in length, with a pointed free tip.



The wall has a maximum thickness of 0.04 oral diameter in the anterior part of the bowl, and two-thirds as much in the lower bowl. There are exceedingly thin laminae with enclosed hyaline matter. The anterior half of the bowl is free of markings. The free lines are short, anastomosing, thin, subvertical lines, and the reticulations are large, thick-walled areas of subcircular form. Most of the horn is hyaline.

Length, 93 to 110 $\mu$ .

*Epiplocypris exquisita* has a wider, shorter bowl than *E. blanda*, thinner walls, shorter free lines, and more sharply differentiated horn than *E. undella*, much less rotund bowl than *E. pacifica*, and shorter bowl than *E. impensa*.

Recorded from four stations, one in the Atlantic and three in the Pacific, as follows: one (25) in the Atlantic equatorial region, two (35, 35-36) in the Pacific equatorial region, and one (100) in the North Pacific trade region.

There are 4 net samples, of which 1 was taken at the surface, 2 at 50 meters, and 1 at 100 meters. Frequency, 39 per cent at station 100; 4 to 7 per cent at stations 25, 35-36; average in the Pacific, 21.5 per cent.

Temperature: Atlantic, 14°60; Pacific, 16°30-27°67 (21°98). Salinity: Atlantic, 35.70; Pacific, 34.71-34.88 (34.79). Density: Atlantic, 26.62; Pacific, 22.31-25.60 (23.95). pH: Atlantic, 7.93; Pacific, 7.92-8.21 (8.06).

#### *Epiplocypris impensa* Kofoid and Campbell

*Epiplocypris impensa* Kofoid and Campbell, 1929, p. 180, fig. 343.

The fairly tall, tapering, goblet-shaped lorica, with strong angles, low reticulated region, and thick aboral horn, has a length of 1.44 oral diameters. The oral margin is sharp-edged and erect. The bowl is conical (10°) in the upper 0.56 oral diameter, the diameter at the lower end being 0.93 oral diameter. Below this level it contracts (33° in the upper part increasing to 83° below); the upper part is 0.94 oral diameter in length. The lateral contour of the whole is distinctly angled at important levels of change. The aboral horn is conical (23°), and blunt at the free tip.

The wall reaches a thickness of a little more than 0.06 oral diameter in the suboral region; in the lower bowl it is about half as much, or less. There are thin laminae with enclosed alveoles. The reticulated region occupies about 0.5 oral diameter and the free lines extend subvertically for as much as 0.6 oral diameter. The reticulations are moderately pitted and subpentagonal to hexagonal, and on the horn free vertical lines are continued for 0.75 of its length.

Length, 115 to 126 $\mu$ .

*Epiplocypris impensa* has angled instead of convex lateral contour, and a longer horn and much coarser reticulations than *E. atlantica*, which is otherwise much like it. *Epiplocypris lineata*, its neighbor, is conical, with a long horn and very long free lines. *Epiplocypris blanda* is narrower, with a longer free region and finer reticulations.

Recorded from two stations in the Atlantic, as follows: one (19) in the Sargasso Sea and one (27) in the Atlantic equatorial region.

There are 3 net samples, 2 of which were taken at 50

meters and 1 at 100 meters. Frequency, 8 per cent at station 27.

Temperature, 18°08-26°04 (23°14); salinity, 36.03-37.15 (36.47); density, 23.98-26.06 (24.91); pH, 8.09-8.30 (8.22).

#### *Epiplocypris inconspicuata* Kofoid and Campbell

*Epiplocypris inconspicuata* Kofoid and Campbell, 1929, pp. 180-181, fig. 326.

The short, wide lorica, with conical bowl and narrow free region, has a length of 1.2 oral diameters. The oral margin is sharp-edged. The bowl expands with distinct lateral concavity to a diameter of 1.04 oral diameters near 0.18 oral diameter below the rim. The swollen band has a width of approximately 0.27 oral diameter. The bowl below this lower level contracts (44° increasing to 115°), being least in the anterior 0.38 oral diameter and thence, with sharp angular change, greater. The aboral horn is narrow conical (26°) and only 0.2 oral diameter in length, and has a sharply pointed free tip.

The wall is thickest in the swollen region, where it is over 0.07 oral diameter; lower down in the bowl it is less than a third as much. There are extraordinarily thin laminae which enclose pallid, minute alveoles. There are no free lines, the upper region being 0.15 oral diameter in width. The reticulations are coarse, subequal, deeply pitted, and squarish to rounded.

Length, 72 $\mu$ .

*Epiplocypris inconspicuata* differs from *E. inflata* in having a narrower free region, less suboral thickening, and less width.

Recorded from two stations (65, 67) in the South Pacific middle latitudes, in 2 net samples taken at 100 meters. Frequency, minimum.

Temperature, 15°03-16°36 (15°69); salinity, 34.30-34.70 (34.50); density, 25.44-25.45 (25.445); pH, 8.09-8.10 (8.095).

#### *Epiplocypris inflata* Kofoid and Campbell

*Epiplocypris inflata* Kofoid and Campbell, 1929, p. 181, fig. 329.

The short, distinctly wide lorica, with short free region, has a length of 1.0 oral diameter. The oral margin is thin and sharp. The bowl is subcylindrical in the anterior 0.16 oral diameter, then swollen to a diameter of 1.07 oral diameters within a band 0.22 oral diameter in width, and gradually contracts in the remaining region (50° increasing to 105°), the angle being least in the upper two-thirds of the section. The aboral horn is narrow conical (23°) and only 0.16 oral diameter in length, and has a sharp free tip.

The wall is thickest in the wide band, where it reaches about 0.09 oral diameter; elsewhere it is reduced to a third as much, or less. There are extremely thin laminae, between which are packed minute alveoles. The surface reticulations are lacking in the subcylindrical section. There are a few scattered, subvertical, short free lines, and the reticulations are large subpentagons or hexagons.

Length, 77 to 85 $\mu$ .

*Epiplocylix inflata* is much like *E. laackmanni*, but its horn is shorter and the lower bowl is fuller. It is much wider and relatively shorter, and has a wider free region than *E. calyx*. It only remotely resembles *E. acuminata*, which has a longer bowl and horn and different proportions.

Recorded from station 23 in the Atlantic equatorial region, in a net sample taken at 50 meters. Frequency, 2 per cent.

Temperature, 20°99; salinity, 36.04; density, 25.30; pH, 8.14.

#### *Epiplocylix labiosa* Kofoid and Campbell

(Figure 74)

*Epiplocylix labiosa* Kofoid and Campbell, 1929, p. 182, fig. 338.

The subconical, rather elongated lorica, with short reticulated region and thick suboral area, has a length of 1.87 oral diameters. The oral margin is thin and erect. The acorn-shaped bowl expands (45°) to 1.17 oral diameters at 0.22 oral diameter below the rim and then contracts below the thickened zone (0.38 oral diameter in width) as a segment of inverted flat-sided cone (30°) with a length of 0.43 oral diameter; its diameter at the lower end is 0.81 oral diameter. Below this section the bowl becomes more widely conical (73°), and the diameter at the truncate lower end is only 0.16 oral diameter. The aboral horn is 0.54 oral diameter in length and narrow conical (15°). Its free tip is sharp.

The wall has a thickness of 0.16 oral diameter in the thickened suboral zone, but elsewhere is reduced to three-tenths as much. There are extremely thin laminae, which enclose many layers of very small alveoles. The reticulated region is deeply pitted and coarse, and covers the lowermost conical section of the bowl; above it is a faint network of large, virtually hexagonal areas which reach to just below the thick suboral region; the vertical lines of the mesh are stronger than the horizontal ones.

Length, 73 to 85 $\mu$ .

The *Carnegie* loricae are shorter and have a finer mesh than is usual for this species.

*Epiplocylix labiosa* is longer and narrower, with a shorter free zone and a thicker suboral band than *E. calyx*. *Epiplocylix exigua* is shorter and wider and has a lower zone of reticulations. *Epiplocylix lata* has a more cylindrical upper bowl, wider aboral cone, and even coarser reticulum.

Recorded from thirty stations, ten in the Atlantic and twenty in the Pacific, as follows: four (19, 20, 20-21, 21) in the Sargasso Sea, six (22, 23, 24, 25, 29, 30) in the Atlantic equatorial region, four (82, 85, 87, 93) in the region of South Pacific island fields, ten (100, 101, 102, 103, 104, 105, 106, 107, 150, 151) in the North Pacific trade region, four (137, 147, 148, 149) in the California region, and two (153, 154) in the Pacific equatorial region.

There are 26 pump and 20 net samples, of which 15 were taken at the surface, 17 at 50 meters, and 14 at 100 meters. Maximum frequency, 6 per cent at station 21; other records above minimum (2 to 3 per cent) from stations 19, 22, 137, 153, 154; averages, 1.6 and 1.7 per cent in Atlantic and Pacific net samples; none of the pump samples had more than 3 loricae.

Temperature: Atlantic, pump samples 14°60-27°56 (22°79), net samples 14°60-27°88 (23°02); Pacific, 18°28-25°81 (22°15) and 23°15-28°74 (25°95), respectively. Salinity: Atlantic, pump samples 35.70-36.21 (35.80), net samples 35.70-37.15 (36.29); Pacific, 34.39-36.32 (35.16) and 34.42-35.12 (34.81), respectively. Density: Atlantic, pump samples 23.36-26.62 (24.65), net samples 23.26-26.62 (24.73); Pacific, 21.95-24.26 (23.26) and 22.98-24.77 (24.03), respectively. pH: Atlantic, pump samples 7.93-8.31 (8.17), net samples 7.93-8.37 (8.21); Pacific, 8.21-8.34 (8.26) and 7.93-8.38 (8.23), respectively.

#### *Epiplocylix lata* Kofoid and Campbell

(Figure 78)

*Epiplocylix lata* Kofoid and Campbell, 1929, p. 182, fig. 336.

The short lorica, with greatly thickened suboral band and abruptly contracted aboral end, has a length of 2.2 oral diameters. The oral rim is the rounded edge of the thickened suboral region. The bowl expands rapidly (55°) for 0.24 oral diameter to 1.07 oral diameters. Below this level it tapers (14°) for 1.0 oral diameter, the diameter at the lower end being 0.92 oral diameter. The aboral region is convex conical (80°) for about 0.5 oral diameter. At its lower end is the sharply pointed, conical (16°) aboral horn, the length of which is 0.6 oral diameter.

The wall thickens to 0.16 oral diameter in the suboral region (the width of the band reaches 0.52 oral diameter), and is elsewhere less than three-tenths as much. The reticulated area extends to a little below the thickened zone and is made up of large rectangular to pentagonal areas; some are even subcircular, and all are deeply pitted. The horn has long vertical ridges on its upper part.

Length, 82 to 110 $\mu$ .

A few of the *Carnegie* loricae are longer than is usual for this species.

*Epiplocylix lata* is more abruptly rounded aborally and its aboral horn, which is distinctly spinelike, is set off more suddenly from the lower bowl than in *E. calyx*, *E. exigua*, or *E. labiosa*. In the *Carnegie* collection it is not easily distinguished from *labiosa*.

Recorded from fourteen stations in the Pacific, as follows: six (45, 46, 47, 75, 78, 80) in the Galápagos region, four (48, 82, 84, 85) in the region of South Pacific island fields, and four (54, 61, 64, 65) in the South Pacific middle latitudes.

There are 7 pump and 16 net samples, of which 7 were taken at the surface, 11 at 50 meters, and 5 at 100 meters. Maximum frequency, 44 per cent at station 45; other records above minimum (2 to 5 per cent) from stations 46, 47, 48, 54, 82, 84, 85; average in net samples, 7.9 per cent; in pump samples there were 1 to 33 loricae, average 10.8.

Temperature: pump samples 14°03-23°30 (20°82), net samples 10°92-27°89 (22°23). Salinity: pump samples 33.96-35.96 (35.09), net samples 34.05-36.44 (35.55). Density: pump samples 24.11-25.40 (24.52), net samples 23.38-26.06 (25.23). pH: pump samples 8.05-8.16 (8.13), net samples 8.03-8.23 (8.15).

***Epiplocypris mucronata* (Zacharias) Kofoid and Campbell**

(Figures 75, 76)

*Epiplocypris mucronata*, Kofoid and Campbell, 1929, p. 183, fig. 346.

The tall, conical lorica, with gradually differentiated aboral horn and wide free region, has a length of 2.00 to 2.92 oral diameters. The oral margin is sharp-edged. The long bowl tapers as much as  $10^\circ$  for 1.2 oral diameters and shows some lateral convexity. The lower bowl contracts ( $45^\circ$  to  $65^\circ$ ) for 1.13 oral diameters, the change in diameter between upper and lower bowls being gradual. The aboral horn is gradually differentiated out of the lower bowl, is conical ( $22^\circ$  to  $30^\circ$ ), and has a length of 0.16 to 0.30 oral diameter; its free tip is sharp.

The wall reaches a maximum thickness of 0.1 oral diameter suborally; elsewhere it is reduced to less than one-fifth as much. The laminae, with enclosed alveoles, are thin. The upper bowl is entirely free of lines; subvertical, thick, and unbranched free lines creep to its lower edge from the reticulated region below. The reticulations are coarse, thick-walled, heavy, and not deeply pitted, and on the horn are extended as heavy vertical ridges.

Length, 175 to 185 $\mu$ .

The *Carnegie* loricae are much more gradually contracted at the transition of lower bowl and horn than is typical; there are also strong free lines.

*Epiplocypris mucronata* differs from *E. obtusa*, in which there is a saccular bowl and short, wide horn. It differs from *E. blanda* in larger size, more taper, and heavier reticulum. *Epiplocypris sargassensis* is generally more conical and wider in the aboral region. *Epiplocypris acuminata* has a wider suboral thickening and spikelike horn, as well as different mesh.

Recorded from six stations, three each in the Atlantic and the Pacific, as follows: two (28, 29) in the Atlantic equatorial region, one (31) in the Caribbean Sea, one (47) in the Galápagos region, and two (64, 65) in the South Pacific middle latitudes.

There are 8 net samples, of which 2 were taken at the surface, 1 at 50 meters, 4 at 100 meters, and 1 at 1000 meters. Maximum frequency, 54 per cent at station 47; other records above minimum (2 to 3 per cent) from stations 28, 31, 65; average in Pacific, 14.7 per cent.

Temperature: Atlantic,  $22^\circ 56' - 26^\circ 79'$  ( $23^\circ 94'$ ); Pacific,  $3^\circ 98' - 23^\circ 88'$  ( $15^\circ 87'$ ). Salinity: Atlantic, 36.31–36.63 (36.51); Pacific, 34.30–35.96 (34.79). Density: Atlantic, 23.79–25.22 (24.80); Pacific, 24.33–27.23 (25.36). pH: Atlantic, 8.19–8.26 (8.22); Pacific, 7.76–8.23 (8.06).

***Epiplocypris pacifica* Kofoid and Campbell***Epiplocypris pacifica* Kofoid and Campbell, 1929, p. 184, fig. 335.

The fairly tall lorica, with moderately convex conical bowl, short free lines, and long aboral horn, has a length of 1.83 oral diameters. The oral margin is thin and erect. The bowl expands from the margin to 1.08 oral diameters at 0.3 oral diameter below the rim, and gradually contracts ( $20^\circ$

then  $80^\circ$  in the aboral 0.5 oral diameter) to the aboral end. The aboral horn is narrow conical ( $12^\circ$ ), nearly 0.46 oral diameter in length, and sharply pointed at its free tip.

The wall reaches a thickness of 0.09 oral diameter across the thickest part, which is within a band 0.67 oral diameter in width; the lower parts of the bowl are less than a third as much. The upper region of the bowl, corresponding to the thickened zone in width, is free of reticulations. The reticulations of the lower region are large, commonly sub-pentagonal, with thick walls, and modestly pitted, and have short, unbranched, deflected ( $20^\circ$ ) free lines.

Length, 105 to 115 $\mu$ .

*Epiplocypris pacifica* resembles *E. constricta*, but its bowl is decidedly less convex, its horn is longer, and the free lines are much shorter and less oblique. In general form it is close to *E. lata*, but it is obviously different in the more diffuse suboral thickening, and in the character of the reticulum and its distribution. In some ways it is like *E. undella*, but it is less wide, with more sharply differentiated horn, and with shorter, deflected free lines.

Recorded from sixteen stations in the Pacific, as follows: three (35, 36, 99) in the Pacific equatorial region, one (62) in the South Pacific middle latitudes, two (77, 78) in the Galápagos region, four (81, 82, 83, 159) in the region of South Pacific island fields, three (101, 102, 103) in the North Pacific trade region, and three (133, 134, 137) in the California region.

There are 15 pump and 7 net samples, of which 11 were taken at the surface, 5 at 50 meters, and 6 at 100 meters. Maximum frequency, 7 per cent at station 77; other records above minimum (2 to 5 per cent) from stations 78, 159; average in net samples, 3.1 per cent; in pump samples there were 1 to 4 loricae.

Temperature: pump samples  $13^\circ 28' - 27^\circ 93'$  ( $24^\circ 47'$ ), net samples  $14^\circ 33' - 28^\circ 60'$  ( $24^\circ 80'$ ). Salinity: pump samples 31.62–36.49 (34.98), net samples 34.91–36.03 (35.70). Density: pump samples 20.34–24.98 (22.77), net samples 22.77–26.06 (23.79). pH: pump samples 8.06–8.39 (8.25), net samples 7.88–8.37 (8.18).

***Epiplocypris sargassensis* (Brandt) Kofoid and Campbell***Epiplocypris sargassensis*, Kofoid and Campbell, 1929, p. 185, fig. 331.

The moderately elongated, generally conical lorica, with full aboral region and broad horn and lacking free lines, has a length of 1.6 oral diameters. The oral margin is thin and rounded. The bowl tapers ( $16^\circ$ ) in its upper 0.52, the diameter at the lower end of this upper section being 0.5 oral diameter. The lower bowl is subconical ( $55^\circ$ ), and from its lower end the aboral horn is gradually differentiated; this latter becomes narrow conical ( $20^\circ$ ), its length is 0.26 oral diameter, and its free tip is blunted.

The wall reaches as much as 0.03 oral diameter at its thickest, which is near the oral rim. In the middle and lower bowl it is about two-thirds as much. There are thin laminae and enclosed minute alveoles. There are no free lines, but the reticulated region occupies the lower 0.83 oral

diameter. The reticulations are subcircles, large and heavy-walled, and smaller circles occur with the large ones. On the upper horn are heavy vertical lines. All the reticulations are deeply pitted.

Length, 130 $\mu$ .

*Epiplocylius sargassensis* has a fuller lower bowl and shorter horn than *E. mucronata*; it also has no free lines. It differs from *E. blanda* in similar respects. It has a less baggy bowl and longer horn than the peculiar species *E. obtusa*.

Recorded from twenty stations, nine in the Atlantic and eleven in the Pacific, as follows: three (19, 20, 21) in the Sargasso Sea, four (23, 28, 29, 30) in the Atlantic equatorial region, two (31, 34) in the Caribbean Sea, seven (134, 135, 136, 146, 147, 148, 149) in the California region, two (144, 145) in the North Pacific middle latitudes, and two (150, 151) in the North Pacific trade region.

There are 5 pump and 18 net samples, of which 2 were taken at the surface, 4 at 50 meters, and 17 at 100 meters. Maximum frequency, 13 per cent at station 29; other records above minimum (2 to 12 per cent) from stations 20, 21, 28, 30, 31, 34, 136, 146, 147, 149, 151; averages in net samples 6.8 and 4 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, net samples 20°09–27°88 (24°19); Pacific, net samples 18°87–25°95 (20°56), pump samples 16°58–19°16 (18°06). Salinity: Atlantic, net samples 36.04–37.05 (36.45); Pacific, net samples 34.02–35.04 (34.70), pump samples 34.32–34.88 (34.62). Density: Atlantic, net samples 23.26–25.76 (24.67); Pacific, net samples 22.34–25.09 (24.38), pump samples 24.48–25.11 (24.90). pH: Atlantic, net samples 8.14–8.32 (8.22); Pacific, net samples 8.26–8.39 (8.32), pump samples 8.31–8.37 (8.34).

*Epiplocylius undella* (Ostenfeld and Schmidt) Jørgensen  
emended Kofoid and Campbell

(Figures 71, 77)

*Epiplocylius undella*, Kofoid and Campbell, 1929, p. 185, fig. 345; Marshall, 1934, p. 645, fig. 18.

The rather large, wide lorica, with conical aboral end, tapering horn, short reticulated zone, and short free lines, has a length of 2.06 to 2.28 oral diameters. The oral margin is thin, rounded, and angular. The bowl is usually cylindrical in the anterior 1.0 oral diameter, with a diameter of as much as 1.23 oral diameter at the lower end in unusually swollen individuals. The lower bowl is distinctly convex conical (72° to 80°). The aboral horn tapers (16° to 18°), is sharply pointed, and has a length of 0.50 to 0.53 oral diameter.

The wall is relatively thick, reaching 0.11 oral diameter through the upper anterior bowl, and gradually becoming less than half as much lower down. There are thick laminae which enclose small, circular alveoles in two to five layers. The upper 1.0 oral diameter is free of lines and reticulations. The reticulated zone occupies approximately the lower two-thirds of the lower bowl, and the free lines, on occasion, reach the lower end of the upper bowl. The reticulations are subcircular, rather large, in 4 or more rows, and deeply

pitted. The free lines are subvertical, relatively few, and mostly unbranched.

Length, 103 to 180 $\mu$ .

The *Carnegie* loricae are longer (168 to 180 $\mu$ ) than usual (as low as 103 $\mu$ ), with convex sides and swelling, and with thick laminae.

*Epiplocylius undella* resembles *E. blanda* in general shape, but may be distinguished by the much shorter upper region in which there are no free lines; it is generally wider. *Epiplocylius mucronata* has a very much longer bowl and coarser reticulations.

Recorded from seventy-six stations, nineteen in the Atlantic and fifty-seven in the Pacific, as follows: two (15, 16) in the Gulf Stream, six (17, 18, 19, 20, 20-21, 21) in the Sargasso Sea, nine (22, 23, 24, 25, 26, 27, 28, 29, 30) in the Atlantic equatorial region, two (33, 34) in the Caribbean Sea, seven (37, 38, 99, 152, 153, 155, 156) in the Pacific equatorial region, nine (45, 46, 47, 69, 70, 71, 77, 78, 80) in the Galápagos region, five (62, 62-63, 65, 66, 67) in the South Pacific middle latitudes, seventeen (81, 82, 84, 85, 86, 89, 90, 91, 92, 93, 95, 96, 97, 157, 158, 159, 160) in the region of South Pacific island fields, nine (100, 101, 105, 107, 109, 139, 140, 150, 151) in the North Pacific trade region, eight (131, 133, 134, 135, 136, 137, 146, 148) in the California region, and two (142, 145) in the North Pacific middle latitudes. *Epiplocylius undella* and *Eutintinnus lusus-undae* are perhaps the most abundant species of Tintinnoina in the warmer regions of the ocean; either may be expected in almost any plankton catch in tropical waters.

There are 84 pump and 64 net samples, of which 42 were taken at the surface, 48 at 50 meters, and 58 at 100 meters. Maximum frequency, 98 per cent at station 140; other records above minimum (2 to 78 per cent) from stations 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 29, 33, 38, 46, 67, 69, 70, 81, 85, 95, 99, 109, 131, 137, 145, 148, 150, 151, 152, 155, 156, 157, 158, 159, 160; averages in net samples, 7.1 and 17.1 per cent in the Atlantic and Pacific, respectively; in pump samples there were 1 to 12 loricae; average in the Pacific, 2.

Temperature: Atlantic, pump samples 14°60–27°88 (22°23), net samples 18°08–37°18 (24°90); Pacific, 14°77–29°21 (24°40) and 11°48–28°74 (23°70), respectively. Salinity: Atlantic, pump samples 35.61–37.15 (36.00), net samples 35.22–37.15 (36.26); Pacific, 33.68–36.46 (35.01) and 31.68–36.42 (34.72), respectively. Density: Atlantic, pump samples 23.26–26.62 (25.65), net samples 22.84–26.07 (24.81); Pacific, 21.60–25.91 (23.99) and 20.20–26.50 (23.60), respectively. pH: Atlantic, pump samples 7.93–8.28 (8.18), net samples 8.09–8.32 (8.24); Pacific, 7.86–8.47 (8.28) and 7.68–8.39 (8.23), respectively.

*EPIORELLA* Kofoid and Campbell

*Epiorella* Kofoid and Campbell, 1939, p. 134.

*Epiorella* includes species which were formerly included in *Epiplocylius*, but which have a collar. Kofoid and Campbell (1939) define these as a new genus. *Epiorella* evidently arose from *Epiplocylius* by the addition of the collar, as *Codonaria* arose from *Codonella*.

*Epiorella* frequently occurs in cooler waters than does *Epiplocyilis*, often, in the tropics, being in deep water at lower than surface temperatures. It frequently occurs in dense swarms where nearly all the Tintinnoina are of one species.

Four species are described here.

#### *Epiorella acuta* Kofoid and Campbell

*Epiplocyilis acuta* Kofoid and Campbell, 1929, pp. 175-176, fig. 322.

The short, distinctly subconical lorica, with free lines on the upper half, has a length of 1.6 oral diameters. The low suboral cuff surrounds the oral rim. The cup flares ( $87^\circ$ ) within the anterior 0.1 oral diameter, and its free edge forms a ledge with a diameter of 1.22 oral diameters; a trough separates cuff and ledge. The cup tapers ( $7^\circ$ ) in the upper half and then becomes convex conical ( $65^\circ$ ); the diameter at the level of change is 0.89 oral diameter. The aboral horn is short (0.22 oral diameter), conical ( $25^\circ$ ), and sharply pointed.

The thin wall (0.02 oral diameter) has laminae with enclosed small alveoles. The cuff is hyaline, the ledge and cup denser. The upper bowl (0.45 total length) has 64 free lines, which are commonly interrupted, anastomosed, and generally vertical. The lower section has large pentagonal areas with heavy walls and sunken enclosures.

Length, 72 $\mu$ .

*Epiorella acuta* resembles most closely *E. valumensis*, but it has a region of free lines well differentiated, whereas *valumensis* has a fully reticulated surface. The aboral end and horn are longer in *valumensis*. *Epiorella curta* is also conical, but has scarcely any horn.

Recorded from nineteen stations in the Pacific, as follows: two (36, 38) in the Pacific equatorial region, thirteen (40, 41, 42, 43, 44, 45, 46, 69, 70, 71, 72, 74, 77) in the Galápagos region, two (49, 85) in the region of South Pacific island fields, one (108) in the North Pacific trade region, and one (113) in the North Pacific middle latitudes.

There are 22 pump and 15 net samples, of which 14 were taken at the surface, 12 at 50 meters, and 11 at 100 meters. Maximum frequency, 54 per cent at station 70; other records above minimum (2 to 10 per cent) from stations 38, 40, 41, 42, 69, 71, 74, 113; average in net samples, 8.9 per cent; in pump samples there were 1 to 128 loricae, average 9.8.

Temperature: pump samples  $12^\circ 73$ - $26^\circ 54$  ( $19^\circ 80$ ), net samples  $14^\circ 55$ - $27^\circ 94$  ( $20^\circ 24$ ). Salinity: pump samples 31.62-36.17 (35.49), net samples 32.88-36.25 (34.99). Density: pump samples 20.34-26.28 (23.08), net samples 21.31-26.28 (24.63). pH: pump samples 7.85-8.25 (8.04), net samples 7.68-8.89 (8.10).

#### *Epiorella brandti* Kofoid and Campbell

*Epiplocyilis brandti* Kofoid and Campbell, 1929, p. 177, fig. 324.

The short, rather stout, wide lorica, with free lines limited to the upper third, has a length of 1.18 oral diameters. The erect suboral cuff surrounds the thin oral rim. The cup

flares ( $70^\circ$ ) with a narrow ledge the diameter of which is 1.11 oral diameters. It is separated from the cuff by a shallow trough. The lower part of the cup is convex conical ( $18^\circ$  in the anterior half and increasing from  $60^\circ$  to  $100^\circ$  in the lower section). The aboral horn is short (0.1 oral diameter) and conical ( $18^\circ$ ), and its free tip is sharp.

The suboral cuff is finely reticulated with minute primary alveoles, the ledge is dense, and the cup proper translucent. The wall is 0.02 oral diameter in thickness across the cup. The free lines are about 30 in number, but some anastomose and all are more or less crooked in course. The lower two-thirds of the cup is reticulated, as is the horn, with large, prevailingly pentagonal meshes, the walls of which are raised above the enclosed material. The horn, as in other species, is solid.

Length, 59 to 70 $\mu$ .

*Epiorella brandti* has free lines and a less saccular bowl than *E. reticulata*. Its bowl is not so definitely conical nor its horn so long as in *E. acuta* or *E. valumensis*. None of the species in this collection resembles *E. freymadli* of the Indian Ocean.

Recorded from twelve stations in the Atlantic, as follows: two (2, 16) in the Gulf Stream, two (17, 18) in the Sargasso Sea, six (22, 23, 24, 25, 26, 27) in the Atlantic equatorial region, and two (31, 33) in the Caribbean Sea.

There are 5 pump and 13 net samples, of which 1 was taken at the surface, 9 at 50 meters, and 8 at 100 meters. Frequency, 2 per cent at stations 2, 17, 18, 26, 27; other records all minimum; averages, 1.2 loricae and 1.6 per cent in pump and net samples, respectively.

Temperature: pump samples  $23^\circ 12$ - $28^\circ 25$  ( $25^\circ 73$ ), net samples  $14^\circ 60$ - $26^\circ 04$  ( $20^\circ 73$ ). Salinity: pump samples 35.90-36.25 (36.09), net samples 35.70-36.81 (36.39). Density: pump samples 23.23-24.67 (23.94), net samples 23.98-26.07 (25.55). pH: pump samples 8.14-8.30 (8.22), net samples 7.93-8.30 (8.26).

#### *Epiorella curta* Kofoid and Campbell

*Epiplocyilis curta* Kofoid and Campbell, 1929, p. 178, fig. 319.

The short, saccular lorica, with clear-cut free lines on the upper half, has a length of 1.73 oral diameters. The thin oral margin is surrounded by the low, incurved suboral cuff. The cup or bowl flares ( $30^\circ$ ) within the anterior 0.14 oral diameter, and its diameter at the free end is nearly 1.2 oral diameters. It is separated from the cuff by a shallow trough. The section below has a length of 0.91 oral diameter and its diameter at the lower end is 1.09 oral diameters. The lower end of the bowl is subhemispherical ( $87^\circ$ ), with very full, distinctly convex sides. The short (0.18 oral diameter), conical ( $40^\circ$ ) aboral horn is sharply pointed.

The cuff is hyaline, and the bowl, especially around the flaring region, is denser. The wall has a thickness of 0.02 oral diameter or less. The upper half has about 40 longitudinal, commonly anastomosing free lines, and the lower bowl has an irregular meshwork of prevailingly pentagonal deep areas, as does also the horn.

Length, 76 $\mu$ .

The *Carnegie* loricae are more saccular aborally than is usual for the species.

*Epiorella curta* is more elongate and has less regular free lines than *E. brandti*. The free lines are longer than those of *E. reticulata*, and the aboral region is more conical than in *E. healdi*.

Recorded from two stations (41, 42) in the Galápagos region.

There are 3 net samples, 1 taken at the surface and 2 at 100 meters. Frequency, 22 per cent at station 41 at the surface; 8 per cent at station 41, and 18 per cent at station 42, both at 100 meters; average, 16 per cent.

Temperature, 14°33–20°42 (16°43); salinity, 34.19–35.04 (34.75); density, 24.06–26.17 (25.44); pH, 7.91–8.11 (7.98).

#### *Epiorella healdi* Kofoid and Campbell

(Figure 79)

*Epirocylis healdi* Kofoid and Campbell, 1929, p. 180, fig. 321; Marshall, 1934, p. 643, fig. 16.

The small, cup-shaped lorica, with many free lines on the upper two-thirds of the bowl, has a length of 1.5 oral diameters. The low, faintly crenulated suboral cuff is a low cylinder and surrounds the oral margin. The cuff is separated from the cup below by a shallow trough. The cup or bowl proper flares (50°) for a distance of about 0.13 oral diameter, and its free margin is 1.13 oral diameters in diameter. The lower part tapers (19°) for a distance of approximately 0.66 total length, the diameter at the lower end being nearly 0.83 oral diameter. The posterior section is narrow oval, increasing from 42° in its upper part to 100° in the lower. At the aboral end is a short (0.2 oral diameter), conical (17°) horn with a blunt free tip.

The wall is thin, hardly exceeding 0.02 oral diameter in the cup. The cuff is hyaline and the bowl only a little denser. The upper two-thirds of the bowl has subvertical, frequently anastomosing free lines, which reach right to the free edge of the suboral flare. The posterior third is heavily reticulated with large, deep pentagonal to hexagonal areas, as is also the horn.

Length, 71 $\mu$ .

The *Carnegie* specimens have more free lines (22 to 28) than the loricae recorded by Marshall (1934), and conform to type in shape more closely than these last. The one figured here (fig. 79) is typical of the species. Perhaps Marshall's are of another, undifferentiated species.

*Epiorella healdi* has long free lines on the upper bowl, unlike *E. reticulata*. There is in this respect no intergradation. The lorica is also less wide and less full aborally. Its aboral end is less conical than that of *E. curta*, but not so sharply pointed as in *E. ralumensis* or *E. acuta*. *Epiorella brandti* is generally more conical and has much shorter free lines.

Recorded from seven stations (40, 41, 42, 43, 71, 72, 73) in the Galápagos region.

There are 10 pump and 4 net samples, of which 5 were taken at the surface, 5 at 50 meters, and 4 at 100 meters.

Maximum frequency, 53 per cent at station 40; other records above minimum (2 to 29 per cent) from stations 41, 42, 43, 71, 72, 73; averages, 4.6 loricae and 31.7 per cent in pump and net samples, respectively.

Temperature: pump samples 14°55–25°27 (19°65), net samples 14°33–20°92 (16°28). Salinity: pump samples 34.80–35.42 (35.17), net samples 34.19–35.04 (34.78). Density: pump samples 23.60–26.11 (24.95), net samples 24.06–26.51 (25.54). pH: pump samples 7.92–8.21 (8.05), net samples 7.91–8.11 (7.95).

#### EPICANCELLA Kofoid and Campbell

*Epicancella* Kofoid and Campbell, 1929, p. 173.

*Epicancella* has dominant vertical and distinct horizontal bars and ribs, the horizontal elements being supplementary to the vertical structures. Relationship to *Rhabdonella* on the one hand, and to *Epirocylis* on the other, is indicated; the genus may have arisen from the latter.

*Epicancella* occurs in warm, tropical oceans.

There is but one species.

#### *Epicancella nervosa* (Cleve) Kofoid and Campbell

*Epicancella nervosa*, Kofoid and Campbell, 1929, p. 173, fig. 318.

The transparent, conical lorica has a recurved lip, and raised lattice work on the surface; its length is 1.6 oral diameters. The oral margin is thin and the hyaline collar below it spreads from its base, forming a cuff with a width of considerably less than 0.1 oral diameter. The conical bowl forms a flattened shoulder below the cuff, which shoulder rounds over and decreases regularly in diameter; its diameter, at the widest part of the shoulder, is 1.17 oral diameters. The bowl is a narrow cone (6°) in the anterior half, and then a wider one (52°) in the lower section. Its sides are full, and the bowl as a whole is decidedly convex. The aboral end is pointed but not prolonged or otherwise modified.

The surface of the lorica is strikingly unique. The cuff is glass-clear, and the shoulder region is alveolar with more or less rounded pentagons of mixed sizes. The remaining part of the bowl has 16 to 18 subvertical or slightly left-wound ribs, possibly correlated in their number with the number of membranelles. These ribs are ridges, and they branch horizontally so that each interface between two ribs has 14 to 17 crossbars. These crossbars may rarely branch again with small vertical ridges, especially near the equatorial region of the bowl. The crossbars and their ridges are never so conspicuous as the vertical ribs. The whole lorica is almost transparent, and not easy to see in a brightly illuminated microfield save as the ribs are darker than the general outline of the bowl; the denser shoulder region is in contrast with the rest of the bowl. The cavity follows the outer contour, and the wall is exceedingly thin.

Length, 80 to 82 $\mu$ .

*Epicancella nervosa* is so definitely unique among the Tin-

tinnoina that confusion with other species is unlikely. The dominant vertical ribs suggest relationship with *Rhabdonella*, but horizontal crossbars are not developed in that genus, although anastomoses of vertical ribs suggest a tendency toward their definite differentiation. From any species of *Epiplocyis*, *E. nervosa* differs in that the vertical ribs extend the whole length of the bowl, and none of the members of that genus have crossbars.

Recorded from thirty stations, seven in the Atlantic and twenty-three in the Pacific, as follows: five (17, 18, 19, 20, 21) in the Sargasso Sea, two (28, 29) in the Atlantic equatorial region, one (45) in the Galápagos region, four (52, 54, 63, 64) in the South Pacific middle latitudes, two (83, 84) in the region of South Pacific island fields, eight (133, 134, 135, 136, 137, 146, 147, 148) in the California region, four (138, 139, 140, 150) in the North Pacific trade region, and four (141, 142, 144, 145) in the North Pacific middle latitudes.

There are 29 pump and 12 net samples, of which 3 were taken at the surface, 14 at 50 meters, 23 at 100 meters, and 1 at 150 meters. Maximum frequency, 8 per cent at stations 136, 144; other records above minimum (2 to 6 per cent) from stations 18, 19, 20, 21, 54, 64, 133, 135, 141, 142, 145, 147, 148; averages, 2.6 and 2.1 loricae in Atlantic and Pacific pump samples, and 1.7 and 2.6 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump samples 20°32–27°11 (22°78), net samples 20°32–26°79 (23°15); Pacific, 14°73–27°46 (18°94) and 18°74–20°07 (19°31), respectively. Salinity: Atlantic, pump samples 36.22–36.81 (36.59), net samples 36.31–37.15 (36.73); Pacific, 34.27–36.49 (34.96) and 34.32–35.40 (34.90), respectively. Density: Atlantic, pump samples 23.62–26.07 (25.18), net samples 23.79–26.07 (25.20); Pacific, 22.90–25.48 (24.53) and 24.24–25.37 (24.88), respectively. pH: Atlantic, pump samples 8.20–8.29 (8.23), net samples 8.19–8.27 (8.24); Pacific, 8.07–8.39 (8.26) and 8.16–8.39 (8.27), respectively.

#### XYSTONELLIDAE Kofoid and Campbell

Xystonellidae Kofoid and Campbell, 1929, p. 225.

Included in this family are four genera: *Parafavella*, *Xystonellopsis*, *Parundella*, and *Xystonella*. All four are present in the material of this expedition. The family is widely spread in most seas except the Antarctic.

#### PARAFAVELLA Kofoid and Campbell

*Parafavella* Kofoid and Campbell, 1929, pp. 157–158.

*Parafavella* is one of the most interesting genera of the Tintinnoina in extent of speciation and extraordinary numbers of individuals; the latter fact offers extensive opportunity for statistical investigation on a quantitative basis, which should at some time be undertaken in special memoirs. The geographical distribution of the genus is no less interesting. Limited to regions of low temperature and never ex-

tending far below about latitude 45° north, *Parafavella* offers opportunity for study of the effects of latitude and temperature on evolution. Certain species are limited to the Pacific, and others to the North Atlantic. Only battered specimens extend the range south of the arctic regions, where the genus reaches its greatest development in numbers and kinds; perhaps polar seas will reveal yet more when these are more closely examined.

Eleven species are described here, of which one is new, and another is designated by a new name.

#### *Parafavella affinis*, new species

(Plate 1, figure 5)

The lorica is bell-shaped, rather stout, and 2.05 oral diameters in length. The oral margin carries a crown of about 26 sharp, spikelike teeth; these spread outward at about 60° from the horizontal, and are evenly spaced, narrow, and rounded in section. The conical bowl (30°) may be subdivided into two regions. The anterior section has a length of 1.1 oral diameters; it is an inverted truncated cone (12°), and the diameter at the aboral, truncated end is 0.74 oral diameter; the sides are full, distinct arcs. The aboral subdivision has as its base the lower end of the section above it; it is conical (45°), with full sides, and is 0.85 oral diameter in length. The aboral end is the simple, sharp end of this cone, and lacks special differentiation.

The wall is evenly and smoothly contoured, with not the slightest trace of irregularity. It is uniformly less than 0.03 oral diameter in thickness. It has, in section, typical secondary prisms in a single layer enclosed by laminae. The surface has subuniform hexagons at all levels, except near the aboral tip and in the teeth. The cavity follows the contour exactly.

Length, 107 $\mu$ ; oral diameter, 52 $\mu$ .

*Parafavella affinis* resembles *P. pacifica* closely in general form, but has a less elongated upper bowl and fewer teeth (26 as against 32 to 42). It bears some likeness to *P. acuminata*, but its margins bear teeth, and there is a less sharp distinction between upper and lower bowls. *Parafavella acuminata* is figured by Kofoid and Campbell (1929) as *P. greenlandica*.

Recorded from ten adjacent stations in the Pacific, as follows: two (117, 126) in the North Pacific middle latitudes, six (118, 119, 120, 121, 122, 123) in the East Asiatic marginal sea, and two (124, 125) in the Alaskan secondary region.

There are 25 pump and 14 net samples, of which 13 were taken at the surface, 14 at 50 meters, and 12 at 100 meters. *Parafavella affinis* occurs equally at all levels examined. Frequency, 80 per cent at station 124, at the surface; 500 loricae counted in the pump sample at station 119, at 50 meters; all records, except that at station 118, above minimum (2 to 28 per cent); average in net samples, 22.7 per cent; in pump samples, 52 loricae (1 to 500).

Temperature: pump samples 2°01–12°56 (6°21), net samples 2°01–8°22 (5°10). Salinity: pump samples 32.63–

34.22 (33.03), net samples 32.70-33.69 (33.14). Density: pump samples 24.90-26.52 (25.44), net samples 25.74-26.76 (26.09). pH: pump samples 7.85-8.21 (7.86), net samples 7.64-8.03 (7.70).

Type locality, station 121, at 50 meters; latitude  $46^{\circ} 05'$  north, longitude  $171^{\circ} 32'$  east.

*Parafavella cylindrica* (Jørgensen) Kofoid and Campbell

(Figure 51)

*Parafavella cylindrica*, Kofoid and Campbell, 1929, p. 162, fig. 312.

The tall, narrow, elongated lorica, with strong teeth, tapering bowl, and rounded aboral end, has a length of 5.8 oral diameters. The oral margin has 24 sharply pointed, narrow, triangular teeth which are curved outward and the length of which is less than 0.1 oral diameter. These teeth rest on a very low, conical ( $54^{\circ}$ ) crown or collar, the length of which is 0.08 oral diameter, the diameter being 0.93 oral diameter at the lower end. Below this contracted neck the inverted, conical ( $2^{\circ}$ ), decidedly elongated bowl arises. This section has a diameter of 1.06 oral diameters just below the neck, and 0.84 at its bottom end, which is 0.84 total length below the oral rim. The bowl contracts below this last level in the shape of an approximate half-ellipse, being about  $45^{\circ}$  in its anterior half and increasing to  $80^{\circ}$  in the posterior section. Its length is 0.67 of its own diameter, and its sides are convex. At the aboral end is a short, curved, minutely blunted, conical ( $15^{\circ}$ ) aboral horn, the length of which is about 0.37 oral diameter.

The wall has a maximum thickness of 0.06 oral diameter near the upper end of the tapering bowl, and gradually this lessens to as little as three-tenths as much. Thin laminae enclose a single layer of radial, rectangular prisms. There is a meshwork of practically uniform, double-walled hexagons which enclose hyaline contents. The aboral horn is hollow and the cavity follows the outer contour.

Length, 363 $\mu$ .

The *Carnegie* loricae have fewer, longer teeth than usual, as well as slight suboral contraction and more taper.

*Parafavella cylindrica* compares nicely with *P. subrotundata*, but is longer and more slender, with an elliptical rather than rounded aboral end, and without a sharp, pointed horn. It is longer than *P. dilatata*, much less tapering, with fewer teeth, and with a somewhat different aboral region. *Parafavella gigantea* has a longer horn and more teeth, and *P. robusta* has a longer horn and shorter bowl.

Recorded from five stations, one in the Atlantic and four in the Pacific, as follows: one (6-7) in the North Sea, and four (118, 120, 121, 122) in the East Asiatic marginal sea.

There are 9 net samples, of which 3 were taken at the surface, 4 at 50 meters, and 2 at 100 meters. Frequency, 96 per cent at station 118 at 100 meters; all other records, save that in the Atlantic, above minimum (2 to 70 per cent); average in the Pacific, 27.1 per cent.

The following data apply to the Pacific stations only: temperature,  $2^{\circ}01-10^{\circ}18$  ( $5^{\circ}52$ ); salinity, 32.06-33.78 (33.29); density, 25.14-26.57 (26.23); pH, 7.86-8.21 (7.98).

*Parafavella denticulata* (Ehrenberg) Kofoid and Campbell

(Figure 50)

*Parafavella denticulata*, Kofoid and Campbell, 1929, p. 163, fig. 310; Hada, 1932b, pp. 564-565.

*Parafavella dentiula (lapsus)* Hada, 1932a, pp. 50-51, fig. 15.

*Favella denticulata*, Schulz and Wulff, 1929, pp. 344-352, figs. 2-25, pls. 12, 13; also var. *tenuis* forma *arctica*, fig. 21c-g.

The tall lorica, with stout teeth, subcylindrical bowl, contracted aboral region, and moderately long aboral horn, has a length of 3.76 oral diameters. The thin oral rim has 32 short, relatively wide, subequidistant, uniform, suberect, triangular teeth. The slightly tapering ( $2^{\circ}$ ) anterior bowl occupies about 0.55 total length, and its diameter at the lower end is near 0.93 oral diameter; its walls are without traces of minute irregularity. Below its lower end the bowl gradually contracts in the form of a half-ellipse, the length of which is 1.17 its own diameter. It is at first  $30^{\circ}$  and increases to  $52^{\circ}$  in the posterior three-tenths. The aboral horn is conical ( $15^{\circ}$ ) and its length reaches 0.72 oral diameter. Its free tip is minutely blunted.

The wall has a uniform thickness of nearly 0.03 oral diameter except in the horn, where it is somewhat more. There are thin laminae and enclosed radial, rectangular prisms. The outer surface has distinct, although faint, hexagonal prisms of modest size. The cavity approximates the outer contour.

Length, 253 $\mu$ .

The *Carnegie* loricae lack the suboral flare evident in typical loricae. Schulz and Wulff (1929) illustrate and discuss a wide variety of forms, only some of which belong to *denticulata (sensu stricto)*, the others belonging to several distinct forms, some of which may be new. The variability of *Parafavella* is certainly very great, and physical influences profoundly affect formation. The effects of temperature, salinity, density, and hydrogen-ion concentration are yet to be experimentally studied in these ciliates. Observational data are suggestive.

*Parafavella denticulata* resembles *P. gigantea*, but is shorter and stouter, with a less lengthy horn. It is not so stout as *P. robusta*, and there is a sharper transition in lower bowl and horn than in *P. obtusangula*. It has numerous teeth, lacking in the somewhat similar *P. edentata*. The other species are so distinct that they could scarcely be confused with *denticulata*.

Recorded from seven stations, three in the Atlantic and four in the Pacific, as follows: two (between stations 6 and 7) in the North Sea, one (13) in the American cold-water region, two (116, 117) in the North Pacific middle latitudes, one (118) in the East Asiatic marginal sea, and one (130) in the California region.

There are 3 pump and 10 net samples, of which 5 were taken at the surface, 6 at 50 meters, and 2 at 100 meters. Maximum frequency, 95 per cent at station 6-7a; other records above minimum (2 to 56 per cent) from stations 116, 117, 118, 130; average in Pacific net samples, 12.1 per cent.

Temperature: Atlantic, pump sample  $11^{\circ}27$ , net sample  $1^{\circ}64$ ; Pacific,  $8^{\circ}33$  and  $8^{\circ}93-16^{\circ}07$  ( $11^{\circ}54$ ), respectively.



Salinity: Atlantic, pump sample 32.68, net sample 33.40; Pacific, 33.72 and 33.06–34.22 (33.83), respectively. Density: Atlantic, pump sample 24.94, net sample 26.90; Pacific, 26.24 and 24.99–26.41 (25.75), respectively. pH: Atlantic, not recorded; Pacific, pump sample 8.21, net samples 7.98–8.26 (8.12). The data for this species, as for others taken from intermediate stations, are incomplete.

**Parafavella dilatata** (Jørgensen) Kofoid and Campbell

*Parafavella dilatata*, Kofoid and Campbell, 1929, pp. 163–164, fig. 315.

The tall, narrow, bell-shaped lorica, with long bowl and short horn, has a length of 2.94 oral diameters. The thin oral margin has approximately 60 subequidistant, subequilateral, triangular teeth, which invariably turn inward. The contracted conical section of the bowl ( $12^\circ$ ) has a length of 0.7 total length, and its diameter at the lower end is 0.53 oral diameter. This section contracts to 0.7 oral diameter at 0.4 total length from the rim. The aboral region of the bowl is convex conical ( $52^\circ$ ) and has a length of nearly 0.17 total length. The aboral horn is a narrow, pointed, barely bulging cone ( $7^\circ$ ) with a length of almost 0.14 total length.

The wall is subuniformly 0.05 oral diameter in thickness, with little trace of laminae but with well developed large, rectangular radial prisms in a single layer. The outer mesh is made up of uniformly rather small hexagons, except that the horn is glassy. The lumen follows the outer contour and continues to the tip of the closed horn.

Length, 247 to 390 $\mu$ .

This single lorica resembles Brandt's rather more than it does the one figured by Jørgensen.

*Parafavella dilatata* differs from *P. subrotundata* in having a more clearly defined campanulate bowl, and it also has submedian contraction; this last character serves to distinguish *dilatata* from all other species. If it is only a distorted (contracted) *P. cylindrica*, as Kofoid and Campbell suggested, then *dilatata*, *cylindrica*, and *subrotundata* are possibly only extremes of one variable species, the name of which would have to be *subrotundata* by plate precedence.

Recorded from one station (6-7) in the North Sea, in a net sample taken at the surface. Frequency, minimum.

No physical data accompany this and other collections between the regular series stations.

**Parafavella edentata** (Brandt) Kofoid and Campbell

*Parafavella edentata*, Kofoid and Campbell, 1929, p. 164, fig. 296.

The rather short, campanulate lorica lacks oral teeth but has a relatively long aboral horn. Its length is 2.2 oral diameters. The oral margin is the simple, unmodified upper edge of the bowl. The bowl is virtually a cylinder in the upper two-thirds, with a little suboral flare in some loricae and slight local inflation and contraction in others, and with the diameter at the lower end of the cylinder 0.83 to 1.00 oral diameter. The aboral section is about 0.75 oral diameter in length; it is a plane-to-concave cone ( $55^\circ$ ). The aboral horn is 0.5 oral diameter in length, narrow conical ( $8^\circ$ ), and sharply pointed.

The wall is nearly 0.04 oral diameter in thickness, more or less subuniformly. There are exceedingly thin laminae, between which is a single layer of radial prisms. The outer surface has a distinct hexagonal meshwork of small suboral prisms and larger median ones, and is entirely devoid of prisms in the greater part of the horn. The horn is hollow.

Length, 80 to 150 $\mu$ .

There is marked diversity in length and proportions and also in the relative length of the bowl, which varies from short to long.

*Parafavella edentata* resembles *P. subdentata*, but is usually relatively stouter and more widely campanulate, and has a more gradual transition between bowl and horn. The remaining edentulous species, *P. digitalis*, *P. inflata*, and *P. curvata*, lack aboral horns entirely or else have only points, have long cylindrical bowls, and are longer. *Parafavella denticulata* resembles *edentata*, but always has strong teeth; however, *edentata* is not an edentate form of that species.

Recorded from one station (7) in the North Sea, in a net sample taken at the surface. Frequency, minimum.

Temperature, 8°92; salinity, 35.21; density, 27.31; pH, 8.08.

**Parafavella gigantea** (Brandt) emended Kofoid and Campbell

(Figures 52, 53)

*Parafavella gigantea*, Kofoid and Campbell, 1929, p. 165, fig. 311; Hada, 1932a, pp. 51–52, fig. 16; 1932b, p. 565.

The large, tall, generally cylindrical lorica, with narrow, contracted conical aboral region and very narrow, pointed aboral horn of moderate length, has a length of 5.9 to 6.9 oral diameters. The oral margin has approximately 46 equidistant, narrow triangular, outward-flaring ( $45^\circ$ ) teeth, nearly 0.1 oral diameter in length. The long bowl is cylindrical to barely tapering (least diameter 0.77 oral diameter near 0.7 total length), and is without local modification in contour. The lower, shorter, slightly convex conical ( $40^\circ$  to  $45^\circ$ ) part has a length of barely 1.0 oral diameter. The aboral horn is narrow conical ( $5^\circ$  to  $16^\circ$ ), pointed at the free tip, and sometimes as much as 1.17 oral diameters in length.

The wall is slightly thickened suborally but averages 0.06 oral diameter. It has very distinct rectangular radial prisms, and the surface meshwork is of uniform small hexagons in well developed pattern save in the horn.

Length, 337 to 576 $\mu$ .

The Carnegie loricae lack contraction in the bowl, being either directly cylindrical or tapering, and are much more like that figured by Kofoid and Campbell than that figured by Hada.

*Parafavella gigantea* is longer than *P. denticulata* and has a longer horn, but not so long as that of *P. promissa*, which species is also shorter. *Parafavella gigantea* differs also from *P. cylindrica* in horn, the latter having only a short stub. *Parafavella acuta* is shorter and has an acuminate aboral end. The bowl of *P. gigantea* is longer than that of *P. elegans*, which species is shorter. It differs from *P. robusta* in its more slender contour and in being longer.

Recorded from eleven stations, five in the Atlantic and six in the Pacific, as follows: two (between stations 6 and 7) in the North Sea, one (9) in the Atlantic drift, two (12, 13) in the American cold-water region, two (116, 117) in the North Pacific middle latitudes, three (118, 122, 123) in the East Asiatic marginal sea, and one (130) in the California region.

There are 7 pump and 13 net samples, of which 8 were taken at the surface, 5 at 50 meters, and 7 at 100 meters. Maximum frequency, 97 per cent at station 122; other records above minimum (2 to 91 per cent) from stations 6-7a, 6-7b, 9, 13, 117, 118, 122, 130; averages, 11.4 and 55.4 per cent in Atlantic and Pacific net samples, respectively; in Atlantic pump samples, 9.8 loricae.

Temperature: Atlantic, net samples  $1^{\circ}64-11^{\circ}27$  ( $8^{\circ}11$ ); Pacific, pump samples  $2^{\circ}54-18^{\circ}22$  ( $6^{\circ}97$ ), net samples  $2^{\circ}54-10^{\circ}18$  ( $6^{\circ}90$ ). Salinity: Atlantic, net samples 32.68-35.14 (33.71); Pacific, pump samples 32.84-34.06 (33.01), net samples 32.76-33.78 (33.27). Density: Atlantic, net samples 24.94-26.90 (26.22); Pacific, pump samples 25.58-26.45 (26.20), net samples 25.52-26.57 (26.05). pH: Atlantic, net samples 8.08-8.10 (8.09); Pacific, pump samples 7.90-8.02 (8.00), net samples 7.90-8.21 (8.00).

#### *Parafavella hadai*, new name

Not *Favella denticulata* forma *subcylindrica* Schulz and Wulff, 1929, p. 345, fig. 21c.

*Parafavella subcylindrica* Hada, 1932a, pp. 54-55, fig. 20.

"Lorica short finger-shaped, 2.7 oral diameters in length; oral margin denticulate with many small triangular teeth (about 60); bowl subcylindrical, dilated slightly in the suboral 0.16 of the total length, gradually contracting aborally, convex conical ( $8^{\circ}$ ) in the posterior 0.3 of the lorica; aboral end nearly hemispherical, somewhat subacute, without an aboral horn.

"Length, 169 $\mu$ ; oral diameter 63 $\mu$ .

"Differs from *Parafavella digitalis* Kofoid and Campbell in having the denticulate oral rim, from *P. hemispherica* (Meunier) in numerous oral teeth and in the rounded aboral end, and from *P. rotundata* (Jørgensen) in smaller size and in stouter proportions."

*Parafavella hadai* occurs at only one station, off Kamchatka, recorded by Hada in 1932.

*Parafavella hadai* is renamed in this report because the specific name *subcylindrica* had already been applied by Schulz and Wulff to another species, which Hada apparently overlooked. The specific name *hadai* is, thus, appropriate. It was not recorded in the material of the *Carnegie*, although many of the Japanese species have been reported again by this expedition.

#### *Parafavella obtusangula* (Ostenfeld) emended Kofoid and Campbell

*Parafavella obtusangula*, Kofoid and Campbell, 1929, p. 168, fig. 309.

*Favella denticulata* var. *tennis*, Schulz and Wulff (part), 1929, p. 344, fig. 20g (see also *P. denticulata*).

The lorica is short and bell-shaped, with an angular lower

bowl, a pointed aboral horn, and a length of 2.8 oral diameters. The oral margin is regularly denticulate with approximately 36 short, erect, wide triangular teeth. The bowl is cylindrical in the upper 1.5 oral diameters, and obtusely conical ( $46^{\circ}$ ) in the lower section, having there plane-to-barely-convex sides. The aboral horn is short (0.2 oral diameter) and narrow conical ( $8^{\circ}$ ), and has a sharp point.

The wall is within 0.05 oral diameter in thickness uniformly at all levels, and has thin laminae which enclose a single layer of radial, rectangular secondary prisms. The outer surface has moderately large, rounded hexagons except in the aboral horn, which is usually hyaline.

Length, 140 $\mu$ .

Schulz and Wulff figure one lorica (fig. 20g) which belongs to this species; the others of their series do not appear to be related.

*Parafavella obtusangula* differs from its close relative *P. denticulata* in the obtuse, long, conical lower bowl and shorter horn. The transition between bowl and horn is also less marked and the cylindrical part of the bowl is shorter. It is unlike *P. parumdentata*, which has suboral flare and much less transition between bowl and horn.

Recorded from one station (117) in the North Pacific middle latitudes, in a net sample taken at 50 meters. Frequency, 2 per cent.

Temperature,  $12^{\circ}56$ ; salinity, 34.22; density, 25.89; pH, 8.06.

#### *Parafavella parumdentata* (Brandt) Kofoid and Campbell (Figures 49, 54, 55)

*Parafavella parumdentata*, Kofoid and Campbell, 1929, p. 168, fig. 306; Hada, 1932a, pp. 49-50, fig. 14.

The lorica is goblet-shaped, small, with evenly contracted bowl and pointed aboral end lacking a distinct horn, and is 1.9 to 2.1 oral diameters in length. The oral margin has about 32 incurved, short, equidistant, clawlike, triangular teeth (omitted in the drawings). The suboral region of the bowl flares as a low, basal, inverted segment of a cone ( $46^{\circ}$  to  $60^{\circ}$ ) with a length of within 0.17 oral diameter and with a diameter at the lower end of within 0.86 oral diameter. Below this throat the bowl contracts as an inverted cone ( $5^{\circ}$ ) for about 0.5 total length and then ( $32^{\circ}$  to  $48^{\circ}$ ) becomes a wider cone with full sides. The aboral end is not prolonged as a pedicel, being but the simple sharp end of the lower bowl.

The wall is uniformly approximately 0.05 oral diameter in thickness, but its structure was indeterminate in the loricae of this expedition. The outer surface has distinct, very small, elongated hexagons.

Length, 97 to 107 $\mu$ .

The *Carnegie* loricae are distinctly shorter and stouter than those included by Kofoid and Campbell, which are 127 to 200 $\mu$  and 2.8 to 3.0 oral diameters. The shape of their figured lorica is somewhat different, as is also that of Hada. One of the loricae figured here (fig. 49) is aberrant in shape, proportions, and size.

*Parafavella parumdentata*, though showing considerable

variation, may be compared with *P. pacifica*, from which it differs in the more tapering aboral end and lack of horn; from *P. obtusangula* it differs in aboral characters.

Recorded from seven adjacent stations in the Atlantic, as follows: one (7) in the North Sea, four (8, 9, 10, 11) in the Atlantic drift, and two (12, 13) in the American cold-water region.

There are 3 pump and 17 net samples, of which 7 were taken at the surface, 8 at 50 meters, and 5 at 100 meters. Maximum frequency, 100 per cent at station 8 at 100 meters, station 11 at the surface, station 12 at 100 meters, and station 13 at 50 meters; all other records 2 to 99 per cent.

Temperature: pump samples 7°01–14°47 (11°27), net samples 1°64–11°27 (7°91). Salinity: pump samples 32.68–34.97 (34.18), net samples 33.40–35.25 (34.82). Density: pump samples 24.94–27.42 (26.38), net samples 24.94–27.96 (27.14). pH: pump samples 7.92–8.06 (7.99), net samples 7.93–8.08 (7.98).

#### *Parafavella promissa* Hada

*Parafavella promissa* Hada, 1932a, p. 53, fig. 18.

The elongated, narrow lorica, with sharply recurved oral teeth, cylindrical bowl, and very long, spinelike aboral horn, has a length of 7.3 oral diameters. The oral margin flares very slightly, and there are 24 subequidistant, narrow, decidedly outward-flaring, triangular teeth. The long upper bowl is a cylinder expanded a bit near the upper end, and occupies 2.56 oral diameters. The aboral convex-conical (45°) section has a length of nearly 1.0 oral diameter. The very elongated aboral horn is conical (not over 2°) and is about 0.5 or more of the total length. At its free tip there is sometimes a minute disk-shaped expansion.

The wall has a thickness of 0.06 oral diameter in the bowl, a little more suborally, and somewhat less near the horn. There are exceedingly thin inner and outer laminae enclosing a single layer of radially arranged secondary prisms. The rather small surface meshwork of hexagons covers the bowl everywhere, but the long aboral horn and the teeth are free of prisms. The lumen enters the horn and elsewhere precisely conforms to the outer contour.

Length, 334 $\mu$ t.

The specimens of this expedition differ only in minor ways from Hada's (1932a) figured lorica.

*Parafavella promissa* bears only slight resemblance to *P. subula*. It is longer and much more slender, with a cylindrical instead of short, wide bowl, and the stronger, recurved teeth are prominent. Its bowl and aboral horn are also unlike those of *P. elegans*, and it could hardly be confused with the other species, with which, also, it is seldom associated in the Pacific.

Recorded from two stations in the Pacific, as follows: one (128) in the North Pacific middle latitudes, and one (130) in the California region.

There are 3 pump and 2 net samples, of which 3 were taken at 50 meters and 2 at 100 meters. Maximum frequency, 45 per cent at station 130; another record above minimum (9 per cent) from station 128; averages, 4 and

26.5 per cent in pump and net samples, respectively.

Temperature: pump samples 8°96–12°91 (11°25), net samples 8°96–12°91 (10°93). Salinity: pump samples 33.07–33.72 (33.39), net samples 33.40–33.72 (33.56). Density: pump samples 25.13–26.14 (25.48), net samples 25.19–26.14 (25.66). pH: pump samples 8.06–8.26 (8.14), net samples 8.06–8.26 (8.16).

#### *Parafavella ventricosa* (Jørgensen) Kofoid and Campbell

*Parafavella ventricosa*, Kofoid and Campbell, 1929, p. 171, fig. 314; Hada, 1932b, p. 566, fig. 18.

*Favella denticulata* var. *robusta* forma *arctica* Schulz and Wulff, 1929, p. 345, fig. 21c.

The rather large, stout, aborally inflated lorica, with a short aboral horn, has a length of 5.17 oral diameters. The thin oral margin has about 36 very short, subequidistant, somewhat curved teeth. The bowl is cylindrical in the anterior 0.45 total length and then gradually expands in the remaining section to 1.25 oral diameter at 0.65 total length from the rim. Below this level it contracts rapidly as a convex cone (60°) with a length of 0.26 total length. At its lower end is the short (0.4 oral diameter), conical (5°), pointed aboral horn.

The thin wall (0.05 oral diameter) is subuniform, with thin laminae and enclosed radial, rectangular prisms in a single layer. The wall has distinct, rounded hexagons of nearly uniform size at all levels; the aboral horn is hyaline near the free tip.

Length, 346 $\mu$ t.

Although in some ways differing from the typical form, the lorica figured by Schulz and Wulff (1929) appears to belong to this species. The loricae of this expedition conform neatly to type.

*Parafavella ventricosa* differs from all the other species in the extent of inflation of the aboral region, which has a decidedly gourdlike shape.

Recorded from one station (121) in the East Asiatic marginal sea, in a net sample taken at 50 meters. Frequency, minimum.

Temperature, 3°77; salinity, 33.06; density, 26.28; pH, 7.92.

#### *XYSTONELLOPSIS* Jørgensen

*Xystonellopsis*, Kofoid and Campbell, 1929, pp. 238–239.

*Xystonellopsis* has very much the same position and abundance in the tropics as *Parafavella* in arctic seas. As regards abundance, it is not so frequent, but is common in small percentages in nearly any catch in warm seas. In number of species it ranks somewhat better. The two genera have in common the simple oral margin, the somewhat similar form, and close likeness in wall structure. For these reasons they are allied here. Kofoid and Campbell (1929) placed *Parafavella* near *Favella*, partly for historical reasons, and because the surface hexagonal patterning of the wall of *Favella*, in some species, is much like that in *Parafavella*. More careful work and consideration seem to indicate closer relationship to the Xystonellidae on the part of *Parafavella*. Both *Xystonellopsis* and *Parafavella* are specialized genera of

highly peculiar, special habitats in very different parts of the ocean. *Favella* is a more generalized genus of more temperate waters, especially coastal. Few if any species of *Xystonellopsis* ever enter neritic environments, this genus being common in the high seas. It is interesting that none of the Xystonellidae enter the Antarctic, although the family has mastered most other seas.

Twenty-two species are described here.

*Xystonellopsis abbreviata* Kofoid and Campbell

*Xystonellopsis abbreviata* Kofoid and Campbell, 1929, p. 239, fig. 468.

The moderately stout lorica, with *pulchra*-like form and short pedicel, has a length of 5.1 oral diameters. The oral margin is thin and erect. The suboral band occupies the anterior 0.16 total length and has 3 rounded, subequal rings with diameters of nearly 1.27 oral diameters; these rings are thin, and virtually equidistant, the upper one being a little below the oral rim. The interspaces between the rings are thickened. The bowl below the band is subconical ( $10^\circ$  in the upper 0.21 and  $38^\circ$  in the lower 0.16 total length). The pedicel is thick (0.36 oral diameter at the upper end) and tapering ( $5^\circ$ ), with a slight, aborally truncated skirt at the distal end. The lance is conical ( $2^\circ$ ) and distally pointed, and has a length of 0.55 oral diameter.

The wall has a thickness of 0.1 oral diameter just below the spool, and there are thin laminae which enclose small hexagons in several layers in the spool, radial secondary prisms in a single layer in the bowl, and large hexagons in the skirt and lance. The lumen does not enter the spool, and forms a narrow canal in the lance.

Length, 275 to 336 $\mu$ .

*Xystonellopsis abbreviata* is much like *X. pulchra*, but is not so long; its suboral spool is shorter and the pedicel is short.

Recorded from one station (108) in the North Pacific trade region, in a pump sample taken at 100 meters. Frequency, minimum.

Temperature,  $25^\circ 36$ ; salinity, 34.99; density, 23.24; pH, 8.23.

*Xystonellopsis acuminata* Kofoid and Campbell

*Xystonellopsis acuminata* Kofoid and Campbell, 1929, p. 239, fig. 482.

The moderately tall lorica, with *heros*-like bowl, stout pedicel, and pencil-shaped lance, has a length of 5.56 oral diameters. The oral margin is sharp, with a trace of flare within the upper tenth. The bowl is subcylindrical in the anterior half and conical ( $14^\circ$ ) in the aboral region, which merges with the pedicel. The lance arises from the barely differentiated skirt; it is pencil-like, 0.5 oral diameter in length, and sharply pointed.

The wall is nearly 0.08 oral diameter in thickness, and the thin laminae enclose several layers of minute alveoles. On the pedicel are 8 right-twisted ( $3^\circ$ ) ridges.

Length, 354 to 414 $\mu$ .

*Xystonellopsis acuminata* has a clear-cut skirt wholly lack-

ing in *X. dahli*. It is not so long as *X. heros*, and has a pencil-shaped rather than conical lance. *Xystonellopsis gaussi* has a stouter, conical lance and more definite pedicel.

Recorded from five stations in the Pacific, as follows: one (35-36) in the Pacific equatorial region, three (112, 113, 145) in the North Pacific middle latitudes, and one (131) in the California region.

There are 1 pump sample and 4 net samples, of which 1 was taken at the surface and 4 at 100 meters. Maximum frequency, 11 per cent at station 112; other records above minimum (2 to 8 per cent) from stations 113, 131; average in net samples, 7.6 per cent.

Temperature: pump sample  $16^\circ 58$ , net samples  $12^\circ 12$ – $21^\circ 74$  ( $18^\circ 00$ ). Salinity: pump sample 34.71, net samples 33.36–34.71 (34.24). Density: pump sample 25.00, net samples 24.06–25.31 (24.63). pH: pump sample 8.31, net samples 8.23–8.32 (8.25).

*Xystonellopsis armata* (Brandt) Kofoid and Campbell

*Xystonellopsis armata*, Kofoid and Campbell, 1929, p. 241, fig. 481.

The rather tall lorica, with contracted lower bowl, expanded pedicel, and short, conical lance, has a length of 6.65 oral diameters. The oral margin is thin and sharp. The bowl tapers ( $5^\circ$ ) in the upper 0.48 total length and becomes subconical ( $30^\circ$ ) in the lower 0.2 total length. The pedicel increases in diameter from the lower bowl ( $4^\circ$ ) and has a length of nearly 0.32 total length; at its distal end is the squarely truncated, non-expanded skirt. The lance is conical ( $32^\circ$ ), only 0.5 oral diameter in length, and sharply pointed.

The wall reaches nearly 0.1 oral diameter in thickness suborally, and becomes a little less in the lower bowl. There are comparatively thick, dark laminae, which enclose homogeneous material. The lumen forms a canal in the lance. The pedicel has 8 subvertical pleats.

Length, 365 to 410 $\mu$ .

*Xystonellopsis armata* resembles *X. gaussi*, but the pedicel becomes distally wider instead of contracted, and the lance is conical and wide rather than pencil-shaped. It differs from *X. heros* in having a subconical lower bowl with distinct transition to the pedicel, as well as in being shorter. It lacks the suboral thickening of *X. tenuirostris*.

Recorded from twenty-one stations, two in the Atlantic and nineteen in the Pacific, as follows: two (23, 24) in the Atlantic equatorial region, two (35, 153) in the Pacific equatorial region, two (45, 68) in the Galápagos region, three (65, 66, 67) in the South Pacific middle latitudes, two (109, 150) in the North Pacific trade region, eight (133, 134, 135, 136, 146, 147, 148, 149) in the California region, and two (142, 145) in the North Pacific middle latitudes.

There are 6 pump and 16 net samples, of which 4 were taken at 50 meters and 18 at 100 meters. Maximum frequency, 26 per cent at station 67; other records above minimum (2 to 25 per cent) from stations 23, 24, 35, 45, 65, 66, 68, 109, 135, 142, 145, 146, 148, 150; averages in net samples, 1.2 and 11.0 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, net samples  $20^\circ 99$ – $23^\circ 12$  ( $22^\circ 05$ );

Pacific, pump samples 16°90–28°05 (21°36), net samples 14°33–21°69 (18°27). Salinity: Atlantic, net samples 36.00–36.04 (36.02); Pacific, pump samples 34.40–35.02 (34.74), net samples 34.30–35.21 (34.79). Density: Atlantic, net samples 24.67–25.30 (24.98); Pacific, pump samples 21.95–25.26 (24.56), net samples 24.24–26.06 (25.04). pH: Atlantic, net samples 8.14–8.18 (8.15); Pacific, pump samples 8.12–8.39 (8.30), net samples 7.88–8.38 (8.18).

#### *Xystonellopsis brandti* (Laackmann) Jörgensen

*Xystonellopsis brandti*, Kofoid and Campbell, 1929, p. 241, fig. 474.

The rather short lorica, of extreme narrowness, with suboral swelling and conical pedicel with merged lance, has a length of 7.8 oral diameters. The oral margin is thin and erect. The bowl swells in a zone of the uppermost oral diameter to 1.3 oral diameters at 0.3 oral diameter below the rim. The upper part of this swollen region has a rounded shoulder, and the lower part tapers (23°) and merges with the bowl below. The bowl below the swollen region swells to 1.1 oral diameters at 2.8 oral diameters below the rim, and then is conical (12°) for the remainder of the length of the lorica. The pedicel-lance occupies about 1.5 oral diameters, and the distal tip is sharp.

The wall has a thickness of nearly 0.2 oral diameter across the widest part of the bowl, but in the lower bowl is only 0.05 or less. There are thin laminae with faint, fine hexagons in several layers, especially suborally. The lorica is hyaline, save that the pedicel-lance is dense. There are 6 low, winglike fins which continue from the lower bowl to the lower pedicel. The lumen is reduced to a canal in the lance, and does not enter the suboral thickening.

Length, 196 to 225 $\mu$ .

In many respects *Xystonellopsis brandti* is unique, but it is possibly somewhat like *X. constricta*. It is, however, shorter, lacks the tubular, constricted lower bowl, and has more suboral thickening.

Recorded from two stations, one each in the Atlantic and the Pacific, as follows: one (19) in the Sargasso Sea, and one (80) in the Galápagos region.

There are 1 pump and 1 net sample, both taken at 50 meters. Frequency, minimum.

Temperature: Atlantic, net sample 25°31; Pacific, pump sample 26°06. Salinity: Atlantic, net sample 37.15; Pacific, pump sample 35.95. Density: Atlantic, net sample 24.89; Pacific, pump sample 23.75. pH: Atlantic, net sample 8.27; Pacific, pump sample 8.19.

#### *Xystonellopsis conicacauda* Kofoid and Campbell

*Xystonellopsis conicacauda* Kofoid and Campbell, 1929, p. 243, fig. 465.

The fairly short lorica, with duplicated skirts and short, conical lance, has a length of 5.7 oral diameters. The oral margin is thin and erect. The bowl swells rapidly to a diameter of 1.93 oral diameters within the anterior 0.1 oral diameter, forming a thickened ledge. The lower part of the swollen region extends for the anterior 0.25 total length,

gradually being reduced posteriorly. Below this region the bowl becomes subconical (10°) for the remainder of its length. At the lower end it swells to form the upper, expanded skirt. Below this skirt is a short cylindrical section (approximately 1 oral diameter in length) with a slight skirt at its lower end. From the center of this skirt arises the lance, which is conical (60°), with its length less than its basal diameter.

The wall has a thickness of 0.28 oral diameter across the ledge. The lumen does not enter the ledge, but does follow the external contour of the lance. The wall is otherwise like that of *X. paradoxa*.

Length, 188 to 229 $\mu$ .

*Xystonellopsis conicacauda* resembles *X. paradoxa*, but its lance is shorter, wider, and more conical; the bowl is proportionately longer.

Recorded from one station (19) in the Sargasso Sea, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 22°42; salinity, 37.05; density, 25.67; pH, 8.25.

#### *Xystonellopsis crassispinosa* Kofoid and Campbell

(Figure 64)

*Xystonellopsis crassispinosa* Kofoid and Campbell, 1929, p. 244, fig. 460.

The fairly short lorica, of general *cymatica* type but with thick pedicel and stout lance, has a length of 4.7 oral diameters. The oral margin is thin and erect. The bowl swells immediately below the rim to form a rounded, thick ledge with a diameter of 1.28 oral diameters; the ledge has a width of 0.32 oral diameter. The bowl below the ledge is subconical (8° increasing to 33° in the aboral 0.76 oral diameter). The pedicel is thick (0.25 oral diameter) and tubular, with a length of 0.32 total length, and with a slightly expanded skirt at its distal end. The skirt has 8 (12) clawlike points, and above each is a short pleat which reaches the lower end of the pedicel. The lance arises from the center of the skirt, has a length of 0.6 oral diameter, and is stout, conical (16°), and distally blunted.

The wall is thickest suborally, where it reaches nearly 0.09 oral diameter; it tapers to less than three-tenths as much in the lower bowl. There are thin laminae, which enclose radial, secondary rectangles, save in the ledge, where there are several layers of small hexagons. The lumen does not enter the ledge.

Length, 244 to 265 $\mu$ .

*Xystonellopsis crassispinosa* differs from *X. cymatica* and related species in the stoutness of the pedicel and lance, and from *X. spicata* in the narrower ledge.

Recorded from ten stations, three in the Atlantic and seven in the Pacific, as follows: one (18) in the Sargasso Sea, two (22, 23) in the Atlantic equatorial region, two (41, 45) in the Galápagos region, one (95) in the region of South Pacific island fields, two (136, 146) in the California region, one (145) in the North Pacific middle latitudes, and one (150) in the North Pacific trade region.

There are 1 pump and 9 net samples, of which 1 was taken at 50 meters and 9 at 100 meters. Maximum frequency,

20 per cent at station 145; other records above minimum (4 to 6 per cent) from stations 41, 95, 136, 146; average in Pacific net samples, 6.8 per cent.

Temperature: Atlantic, pump sample 20°32, net samples 20°99–24°44 (22°71); Pacific, net samples 14°55–28°74 (19°54). Salinity: Atlantic, pump sample 36.81, net samples 36.04–36.18 (36.11); Pacific, net samples 34.32–35.33 (34.53). Density: Atlantic, pump sample 26.07, net samples 24.42–25.30 (24.86); Pacific, net samples 22.43–26.11 (24.50). pH: Atlantic, pump sample 8.21, net samples 8.14–8.21 (8.17); Pacific, net samples 7.92–8.39 (8.22).

#### *Xystonellopsis cyclas* Kofoid and Campbell

*Xystonellopsis cyclas* Kofoid and Campbell, 1929, p. 244, fig. 457.

The fairly short lorica, of general *cymatica* type, with thickened cylindrical pedicel and long lance, has a length of 5.0 oral diameters. The oral margin is thin and spread. The bowl has a ringlike (0.25 oral diameter in width) ledge (1.15 oral diameters in diameter) located just below the anterior 0.1 oral diameter. The bowl below this ledge tapers subconically (8° in the anterior 0.39 and 25° in the aboral 0.17 total length). The pedicel is subcylindrical, with a diameter near 0.3 oral diameter and with a length of 0.32 total length. At its aboral end is a slightly flaring skirt. From the center of the skirt arises the conical (15°), sharply pointed lance, the length of which is 0.14 total length.

The wall reaches a thickness of nearly 0.2 oral diameter at the ledge, and is half as much just below; it thins down in the lower bowl. There are very thin laminae and enclosed radial secondary prisms in a single layer. In the ledge are small, crowded alveoles in several rows. In the lance are large hexagons in two layers. The surface has neat hexagonal structure, and there are 6 short pleats above the skirt. The lumen does not enter the ledge, and in the lance it is reduced to a canal.

Length, 238 to 249 $\mu$ .

*Xystonellopsis cyclas*, like *X. crassispinosa*, has a thickened, subcylindrical pedicel, but the lance is longer and more slender, and the ledge more ringlike. It differs from *X. cymatica* in having a thicker, more cylindrical pedicel and thicker ledge.

Recorded from three stations in the Pacific, as follows: one (156) in the Pacific equatorial region, and two (158, 160) in the region of South Pacific island fields.

There are 3 net samples, all taken at 100 meters. Frequency, 4 per cent at stations 156, 160; average, 3.3 per cent. Temperature, 26°62–28°52 (27°65); salinity, 35.06–35.89 (35.54); density, 22.76–23.14 (22.93); pH, 8.34–8.44 (8.39).

#### *Xystonellopsis cymatica* (Brandt) Jørgensen emended Kofoid and Campbell

(Figure 65)

*Xystonellopsis cymatica*, Kofoid and Campbell, 1929, p. 245, fig. 458.

The relatively short lorica, with wide upper ledge, bare

secondary ledge, conical bowl, thin pedicel, and short lance, has a length of 4.82 oral diameters. The thin oral margin is smooth. The bowl has a low upper cylindrical section about 0.1 oral diameter in width, and the flat-edged, horizontal ledge arises from its lower end. This upper ledge has a diameter of 1.37 oral diameters, and its lower surface contracts with concave contour to the bowl below. The lateral wall within a length of 0.7 oral diameter is distinctly concave. At the lower end arises a secondary ledge, with a diameter of 1.25 oral diameters. Below this less distinct ledge the bowl rapidly resumes its concave-conical form (20° in the upper 0.6 total length and 33° in the lower 0.4 total length), with diameter at the aboral end, at the upper end of the pedicel, only 0.16 oral diameter. The pedicel is narrow and tubular, with a length of 0.37 total length, with some slight skirtlike expansion at its distal end, and with little lateral concavity in some individuals. From the lower end of the skirt arises the narrow conical (7°), pointed lance, with a length of 0.58 oral diameter.

The wall is thickest under the upper ledge, where it reaches nearly 0.13 oral diameter; in the lower bowl it is about three-tenths as much. There are thin, hyaline laminae with enclosed radial secondary prisms in a single row, save suborally, where there are several layers of small hexagons. The lumen does not enter the ledges, but does follow the outer contour of the skirt, and in the lance forms a narrow canal.

Length, 180 to 258 $\mu$ .

A part of the *Carnegie* loricae conform exactly to the typical form, but a good many, like the figured specimen (fig. 65), differ in two respects: (a) in the presence of a secondary ledge, and (b) in the presence of a slight skirt below a thinner pedicel. These differences are not, in our opinion, sufficient to justify designating a new species, at least with the material at hand.

*Xystonellopsis cymatica* lacks the thick suboral angular swelling of *X. spicata*, the more robust pedicel of *X. cyclas* and *X. crassispinosa*, and the extremely narrow posterior cone of *X. mascarensis*. In no case is the secondary ledge like that of *X. dicymatica*.

Recorded from twelve stations, five in the Atlantic and seven in the Pacific, as follows: one (19) in the Sargasso Sea, four (22, 23, 25, 27) in the Atlantic equatorial region, one (41) in the Galápagos region, five (86, 92, 93, 96, 98) in the region of South Pacific island fields, and one (110) in the North Pacific trade region.

There are 7 pump and 6 net samples, of which 2 were taken at 50 meters and 11 at 100 meters. Frequency, 3 loricae in a pump sample at station 110; average in pump samples, 1.2 loricae.

Temperature: Atlantic, net samples 14°60–22°42 (18°68); Pacific, pump samples 14°55–27°65 (23°85). Salinity: Atlantic, net samples 35.70–37.05 (36.15); Pacific, pump samples 34.73–36.22 (35.52). Density: Atlantic, net samples 25.30–26.62 (25.98); Pacific, pump samples 22.75–26.11 (23.55). pH: Atlantic, net samples 7.93–8.25 (8.09); Pacific, pump samples 7.92–8.28 (8.17).

***Xystonellopsis dahli* (Brandt) Kofoid and Campbell**

*Xystonellopsis dahli*, Kofoid and Campbell, 1929, p. 245, fig. 483.

The rather elongated lorica, with little-differentiated aboral region and without a skirt, has a length of 6.15 oral diameters. The oral margin is thin and barely spread. The long bowl is subcylindrical in the upper three-fifths, and subconical ( $23^\circ$ ) below. The pedicel is subcylindrical, 0.19 total length in length, and without a skirt. The lance is short, conical ( $2^\circ$ ), 0.54 oral diameter in length, and sharply pointed at the free tip.

The wall has a thickness of nearly 0.08 oral diameter; it has thin laminae and enclosed fine hexagons; the outer surface is almost clear, but there are 6 subvertical lists on the pedicel.

Length, 396 to 444 $\mu$ .

*Xystonellopsis dahli* is shorter, with less aboral concavity and less aboral differentiation than *X. krämmeri*. It has no skirt as do *X. tenuirostris* and related species.

Recorded from one station (95) in the region of South Pacific island fields, in 1 pump and 1 net sample, both taken at 100 meters. Frequency, 2 per cent.

Temperature,  $28^\circ 74$ ; salinity, 35.35; density, 22.43; pH, 8.22.

***Xystonellopsis dicymatica* (Brandt) Kofoid and Campbell**

*Xystonellopsis dicymatica*, Kofoid and Campbell, 1929, p. 245 (for fig. 467 see *X. inaequalis*).

The moderately tall lorica, with two wide, equal rings marking the ends of a suboral spool, and with conical bowl, thin pedicel, and narrow lance, has a length of 5.7 oral diameters. The oral margin is thin and erect. The thickened suboral spool occupies the anterior oral diameter. Just below the oral rim is the upper ring, with a diameter of 1.4 oral diameters; the lower one has a diameter not exceeding 1.5 oral diameters. The diameter of the bowl midway between the rings is 1.3 oral diameters. The bowl below the spool contracts conically ( $16^\circ$  in the anterior 0.23 and  $20^\circ$  in the posterior 0.28 total length). The pedicel is very thin (less than 0.2 oral diameter at the most) and fairly short (0.29 total length), and has an expanded, aborally truncated skirt. The lance is conical ( $2^\circ$ ), 0.6 oral diameter in length, and sharply pointed.

The wall has a thickness of not over 0.1 oral diameter in the lower bowl. There are thin laminae, which enclose several layers of small hexagons in the spool and a single layer of radial rectangles in the lower bowl; in the skirt region there are several layers of tiny alveoles. The lumen does not enter the rings and in the lance is reduced to a fine canal.

Length, 250 to 280 $\mu$ .

Kofoid and Campbell (1929, fig. 467) have a lorica with a wide lower ring nearly 1.6 oral diameters across. This specimen is better assigned to *Xystonellopsis inaequalis*, though the ring is not saucer-shaped as in the usual *inaequalis*.

*Xystonellopsis dicymatica* differs from *X. inaequalis* in having the two rings subequal. It has 2 rings, whereas *X. cymatica* has but one, and *X. abbreviata* has three.

Recorded from nineteen stations, ten in the Atlantic and nine in the Pacific, as follows: one (19) in the Sargasso Sea, five (22, 23, 24, 27, 28) in the Atlantic equatorial region, four (31, 32, 33, 34) in the Caribbean Sea, two (35, 154) in the Pacific equatorial region, two (61, 67) in the South Pacific middle latitudes, two (68, 75) in the Galápagos region, one (113) in the North Pacific middle latitudes, and two (147, 148) in the California region.

There are 1 pump and 21 net samples, of which 5 were taken at 50 meters and 17 at 100 meters. Maximum frequency, 15 per cent at station 19; other records above minimum (2 to 15 per cent) from stations 19, 28, 32, 33, 35, 61, 67, 148, 154; averages in net samples, 2.9 and 4.0 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, net samples  $17^\circ 34$ – $26^\circ 79$  ( $22^\circ 32$ ); Pacific, pump sample  $21^\circ 74$ , net samples  $10^\circ 92$ – $25^\circ 81$  ( $17^\circ 96$ ). Salinity: Atlantic, net samples 36.00–37.05 (36.34); Pacific, pump sample 34.66, net samples 34.05–35.47 (34.84). Density: Atlantic, net samples 23.98–26.29 (25.15); Pacific, pump sample 24.06, net samples 22.98–26.06 (25.11). pH: Atlantic, net samples 7.99–8.30 (8.17); Pacific, pump sample 8.23, net samples 7.92–8.39 (8.07).

***Xystonellopsis favata* (Brandt) Jörgensen**

*Xystonellopsis favata*, Kofoid and Campbell, 1929, p. 246, fig. 477.

The fairly elongated lorica, with wide bowl, short pedicel, and lance, has a length of 4.0 oral diameters. The oral margin is thin and erect. The bowl swells within the anterior 0.3 oral diameter to 1.08 oral diameters and then contracts ( $21^\circ$ ) for 0.5 oral diameter, forming, within the upper region, a thickened section. Below this thick region the bowl is subconical ( $8^\circ$  in the anterior 1.25 oral diameters and  $33^\circ$  in the lower 1.0). The pedicel is short (0.75 oral diameter), tubular, and squarely truncated aborally. From its lower end arises the conical ( $10^\circ$ ) lance, the length of which is 0.42 oral diameter; its distal tip is sharply pointed.

The wall averages approximately 0.08 oral diameter in thickness in the bowl. There are thin laminae, enclosing several layers of extremely faint, minute alveoles. The lumen follows the contour of the bowl, but in the pedicel it forms a narrow canal which continues to the tip of the lance. On the pedicel are 12 subvertical lines or folds.

Length, 220 to 290 $\mu$ .

*Xystonellopsis favata* resembles *X. scyphium* save that its bowl is relatively longer and narrower, and its pedicel is less set off from the bowl. It is not distant from *X. tenuirostris*, but its bowl is relatively wider, with more aboral taper, and the pedicel is not so stout or so long.

Recorded from one station (75) in the Galápagos region, in a net sample taken at 100 meters. Frequency, 3 per cent.

Temperature,  $18^\circ 40$ ; salinity, 35.47; density, 25.55; pH, 8.10.

*Xystonellopsis gaussi* (Laackmann) Kofoid and Campbell

*Xystonellopsis gaussi*, Kofoid and Campbell, 1929, pp. 246-247, fig. 480.

The moderately elongated lorica, with *armata*-like form, has a narrow lance and a length of 5.23 oral diameters. The oral margin is thin and erect. The elongated bowl is subconical ( $3^\circ$  in the anterior 0.43 and  $23^\circ$  in the posterior 0.27 total length). The pedicel tapers ( $12^\circ$ ), has a length of 0.25 total length, and terminates in a squarely truncated, non-expanded skirt. The lance is pencil-shaped ( $15^\circ$ ), and 0.5 oral diameter in length.

The wall reaches 0.07 oral diameter in thickness in the bowl, and has thin laminae which enclose faint, minute alveoles. There are 8 right-wound ( $3^\circ$ ) discontinuous folds on the pedicel.

Length, 371 to 470 $\mu$ .

*Xystonellopsis gaussi* has a pencil-like lance, rather than a wide, conical lance as in *X. armata*. It differs from *X. acuminata* in size, proportions, and presence of a distinct pedicel; from both of these species it differs in having discontinuous folds rather than ridges on the pedicel. It has a definite skirt, unlike *X. heros* and related species.

Recorded from eight stations, two in the Atlantic and six in the Pacific, as follows: two (2, 16) in the Gulf Stream, two (35, 153) in the Pacific equatorial region, one (63) in the South Pacific middle latitudes, one (75) in the Galápagos region, and two (109, 151) in the North Pacific trade region.

There are 4 pump and 9 net samples, of which 1 was taken at the surface, 4 at 50 meters, and 8 at 100 meters. Maximum frequency, 9 per cent at station 2; other records above minimum (2 to 7 per cent) from stations 35, 63, 75, 151; averages, 4.2 per cent in Atlantic net samples, 4.0 per cent and 3 loricae in Pacific net and pump samples, respectively.

Temperature: Atlantic, net samples  $20^\circ 50' - 23^\circ 64'$  ( $21^\circ 26'$ ); Pacific, pump samples  $15^\circ 84' - 22^\circ 73'$  ( $18^\circ 84'$ ), net samples  $14^\circ 33' - 19^\circ 81'$  ( $17^\circ 22'$ ). Salinity: Atlantic, net samples 36.40-36.43 (36.41); Pacific, pump samples 34.42-34.76 (34.62), net samples 34.86-35.47 (35.03). Density: Atlantic, net samples 24.84-25.76 (25.50); Pacific, pump samples 23.83-25.48 (24.76), net samples 24.72-26.00 (25.48). pH: Atlantic, net samples 8.16-8.23 (8.20); Pacific, pump samples 8.08-8.31 (8.15), net samples 7.88-8.18 (8.02).

*Xystonellopsis hastata* (Biedermann) Kofoid and Campbell  
(Figure 70)

*Xystonellopsis hastata*, Kofoid and Campbell, 1929, p. 247, fig. 456.

The fairly short lorica, with oral teeth, conical bowl, and short pedicel and lance, has a length of 3.66 oral diameters. The oral margin has 24 equidistant, short, triangular denticles. The bowl expands slightly (1.13 oral diameters) within 0.13 oral diameter, then contracts ( $3^\circ$  in the anterior 1.14 oral diameters and  $34^\circ$  in the posterior similar length); the diameter at the lower end of the bowl is 0.3 oral diameter, and the whole lorica is generally convex, with a suboral ledge. The pedicel contracts from the lower end of the bowl

( $10^\circ$ ), has a length of 1.0 oral diameter, and at its lower end has a short, expanded skirt. From the center of the skirt arises the short (0.4 oral diameter), fairly stout, pointed lance.

The wall reaches 0.1 oral diameter in thickness across the ledge where it is widest; it thins down to three-tenths as much in the middle and lower bowl. There are thin laminae with enclosed radial, secondary, rectangular prisms, with minute alveoles within each one in several layers. The surface has large hexagonal areas, except for the lance, which is hyaline. There are 7 (8) short folds above the skirt on the lower pedicel. The lower pedicel is yellowish, and denser than the upper parts.

Length, 244 $\mu$ .

*Xystonellopsis hastata* is unique in the genus in having oral denticles. In general it is related to *X. cymatica* and relatives of that species, but is longer and stouter, with fuller lower bowl, relatively shorter pedicel, and less localized suboral thickening.

Recorded from five stations, three in the Atlantic and two in the Pacific, as follows: three (23, 24, 25) in the Atlantic equatorial region, and two (35, 152) in the Pacific equatorial region.

There are 2 pump and 5 net samples, of which 1 was taken at the surface and 6 at 100 meters. Maximum frequency, 3 per cent at station 152; other records above minimum (2 per cent) from stations 24, 35; average in Pacific net samples, 1.2 per cent.

Temperature: Atlantic, pump samples  $15^\circ 55' - 27^\circ 18'$  ( $21^\circ 36'$ ), net samples  $14^\circ 60' - 15^\circ 55'$  ( $15^\circ 07'$ ); Pacific, net samples  $11^\circ 48' - 14^\circ 33'$  ( $12^\circ 90'$ ). Salinity: Atlantic, pump samples 35.22-35.61 (35.41), net samples 35.61-36.02 (35.83); Pacific, net samples 34.73-34.91 (34.82). Density: Atlantic, pump samples 22.84-26.34 (24.59), net samples 26.34-26.62 (26.44); Pacific, net samples 26.06-26.50 (26.28). pH: Atlantic, pump samples 7.96-8.32 (8.14), net samples 7.93-8.18 (7.99); Pacific, net samples 7.76-7.88 (7.82).

*Xystonellopsis heroica* Kofoid and Campbell

*Xystonellopsis heroica* Kofoid and Campbell, 1929, p. 247, fig. 473.

The rather short lorica, of extreme slenderness and elongation, has a length of 7.4 oral diameters. The oral margin is thin. The bowl is swollen to a maximum of 1.17 oral diameters within the upper oral diameter. Below this swollen region it is subconical ( $4^\circ$  in the anterior 0.37 and  $30^\circ$  in the posterior 0.21 total length). The pedicel-lance has a length of almost 0.33 total length and is distally sharply pointed.

The wall scarcely reaches 0.1 oral diameter in thickness in the thickened region and is elsewhere less than a third as much. There are thin laminae with enclosed fine hexagons. There are no lists or ridges and the whole lorica is glass-clear. The lumen enters the pedicel as a canal.

Length, 174 to 218 $\mu$ .

*Xystonellopsis heroica* has a bowl and pedicel-lance of greater elongation than in *X. pinnata* and *X. heros*, which



species it otherwise rather closely resembles. Were it lacking in suboral thickening, it would be close to *Parundella longa*.

Recorded from one station (94) in the region of South Pacific island fields, in a pump sample taken at 100 meters. Frequency, minimum.

Temperature, 28°66; salinity, 35.47; density, 22.56; pH, 8.21.

#### *Xystonellopsis heros* (Cleve) Kofoid and Campbell

*Xystonellopsis heros*, Kofoid and Campbell, 1929, p. 247, fig. 484.

The very tall lorica, with distinct division between pedicel and lance, has a length of 7.9 oral diameters. The oral rim is flattened. The long bowl tapers (5°) directly from the rim without local modification throughout its whole length, and reaches 0.3 oral diameter at the squarely truncated aboral end, which is the homologue of the skirt of other species. The lance is narrow conical (2°), 0.58 oral diameter in length, and sharp-pointed at the free tip.

The wall has a subuniform thickness of 0.08 oral diameter, has thin laminae with enclosed faint hexagons, and the surface is glass-clear save for a few irregular, discontinuous, subvertical lines down the lower three-tenths. The lumen enters the lance as a canal.

Length, 475 $\mu$ .

*Xystonellopsis heros* is elongated like *X. krämmeri*, but has no skirt. *Xystonellopsis acuminata* has a plumper bowl with distinct pedicel region, as do *X. gausi*, *X. tenuirostris*, and *X. armata*.

*Xystonellopsis heros*, as here described, hardly resembles the figure given by Brandt (1906), differing in length, absence of folds on the bowl, and thinner lance. It is probably the same as the species designated by Kofoid and Campbell (1939) as *X. tropica*, new species. If so, the distributional data in this report include records of both species.

Recorded from twenty-one stations, twelve in the Atlantic and nine in the Pacific, as follows: two (14, 16) in the Gulf Stream, two (17, 18) in the Sargasso Sea, five (24, 25, 27, 28, 29) in the Atlantic equatorial region, three (31, 33, 34) in the Caribbean Sea, one (75) in the Galápagos region, three (109, 139, 151) in the North Pacific trade region, one (113) in the North Pacific middle latitudes, two (136, 147) in the California region, and two (152, 153) in the Pacific equatorial region.

There are 7 pump and 21 net samples, of which 7 were taken at 50 meters and 21 at 100 meters. Maximum frequency, 34 per cent at station 151; other records above minimum (2 to 19 per cent) from stations 14, 16, 27, 29, 31, 33, 34, 75, 136, 147, 152, 153; averages in net samples, 1.5 and 11.3 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, pump samples 18°08–23°64 (22°44), net samples 14°60–26°04 (20°63); Pacific, 19°81–23°77 (22°02) and 14°32–22°73 (18°64), respectively. Salinity: Atlantic, pump samples 36.03–36.48 (36.30), net samples 35.59–36.82 (36.32); Pacific, 34.59–35.18 (34.82) and 34.42–35.47 (34.86), respectively. Density: Atlantic, pump samples

24.84–26.06 (25.63), net samples 23.98–26.66 (25.56); Pacific, 23.42–24.72 (24.08) and 23.83–25.75 (25.01), respectively. pH: Atlantic, pump samples 8.09–8.23 (8.18), net samples 7.93–8.27 (8.16); Pacific, 8.18–8.28 (8.23) and 7.87–8.39 (8.18), respectively.

#### *Xystonellopsis inaequalis* Kofoid and Campbell

*Xystonellopsis inaequalis* Kofoid and Campbell, 1929, pp. 247–248, fig. 466.

*Xystonellopsis dicymatica*, Kofoid and Campbell, 1929, fig. 467 (for p. 245 see *X. dicymatica*).

The fairly short lorica, of general *dicymatica* type, with the lower ledge much wider than the upper one, has a length of 7.0 oral diameters. The thin oral margin is erect. The bowl forms a short cylinder within the anterior 0.25 oral diameter, at the lower end of which arises the flat, ringlike upper ledge, with a diameter of 1.28 oral diameters. Below this ledge the suboral band swells with a wide sigmoid curve to the secondary or lower ledge, the diameter of which is 1.68 oral diameters. The suboral band occupies the anterior 1.08 oral diameters. The bowl below the band is subconical (14° increasing to 30° in the lower oral diameter). The pedicel tapers (2°), with a length of 0.39 total length, and at its distal end is an expanded skirt. The free edge of this skirt has 6 (8) clawlike projections. From the center of the skirt arises the pencil-like lance (0.64 oral diameter in length).

The wall is thickest in the suboral band, where it reaches as much as 0.2 oral diameter; elsewhere it is quickly reduced to three-tenths as much or even less. There are thin, hyaline laminae with enclosed radial secondary prisms in a single layer, save in the band, where there are several layers of smaller hexagons. The lumen does not enter the ledges. The whole lorica, save the skirted region, is translucent; the latter is brownish.

Length, 246 to 350 $\mu$ .

The *Carnegie* loricae are more slender (7.0 oral diameters as against 5.75) than usual; they are also longer (up to 350 $\mu$ ). Most of them have a concave secondary ledge, this being like a dish or saucer rather than a flat ring.

*Xystonellopsis inaequalis* resembles *X. dicymatica* closely except that the lower ledge is much wider and the suboral band is generally wider. Intergrades do not seem to be frequent.

Recorded from eight stations, four each in the Atlantic and the Pacific, as follows: three (18, 19, 20) in the Sargasso Sea, one (34) in the Caribbean Sea, two (35, 37) in the Pacific equatorial region, one (78) in the Galápagos region, and one (82) in the region of South Pacific island fields.

There are 3 pump and 5 net samples, of which 3 were taken at 50 meters and 5 at 100 meters. Frequency, 3 per cent at station 19; 2 per cent at station 35; average in Atlantic net samples, 1.2 per cent.

Temperature: Atlantic, net samples 20°32–24°63 (22°48); Pacific, net sample 16°30, pump samples 19°82–24°34 (22°06). Salinity: Atlantic, net samples 36.55–37.05 (36.78); Pacific, net sample 34.88, pump samples 34.53–36.46 (35.76).

Density: Atlantic, net samples 24.65–26.67 (25.69); Pacific, net sample 25.60, pump samples 24.47–25.11 (24.74). pH: Atlantic, net samples 8.19–8.25 (8.21); Pacific, net sample 7.92, pump samples 8.00–8.19 (8.11).

*Xystonellopsis krämmeri* (Brandt) Kofoid and Campbell

*Xystonellopsis krämmeri*, Kofoid and Campbell, 1929, p. 248, fig. 485.

The greatly elongated lorica, with *heros*-like form and with spiral lines on the pedicel, has a length of 8.9 oral diameters. The oral margin is sharp, with a bare suboral flare. The very long bowl is subconical ( $7^\circ$  as a whole, but  $2^\circ$  in the upper two-thirds and  $10^\circ$  in the aboral third). The pedicel is subcylindrical and about 0.6 oral diameter in length, with a scant skirt at its lower end. The lance is wide conical ( $20^\circ$ ), and 0.6 oral diameter in length.

The wall has a thickness of less than 0.07 oral diameter. There are thin laminae with enclosed minute alveoles in the upper bowl; in the lower bowl and pedicel these become large prisms. The pedicel has 8 slightly ( $5^\circ$ ) left-turned ridges which arise at the skirt and extend the whole length of the pedicel.

Length, 535 to 618 $\mu$ .

*Xystonellopsis krämmeri* is closest to *X. dahli*, but is much longer and has a clearer-cut skirt. It bears some resemblance to *X. heros*, but lacks the distinct lance, and is much longer; it differs similarly from *X. acuminata*.

Recorded from six stations, three each in the Atlantic and the Pacific, as follows: two (28, 30) in the Atlantic equatorial region, one (34) in the Caribbean Sea, one (67) in the South Pacific middle latitudes, one (145) in the North Pacific middle latitudes, and one (146) in the California region.

There are 6 net samples, of which 1 was taken at 50 meters and 5 at 100 meters. Maximum frequency, 7 per cent at station 67; other records above minimum (2 per cent) from stations 28, 145, 146; average in the Pacific, 3.7 per cent.

Temperature: Atlantic,  $21.02$ – $25.54$  ( $23.30$ ); Pacific,  $16.36$ – $20.07$  ( $18.53$ ). Salinity: Atlantic,  $36.40$ – $36.65$  ( $36.56$ ); Pacific,  $34.32$ – $34.70$  ( $34.44$ ). Density: Atlantic,  $24.25$ – $25.76$  ( $25.03$ ); Pacific,  $24.24$ – $25.45$  ( $24.72$ ). pH: Atlantic,  $8.16$ – $8.28$  ( $8.22$ ); Pacific,  $8.09$ – $8.34$  ( $8.23$ ).

*Xystonellopsis laticincta* Kofoid and Campbell

*Xystonellopsis laticincta* Kofoid and Campbell, 1929, p. 248, fig. 469.

The moderately long lorica, with thick suboral band, conical bowl, long pedicel, and flaring skirt, has a length of 6.9 oral diameters. The oral rim is thin and erect. The suboral band occupies the anterior 0.21 total length. It has an upper and a lower ring with diameters of 1.45 oral diameters, and the included region is thickened. The bowl below the spool is subconical ( $10^\circ$  in the anterior 0.19 and  $40^\circ$  in the posterior 0.13 total length). The pedicel is wide at its upper end (0.55 oral diameter) and tapers ( $4^\circ$ ) to just above the flaring skirt. The skirt is repeated. From its middle

arises the lance. The lance is conical ( $2^\circ$ ), needle-like, and 0.56 oral diameter in length.

The wall has a thickness of 0.1 oral diameter below the suboral spool; in other regions it is like that of *Xystonellopsis abbreviata*. There are left-turned striae above the skirt.

Length, 304 to 343 $\mu$ .

*Xystonellopsis laticincta* has a wider suboral band and longer pedicel than *X. abbreviata*. It is narrower, with a shorter, lower bowl, thinner pedicel, and more slender lance than *X. torta*. The pedicel is shorter, the skirt less suddenly differentiated, and the spool wider than in *X. clevei*.

Recorded from two stations (86, 87) in the region of South Pacific island fields, in 2 pump samples taken at 100 meters. Frequency, 2 per cent at station 86; average, 1.5 per cent.

Temperature,  $24.07$ – $25.11$  ( $24.59$ ); salinity,  $36.02$ – $36.22$  ( $36.12$ ); density,  $24.25$ – $24.41$  ( $24.33$ ); pH,  $8.23$ – $8.25$  ( $8.24$ ).

*Xystonellopsis ornata* (Brandt) Kofoid and Campbell

(Figure 69)

*Xystonellopsis ornata*, Kofoid and Campbell, 1929, p. 249, fig. 463.

The rather large lorica, with remarkable spool-like upper differentiation, conical bowl, and lower dagger-like mass, has a length of 3.8 oral diameters. The oral rim is erect, thin, and sharp. The upper bowl has unique differentiation (analogous with that of *Stelidiella simplex* and partially with that of *Epicranella bella*). There is a narrow angular ledge (1.16 oral diameters) within the anterior 0.05 oral diameter, followed by a wider angular but narrowed one (1.45 oral diameters) at 0.84 oral diameter below the rim. The spool-like region thus formed has 12 vertical, sinuous, equidistant ribs, which arise from the upper surface of the wide ledge and run decurrently to just below the upper ledge; these ribs subdivide the upper bowl into 12 curved, subequal facets. The bowl contracts ( $19^\circ$ ) subconically for about 0.42 total length below the lower ledge and at the lower end has a diameter of approximately 0.5 oral diameter; its anterior diameter just below the wide ledge is 0.84 oral diameter. The remaining 0.38 total length is an irregular, dagger-like mass homologous with the pedicel and the lance of other species of *Xystonellopsis*. This mass spreads out ( $20^\circ$ ) to 0.55 oral diameter near 0.8 oral diameter from the aboral tip, and below that level is more or less regularly reduced subconically ( $42^\circ$ ) to the sharply pointed aboral tip. The aboral end is minutely open.

The wall reaches almost 0.28 oral diameter in thickness across the lower ledge, but its average thickness is hardly 0.05. There are thin laminae and enclosed faint radial secondary prisms. The wall thickens up in the aboral 0.38 total length and leaves a narrow canal to descend to the open tip; the canal has a widened region at about 0.75 of its length. The secondary alveoles of this posterior region are in several layers and are hexagons. The lumen does not enter the ledges, being generally conical. The surface has a clear but faint hexagonal meshwork.

The animal is rather small and has 2 macronuclei.

Length, 262 $\mu$ .

The *Carnegie* loricae are longer and also less full aborally than those from other sources.

*Xystonellopsis ornata* can scarcely be confused with any other *Xystonellopsis*, for none of them has the upper spool-like structure, nor the aboral dagger-shaped mass. This upper differentiation is possibly correlated with the relation of the lorica to the water, and the lower mass may act as a counterpoise in directed locomotion.

Recorded from three stations in the Pacific, as follows: one (35) in the Pacific equatorial region, and two (41, 74) in the Galápagos region.

There are 3 net samples, of which 1 was taken at 50 meters and 2 at 100 meters. Frequency, 6 per cent at station 41; average, 3.3 per cent.

Temperature, 14°55–16°55 (15°79); salinity, 34.88–35.14 (35.01); density, 25.60–26.11 (25.82); pH, 7.89–7.92 (7.91).

#### *Xystonellopsis paradoxa* (Cleve) Jörgensen

(Figure 63)

*Xystonellopsis paradoxa*, Kofoid and Campbell, 1929, p. 249, fig. 463.

The fairly short lorica, with duplicated knob and slender lance, has a length of 4.0 oral diameters. The oral margin is sharp-edged and erect. The bowl expands (40°) within the anterior 0.35 oral diameter to a diameter of 1.23 oral diameters, at that level forming a ledge. Below, the bowl contracts, and then swells to 1.12 oral diameters at 0.58 oral diameter below the rim. The swollen region continues over a band of approximately 0.5 oral diameter, and then contracts subconically (11°) for a length equal to 1.62 oral diameters, below which it rapidly contracts (60°) for a short distance. The pedicel begins flaring (75°), and reaches 0.77 oral diameter at 0.71 total length from the rim. The lower edge of this skirt is crenulate, and left-turning, short folds extend upward from the crinkles. The secondary skirt arises at 0.5 oral diameter below the primary one. Its width is similar to its length, and, like the former one, its edge is crenulate. The lance (0.73 oral diameter in length) is narrow conical (9°), arises from a spreading base, and is pointed at its free tip.

The wall is thickest in the suboral swollen region, where it reaches 0.16 oral diameter; elsewhere it is only a tenth as much. There are thin laminae which enclose radial secondary prisms. The lumen is generally conical in the bowl, but in the skirted region it narrows down, and finally forms, in the lance, a sinuous canal. The surface shows hexagonal prisms, save for the hyaline lance.

Length, 231μ.

*Xystonellopsis paradoxa* resembles *X. conicacauda* closely, save that the lance is longer and much more slender. The region between the two skirts, also, is much narrower in *paradoxa*. In some ways its resemblance to *X. dilatata* is apparent, save as the latter lacks the thick suboral region and the two skirts, and has a shorter, wider lance like that of *conicacauda*.

Recorded from eight stations, three in the Atlantic and five in the Pacific, as follows: two (19, 20) in the Sargasso Sea, one

(23) in the Atlantic equatorial region, two (41, 75) in the Galápagos region, one (63) in the South Pacific middle latitudes, and two (101, 110) in the North Pacific trade region.

There are 4 pump and 5 net samples, of which 1 was taken at 50 meters and 8 at 100 meters. Frequency, 2 per cent at station 20; other records minimum.

Temperature: Atlantic, net samples 20°99–22°56 (21°99); Pacific, net sample 18°40, pump samples 14°55–25°12 (18°36). Salinity: Atlantic, net samples 36.02–37.73 (36.71); Pacific, net sample 35.47, pump samples 34.58–35.02 (34.85). Density: Atlantic, net samples 25.30–25.67 (25.45); Pacific, net sample 25.55, pump samples 23.40–26.11 (25.00). pH: Atlantic, net samples 8.14–8.25 (8.19); Pacific, net sample 8.10, pump samples 7.92–8.23 (8.09).

#### *Xystonellopsis pulchra* (Kofoid) Kofoid and Campbell

(Figure 66)

*Xystonellopsis pulchra*, Kofoid and Campbell, 1929, p. 250, fig. 471.

The rather elongated lorica, with three ledges, thick pedicel, skirt, and short lance, has a length of 7.0 oral diameters. The oral margin is thin and erect. The bowl forms a short cylinder with a width of less than 0.1 oral diameter, and from its lower edge arises the thin upper ledge, with a diameter of 1.55 oral diameters. Below this ledge arise two others; the first of these, with a diameter of 1.61 oral diameters, and the second, with a diameter of 1.67 oral diameters, are at 0.9 and 1.42 oral diameters below the oral rim. All these ledges are biconvex, the lower two being thicker than the upper one. The region of the bowl occupied by them is wider and thicker than below. The lower bowl is generally conical (18° in the upper half and 33° in the lower section). The diameter of the bowl at the distal end is 0.42 oral diameter. The pedicel is tubular, and nearly 0.44 total length in length, with a lower, somewhat expanded, skirtlike distal end; this region is pleated with about 12 low, vertical folds. From the center of this structure arises the pencil-like lance (0.61 oral diameter in length), with blunted tip.

The wall is thickest (less than 0.08 oral diameter) in the upper bowl, and thins to two-thirds as much lower down. There are thin laminae which enclose a single layer of radial secondary prisms; these, in turn, include several layers of alveoles. In the ledges there are several layers of hexagons. The lumen conforms to the outer contour except suborally.

Length, 360μ.

*Xystonellopsis pulchra* resembles *X. abbreviata*, but has a wider suboral band, longer pedicel, and stouter proportions. It lacks the distal twisted lines of *X. torta* and the repeated skirts of *X. laticincta*, and has more rings than *X. dicymatica*.

Recorded from seventeen stations, three in the Atlantic and fourteen in the Pacific, as follows: three (23, 25, 29) in the Atlantic equatorial region, two (35, 152) in the Pacific equatorial region, five (41, 42, 44, 45, 68) in the Galápagos region, two (65, 67) in the South Pacific middle latitudes, three (132, 136, 146) in the California region, one (144) in the North Pacific middle latitudes, and one (151) in the North Pacific trade region.

There are 5 pump and 14 net samples, of which 5 were taken at 50 meters and 14 at 100 meters. Maximum frequency, 27 per cent at station 45; other records above minimum (2 to 9 per cent) from stations 25, 35, 41, 65, 67, 136, 151, 152; average in Pacific net samples, 6.3 per cent.

Temperature: Atlantic, pump sample 23°10, net samples 14°60–20°99 (17°79); Pacific, 14°32–20°52 (16°68) and 11°48–21°69 (18°48), respectively. Salinity: Atlantic, pump sample 36.59, net samples 35.70–36.04 (35.87); Pacific, 33.40–34.86 (34.33) and 34.30–35.21 (34.45), respectively. Density: Atlantic, pump sample 25.13, net samples 25.30–26.62 (25.96); Pacific, 24.53–25.75 (25.05) and 24.24–26.50 (25.45), respectively. pH: Atlantic, pump sample 8.21, net samples 7.93–8.14 (8.03); Pacific, 7.87–8.37 (8.14) and 7.76–8.39 (8.04), respectively.

#### *Xystonellopsis tenuirostris* (Brandt) Kofoid and Campbell

*Xystonellopsis tenuirostris*, Kofoid and Campbell, 1929, p. 250, fig. 479.

The fairly short lorica, with suboral swelling, short pedicel, and pencil-shaped lance, has a length of 4.25 oral diameters. The thin oral margin is outspread. The bowl swells within 0.45 oral diameter to 1.1 oral diameters, and then contracts (15°) within an oral diameter. Below the swollen region the bowl is subconical (14° in the anterior 0.29 and 28° in the posterior 0.25 total length). The pedicel is subcylindrical, with distal flare forming the barely extended skirt, and with a length of nearly 0.24 total length. The lance is conical (12°), 0.4 oral diameter in length, and sharply pointed at the free tip.

The wall has a thickness of 0.06 oral diameter in the widest region, and half as much in the lower bowl. There are thin laminae which enclose hyaline substance. The lumen is unaltered by the suboral thickening and extends into the lance as a narrow canal. The pedicel has 12 subvertical ridges on its whole length.

There are 2 oval macronuclei.

Length, 240 to 270 $\mu$ .

*Xystonellopsis tenuirostris* resembles *X. favata* in form, but has a wide suboral thickening and a less slender, more cylindrical pedicel. *Xystonellopsis gausi* is taller and has a thicker pedicel and longer lower bowl.

Recorded from seven stations, two in the Atlantic and five in the Pacific, as follows: two (25, 27) in the Atlantic equatorial region, two (44, 46) in the Galápagos region, one (98) in the region of South Pacific island fields, one (101) in the North Pacific trade region, and one (145) in the North Pacific middle latitudes.

There are 4 pump and 3 net samples, of which 2 were taken at 50 meters and 5 at 100 meters. Maximum frequency, 18 per cent at station 145; 3 per cent at station 98, in a pump sample.

Temperature: Atlantic, net samples 14°60–18°08 (16°34); Pacific, pump samples 14°22–26°89 (22°37). Salinity: Atlantic, net samples 35.70–36.03 (35.86); Pacific, net sample 34.71, pump samples 35.04–35.33 (35.18). Density: Atlantic, net samples 26.06–26.62 (26.34); Pacific, pump samples

22.97–26.19 (24.17). pH: Atlantic, net samples 7.93–8.09 (8.01); Pacific, net sample 8.31, pump samples 7.88–8.23 (8.10).

#### PARUNDELLA Jörgensen emended

*Parundella*, Kofoid and Campbell, 1929, pp. 225–226.

*Parundella* was formerly included as the first among the Xystonellidae. Because of its hyaline, clear wall, rarely with prismatic elements, and smooth, fine finish, it is here placed among the more advanced genera. The oral margin, though simple, is much as in *Xystonellopsis*. *Parundella* leads toward the Undellidae and also toward the Petalotrichidae, in which families the wall is similar or close. In form and in the occasional presence of typical wall characters, it agrees with the other Xystonellidae.

*Parundella* is common in cooler seas as well as sometimes in the deeper waters of the tropics.

Eight species are described here.

#### *Parundella aculeata* Jörgensen

*Parundella aculeata*, Kofoid and Campbell, 1929, p. 226, fig. 430.

The rather tall, elongated lorica, with fairly short, contracted aboral region and lance, has a length of 4.45 oral diameters. The thin oral margin is sharp-edged. The bowl is subcylindrical in the anterior 0.51 total length. The lower section is inverted conical (45°), with a length of nearly 0.29 total length. At its lower end is the narrow, needle-like (8°) lance, the length of which is about 0.2 total length; the free tip is sharp.

The hyaline wall has laminae with homogeneous material enclosed. Its thickness hardly reaches 0.1 oral diameter and is practically uniform. The cavity enters the lance but does not continue its whole length.

Length, 143 $\mu$ .

*Parundella aculeata* differs from *P. longa* in having a shorter aboral cone and longer lance; it is also shorter. *Parundella translucens* flares suborally and has a shorter, less differentiated lance. *Parundella major* is broader, with a longer aboral cone and shorter lance.

Recorded from six stations, four in the Atlantic and two in the Pacific, as follows: four (22, 24, 25, 30) in the Atlantic equatorial region, and two (40, 41) in the Galápagos region.

There are 2 pump and 5 net samples, of which 1 was taken at 50 meters and 6 at 100 meters. Frequency, minimum.

Temperature: Atlantic, net samples 14°60–25°54 (19°26); Pacific, pump samples 13°93–14°55 (14°24). Salinity: Atlantic, net samples 35.61–36.40 (35.92); Pacific, pump samples 34.99–35.02 (35.00). Density: Atlantic, net samples 24.25–26.62 (25.47); Pacific, pump samples 26.11–26.21 (26.16). pH: Atlantic, net samples 7.93–8.28 (8.07); Pacific, pump samples 7.85–7.92 (7.88).

#### *Parundella acuta* Kofoid and Campbell

*Parundella acuta* Kofoid and Campbell, 1929, p. 226, fig. 430.

The stout, bell-shaped lorica, with lateral concavity produced by a double expansion, and with short aboral cone

and acute end, has a length of 2.35 oral diameters. The thin-edged oral margin is sharp. The bowl swells rapidly to a diameter of 1.12 oral diameters within the upper tenth, forming a rounded band nearly 0.5 oral diameter in width. Below the ring, the bowl has a general cylindrical form for a length of nearly 1.0 oral diameter, and then swells again slightly to a diameter equal to that of the suboral ring. The aboral cone ( $67^\circ$ ) is slightly convex and its tip is sharply acute, there being no lance as in other species.

The hyaline wall has inner and outer laminae which enclose regular, radial, rectangular secondary prisms. Its thickness is 0.13 oral diameter across the ring and the thick-walled aboral cone; it is only a third as much in the cylindrical bowl.

There are 2 macronuclei.

Length, 80 to 91 $\mu$ .

*Parundella acuta* resembles *P. aciculifera*, but lacks even a trace of lance, and has thinner, only locally thick walls. The suboral ring and thick-walled aboral cone set *acuta* off from other species, as does the lack of lance. It only remotely resembles *P. invaginata*, and is so unlike all the other species that little chance of confusion exists.

Recorded from two stations in the Pacific, as follows: one (86) in the region of South Pacific island fields and one (116) in the North Pacific middle latitudes.

There are 2 pump samples, of which 1 was taken at the surface and 1 at 100 meters. Frequency, minimum.

Temperature,  $16^\circ.07$ – $25^\circ.11$  ( $20^\circ.59$ ); salinity, 34.02–36.22 (35.12); density, 24.25–24.99 (24.62); pH, 8.17–8.25 (8.21).

#### *Parundella caudata* (Ostenfeld) Kofoid and Campbell

*Parundella caudata*, Kofoid and Campbell, 1929, p. 228, fig. 442.

The moderately tall, bell-shaped lorica, with fins at the junction of bowl and lance, has a length of 3.28 oral diameters. The thin oral margin is slightly incurved. The campanulate bowl swells from the rim to 1.14 oral diameters at 0.28 oral diameter below the rim, and then tapers ( $10^\circ$ ) for 0.52 total length, the diameter at the lower end being 0.86 oral diameter. Below this level the bowl becomes more widely conical ( $40^\circ$ ), and this section has a length of 0.19 total length. The lance has a basal diameter of 0.5 oral diameter, is conical ( $12^\circ$ ), and has a length of 1.0 oral diameter. Its free tip is blunt.

The hyaline wall reaches 0.07 oral diameter in thickness at the anterior end of the lance and is less thick in other parts. The cavity of the lance is reduced by the thickening. Near the oral end of the lance are 4 (?) winglike finlets.

Length, 90 to 125 $\mu$ .

*Parundella caudata* is much like *P. gigantea*, but has wing-like finlets and a less distinct cone and lance. *Parundella lohmanni* is longer and coarser, and has a rounded aboral region and thick lance.

Recorded from two stations, one each in the Atlantic and the Pacific, as follows: one (18) in the Sargasso Sea, and one (130) in the California region.

There are 1 pump and 1 net sample, both taken at 100 meters. Frequency, minimum.

Temperature: Atlantic, pump sample  $8^\circ.96$ ; Pacific, net sample  $20^\circ.32$ . Salinity: Atlantic, pump sample 33.72; Pacific, net sample 36.81. Density: Atlantic, pump sample 26.14; Pacific, net sample 26.07. pH: Atlantic, pump sample 8.06; Pacific, net sample 8.21.

#### *Parundella inflata* Kofoid and Campbell

(Figure 67)

*Parundella inflata* Kofoid and Campbell, 1929, p. 230, fig. 431.

The rather short but elongated lorica, with contracted aboral conical section and long spinelike lance, has a length of 3.96 oral diameters. The thin oral margin is sharp and has no flare. The long bowl is submedianly inflated to 1.14 oral diameters near 0.33 total length from the rim. Below this level it contracts convexly ( $30^\circ$ ) for near 0.29 total length; its diameter at the lower end is 0.64 oral diameter. The lower section tapers ( $15^\circ$ ) for 0.15 total length and then more suddenly contracts ( $70^\circ$ ), the lower end being 0.82 total length below the rim. The lance is narrow conical ( $9^\circ$ ), spinelike, and 0.18 total length in length; its free tip is sharply pointed.

The hyaline wall thickens within the anterior one-fifth to 0.14 oral diameter, and is less than a third that much in the lower bowl and hollow spine.

Length, 92 to 125 $\mu$ .

The loricae of this expedition tend toward greater inflation and somewhat stouter lances than are typical; they are also commonly longer.

*Parundella inflata* differs from *P. aculeata* in the generally more abrupt aboral contraction; from *P. clavus* in being longer and less stout; and from *P. invaginata* not only in being narrower and longer, but also in the lack of the peculiar introverted aboral section which distinguishes *invaginata*. It is more narrow-bowled than *Xystonellopsis scyphium*.

Recorded from six stations, three each in the Atlantic and the Pacific, as follows: two (19, 20) in the Sargasso Sea, one (23) in the Atlantic equatorial region, two (75, 78) in the Galápagos region, and one (115) in the North Pacific middle latitudes.

There are 1 pump and 5 net samples, all taken at 100 meters. Maximum frequency, 25 per cent at station 115; one other record (station 78) was 2 per cent.

Temperature: Atlantic, net samples  $22^\circ.56$ – $36^\circ.02$  ( $27^\circ.00$ ); Pacific, pump sample  $22^\circ.04$ , net samples  $15^\circ.85$ – $18^\circ.40$  ( $17^\circ.12$ ). Salinity: Atlantic, net samples 36.72–37.05 (36.89); Pacific, pump sample 36.17, net samples 34.63–35.47 (35.05). Density: Atlantic, net samples 25.38–25.67 (25.52); Pacific, pump sample 25.11, net samples 25.51–25.57 (25.53). pH: Atlantic, net samples 8.18–8.25 (8.20); Pacific, pump sample 8.14, net samples 8.08–8.10 (8.09).

#### *Parundella lachmanni* (Daday) Kofoid and Campbell

*Parundella lachmanni*, Kofoid and Campbell, 1929, p. 231, fig. 427.

The short, conical lorica, with suboral flare and without distinct lance, has a length of 3.0 oral diameters. The oral

rim is thin. The suboral region flares ( $11^\circ$ ) within the upper 0.84 oral diameter, and the bowl swells a little (to 1.09 oral diameter) near its middle. It contracts below ( $30^\circ$ ), with fairly convex sides. The aboral region tends to a little lateral concavity and is sharply pointed, although not prolonged at the tip.

The hyaline wall hardly exceeds 0.08 oral diameter in thickness.

Length, 90 $\mu$ .

*Parundella lachmanni* is close to *P. minor* and *P. grandis*, but differs from these two species in having suboral flare and median swelling, as well as in being somewhat longer. Other species are so different as to occasion no confusion.

Recorded from seventeen stations, one in the Atlantic and sixteen in the Pacific, as follows: one (14) in the Gulf Stream, one (35-36) in the Pacific equatorial region, seven (44, 68, 69, 71, 75, 76, 77) in the Galápagos region, three (64, 66, 67) in the South Pacific middle latitudes, two (110, 150) in the North Pacific trade region, one (114) in the North Pacific middle latitudes, and two (133, 148) in the California region.

There are 13 pump and 10 net samples, of which 6 were taken at the surface, 6 at 50 meters, and 11 at 100 meters. Maximum frequency, 30 per cent at station 114; other records above minimum (2 to 24 per cent) from stations 14, 35-36, 68, 69, 71, 75, 77, 148; average in Pacific net samples, 7.3 per cent.

Temperature: Atlantic, net sample 14°02; Pacific, pump samples 15°00-23°46 (18°55), net samples 15°03-23°72 (18°08). Salinity: Atlantic, net sample 35.59; Pacific, pump samples 34.54-35.24 (35.12), net samples 34.30-36.04 (35.89). Density: Atlantic, net sample 26.66; Pacific, pump samples 24.00-25.91 (25.04), net samples 24.49-25.55 (25.05). pH: Atlantic, net sample 8.06; Pacific, pump samples 7.86-8.32 (8.25), net samples 8.09-8.19 (8.12).

#### *Parundella longa* Jörgensen

*Parundella longa*, Kofoid and Campbell, 1929, pp. 231-232, fig. 429.

The narrow, elongated lorica, with cylindrical upper bowl, long conical section, and drawn-out lance, has a length of 6.0 oral diameters. The thin, erect oral margin is sharp-edged. The cylindrical section has a length of 0.48 total length; its diameter is uniform. The aboral section is narrow, conical ( $25^\circ$ ), and almost 0.3 total length in length. The lance is also conical ( $7^\circ$ ) and 0.22 total length in length. It is gradually differentiated from the aboral cone, and its free tip is sharp.

The hyaline wall is uniformly 0.15 oral diameter in thickness, save just below the rim.

Length, 190 $\mu$ .

*Parundella longa* differs from *P. aculeata* in the greater elongation of the aboral cone, the longer lance, and the more slender proportions and dimensions. *Parundella translucens* is shorter and wider and has a shorter aboral cone and lance; its suboral margin also flares.

Recorded from six stations in the Atlantic, as follows: two (5, 6) in the Atlantic drift, one (6-7) in the North Sea, two

(13, 14) in the Gulf Stream, and one (18) in the Sargasso Sea.

There are 2 pump and 5 net samples, of which 2 were taken at the surface, 2 at 50 meters, and 3 at 100 meters. Frequency, 4 per cent at station 14; other records minimum; average in net samples, 1.7 per cent.

Temperature: pump samples 14°33-23°88 (17°21), net samples 14°02-22°12 (15°77). Salinity: pump samples 34.88-35.96 (35.19), net samples 35.55-36.82 (35.99). Density: pump samples 24.42-26.17 (25.56), net samples 25.58-26.95 (26.61). pH: pump samples 7.88-8.23 (7.98), net samples 8.06-8.24 (8.16).

#### *Parundella pellucida* (Jörgensen) emended Kofoid and Campbell

*Parundella pellucida*, Kofoid and Campbell, 1929, p. 233, fig. 438; Hada, 1932b, p. 568, fig. 21.

The small, short lorica, with tubular bowl, contracted aboral cone, and lance, has a length of 4.0 oral diameters. The thin-edged oral margin is erect. The long subcylindrical section of the bowl has a length of 0.56 total length and its diameter is similar throughout. The aboral cone ( $42^\circ$ ) has a length of 1.25 oral diameters, below which it contracts as an inverted cone ( $12^\circ$ ), the basal diameter of which is 0.25 oral diameter, the length being 0.75 oral diameter. The lance is conical ( $8^\circ$ ), with a length of 1.0 oral diameter, and with its free tip sharp.

The wall is hyaline and uniformly about 0.02 oral diameter in thickness, except in the lance.

Length, 72 to 102 $\mu$ .

*Parundella pellucida* differs from *P. inflata* in having a cylindrical bowl, and in the fuller aboral cone and stouter lance. It lacks suboral flare, which is present in *P. translucens* and *P. lagena*. *Parundella longa* is longer and lacks the doubled aboral contraction, as does *P. major*. The longer *P. caudata* has a stouter lance.

Recorded from three stations, one in the Atlantic and two in the Pacific, as follows: one (14) in the Gulf Stream, one (65) in the South Pacific middle latitudes, and one (118) in the East Asiatic marginal sea.

There are 2 pump and 1 net sample, of which 1 each was taken at the surface, 50 meters, and 100 meters. Frequency, minimum.

Temperature: Atlantic, pump sample 14°95; Pacific, pump sample 10°18, net sample 15°03. Salinity: Atlantic, pump sample 35.10; Pacific, pump sample 33.61, net sample 34.30. Density: Atlantic, pump sample 26.08; Pacific, pump sample 25.85, net sample 25.44. pH: Atlantic, pump sample 8.18; Pacific, pump sample 8.21, net sample 8.10.

#### *Parundella praetenuis* Kofoid and Campbell

*Parundella praetenuis* Kofoid and Campbell, 1929, p. 233, fig. 439.

The short, wide, bell-shaped lorica, with conical aboral region and conical lance, has a length of 2.56 oral diameters. The thin oral margin is sharp-edged. The plump bowl tapers ( $10^\circ$ ) within its anterior 0.39; the diameter of the

lower end of this section is 0.85 oral diameter. The lower section of the bowl is inverted conical ( $47^\circ$ ), and its length is a little more than 0.33 total length. The lance is about as long as the section above it, and it tapers ( $12^\circ$ ) to the sharply pointed free tip.

The hyaline wall has a maximum thickness of 0.15 oral diameter within the upper one-fifth, the lower bowl and lance having a wall thickness of less than a third as much.

Length, 89 to 113 $\mu$ .

*Parundella praetenuis* differs from *P. difficilis* in its relatively shorter bowl and longer lance; it is actually also shorter. *Parundella humerosa* is longer, with greater suboral bulge and stouter horn; this is also true of *P. caudata* and *P. gigantea*.

Recorded from two stations in the Pacific, as follows: one (75) in the Galápagos region and one (111) in the North Pacific middle latitudes.

There are 1 pump and 1 net sample, of which 1 each was taken at 50 and 100 meters. Frequency, 9 per cent in the net sample.

Temperature: net sample  $18^\circ 40$ , pump sample  $19^\circ 39$ . Salinity: net sample 35.47, pump sample 34.58. Density: net sample 25.55, pump sample 24.62. pH: net sample 8.10, pump sample 8.18.

#### XYSTONELLA Brandt emended

*Xystonella*, Kofoid and Campbell, 1929, p. 234.

The presence of a suboral trough distinguishes this genus from *Xystonellopsis* and marks it as more advanced in oral characters; in the Tintinnoina the suboral region and the aboral section afford the most distinctive characteristics. *Xystonella* is no exception. Wall characters are virtually the same as in other genera of the family.

*Xystonella*, though more advanced in oral characters, is not especially abundant either in kind or in number. As a whole the species seem to prefer somewhat cooler waters than do those of *Xystonellopsis*, but not the icy arctic oceans. One species, *Xystonella treforti*, is likely to be found almost anywhere in warm oceanic waters.

Eight species are described here, of which two are new.

#### *Xystonella acus* (Brandt) Brandt

*Xystonella acus*, Kofoid and Campbell, 1929, p. 234, fig. 447.

The short, chalice-shaped lorica, with long, spindle-like lance, has a length of 4.2 oral diameters. The thin oral rim is erect and scarcely developed. The suboral trough is almost flat, and its outer rim has a diameter of 1.1 oral diameters. The bowl flares ( $21^\circ$ ) within the anterior 0.67 oral diameter; the diameter at the lower end of the flare is similar to the length. Below this level the bowl gradually contracts until it reaches 0.55 oral diameter at 1.33 oral diameters below the rim, and then expands to 0.67 oral diameter at 2.0 oral diameters. Below this last level it is conical ( $33^\circ$ ) for 1.22 oral diameters. The lance is contracted in its middle and swells to a narrow lancet-shaped extension toward the distal end; the free tip is sharp. The lance has a length of little more than 0.31 total length.

The wall is uniformly approximately 0.07 oral diameter in thickness, and there are laminae which enclose secondary prisms. The surface is covered by a fine, pallid hexagonal mesh.

Length, 190 $\mu$ .

*Xystonella acus* has a spindle-like lance, whereas *X. lanceolata* has a tubular one and *X. longicauda* has a needle-like one, as does also the much longer *X. lohmanni*. *Xystonella curticauda* and *X. flemingi* have relatively shorter lances, of different form.

Recorded from six stations, one in the Atlantic and five in the Pacific, as follows: one (5) in the Atlantic drift, two (51, 65) in the South Pacific middle latitudes, one (78) in the Galápagos region, one (113) in the North Pacific middle latitudes, and one (135) in the California region.

There are 3 pump and 3 net samples, of which 2 were taken at the surface and 4 at 100 meters. Maximum frequency, 4 per cent at station 113; other records minimum; average in Pacific net samples, 2.5 per cent.

Temperature: Atlantic, net sample  $13^\circ 51$ ; Pacific, pump samples  $20^\circ 07$ – $24^\circ 55$  ( $22^\circ 79$ ), net samples  $15^\circ 23$ – $21^\circ 74$  ( $18^\circ 48$ ). Salinity: Atlantic, net sample 35.90; Pacific, pump samples 35.12–35.95 (35.56), net samples 34.30–34.66 (34.48). Density: Atlantic, net sample 27.00; Pacific, pump samples 23.83–25.24 (24.42), net samples 24.06–25.44 (24.75). pH: Atlantic, net sample 8.15; Pacific, pump samples 8.17–8.37 (8.25), net samples 8.10–8.23 (8.16).

#### *Xystonella clavata* Jörgensen

*Xystonella clavata*, Kofoid and Campbell, 1929, pp. 235–236, fig. 450.

The narrow, elongate lorica, with lancet-shaped expansion at the end of the lance, has a length of 8.2 oral diameters. The thin oral rim is a low, erect cuff, not visible in side view by reason of the elevation of the outer rim of the suboral trough. The outer rim has a diameter of 1.27 oral diameters, and its free edge is separated from the cuff by a very shallow, concave trough. The long bowl flares ( $25^\circ$ ) within the anterior 1.0 oral diameter, the diameter of this region at the lower end of the flare being 0.86 oral diameter. Below the lower end of the flare the bowl swells to 0.8 oral diameter at 2.26 oral diameters below the rim; the swollen region occupies about 1.53 oral diameters. The lower bowl tapers ( $14^\circ$ ) for 2.13 oral diameters and then becomes a narrow (0.15 oral diameter) tube with a length of nearly 0.28 total length. At the end of this tubular section is the lance-shaped, flat (?), angular expansion which distinguishes the species; it has a length of 1.0 oral diameter and a width of 0.2 its length.

The wall has a maximum thickness of 0.14 oral diameter just below the trough; it gradually thins to less than 0.02 lower down. There are thin laminae which enclose subequal, rectangular, radial secondary prisms, which in their turn enclose minute alveoles. The surface has a meshwork of small hexagons. The aboral expansion is dense and brown, but the rest of the lorica is glassy.

Length, 242 to 350 $\mu$ .

*Xystonella clavata* may be distinguished at once from other species by the aboral expansion. *Xystonella longicauda* is similar in general shape but has a needle-like lance.

Recorded from two stations, one each in the Atlantic and the Pacific, as follows: one (19) in the Sargasso Sea and one (64) in the South Pacific middle latitudes.

There are 2 pump samples, of which 1 each was taken at 50 and 100 meters. Frequency, minimum.

Temperature: Atlantic, 25°31; Pacific, 15°90. Salinity: Atlantic, 37.15; Pacific, 34.54. Density: Atlantic, 24.89; Pacific, 25.43. pH: Atlantic, 8.27; Pacific, 8.10.

*Xystonella curticauda*, new species

(Figure 62)

The elongated, narrow-conical lorica, with short lance, has a length of 6.14 oral diameters. The oral rim is a low, inverted, barely evident cuff. It is surrounded by the shallow, angular suboral trough, the outer edge of which is higher than the oral cuff, which in turn forms its inner rim. The trough has a diameter of 1.4 oral diameters. The bowl tapers evenly and regularly (11°) for almost 0.77 total length, and at its lower end has a diameter of 0.65 oral diameter. The lower part of the bowl is a narrow cone (33°) with a length of 1.0 oral diameter. At its lower end is a short (0.5 oral diameter), rodlike lance with a minutely blunted free end.

The wall is thick, 0.17 oral diameter near the suboral region, and then thins so that near the lance it is only 0.08 oral diameter across. There are thin inner and outer laminae which enclose a single layer of subequal, rectangular, radial secondary prisms; these prisms, in turn, enclose tiny primary alveoles. The surface has hexagonal areas of uniform size. A few coccoliths adhere to the wall.

Length, 360 $\mu$ .

*Xystonella curticauda* was originally recorded in our protocols as *longicauda*, but this identification appears to have been in error. It is now designated as a new species, which differs from all others in the extreme shortening of the lance. It is, possibly, most like *X. flemingi*, but it lacks the suboral flare, the median concavity, and the aboral swelling of that species. Its lance is also shorter, and it is much longer (360 $\mu$  as against 229 $\mu$ ).

Recorded from four stations in the Atlantic, as follows: one (4) in the Atlantic drift, two (14, 16) in the Gulf Stream, and one (19) in the Sargasso Sea.

There are 1 pump and 5 net samples, of which 1 was taken at the surface, 3 at 50 meters, and 2 at 100 meters. Maximum frequency, 18 per cent at station 4 at 50 meters; other records above minimum (2 to 6 per cent) from stations 14, 16; average in net samples, 6.2 per cent.

Temperature: pump sample 25°31, net samples 13°37-23°64 (15°99). Salinity: pump sample 37.15, net samples 35.59-36.41 (35.96). Density: pump sample 24.89, net samples 24.84-27.01 (26.44). pH: pump sample 8.27, net samples 8.06-8.23 (8.16).

Type locality, station 4, at 50 meters; latitude 44° 39' north, longitude 33° 06' west.

*Xystonella flemingi*, new species

(Plate 1, figure 4)

The simple, trumpet-shaped lorica has a length of 5.45 oral diameters. The oral rim stands up erect as a low, barely evident cuff around the opening. It is surrounded by the suboral trough, which is shallow and concave. The outer edge of the trough is higher than the oral cuff, which forms its inner rim. The trough has a diameter of 1.2 oral diameters. The bowl may be subdivided into three divisions. Of these, the first is an inverted truncated cone (29°) with a length of 0.2 total length, and with a diameter at the posterior end of 0.77 oral diameter. The sides of this section are distinctly concave, and gracefully contracted from the outer rim of the trough; especially do they contract in the upper three-tenths. The second subdivision is an inverted truncated cone (about 5°). It has a length of somewhat less than 0.5 total length, and its diameter at the posterior end is somewhat less than 0.64 oral diameter. The sides are even and regular. The third section is, again, an inverted truncated cone (46°), with a length of 0.15 total length; its diameter at the posterior end is 0.35 oral diameter. Its sides are even, regular, and rounded at their junction with the section above. The lance is a narrow cone (7°) with a length of a little less than 0.11 total length. The sides are even and the free tip is minutely rounded. The general contour of the bowl as a whole is laterally concave, and it appears swollen at about 0.33 total length above the aboral region, although it is not actually increased in diameter. The suboral conical region is decidedly asymmetrical, and one side has a generally greater concavity than the other. It is the bulky overhang of this region and its deep concavity that give the effect of aboral swelling to the bowl.

The wall has a subuniform thickness of 0.03 oral diameter. The cuff is membrane-like, as are also the inner and outer laminae. Between these laminae are large secondary prisms in a single layer. Primary alveoles were not visible. The surface has subhexagonal prismatic structure. These hexagons are approximately 16 to 22 across one face of the bowl. In the lance and just underneath the suboral trough the prisms are smaller, more crowded, and less regular in shape. Near the tip of the lance they are altogether wanting. The trough is made up of hyaline material like that of the cuff, with which it is continuous. The cavity of the lorica follows the contour save in the suboral region, where it is more erect and more like the second cone in form.

Length, total 229 $\mu$ , lance 25 $\mu$ ; diameter, oral 42 $\mu$ , shelf 54 $\mu$ ; wall thickness, 5 $\mu$ .

*Xystonella flemingi* shows relationship to *X. acus*, but, in addition to dimensional differences, it has a greater suboral overhang, a relatively shorter and stouter lance, and more pronounced secondary wall structure. It differs from *X. lanceolata* in size and in its relatively shorter lance and greater suboral overhang. From *X. lohmanni* it differs in all the above characters. It lacks the swollen, angular lance of *X. clavata*. Its lance is short and blunt, unlike that of *X. longicauda*, and there is no knob as in *X. treforti*, *X. minuscula*, and *X. scandens*.



Recorded from one station (14) in the Gulf Stream, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 14°02; salinity, 35.59; density, 26.66; pH, 8.06.

Type locality, station 14, at 100 meters; latitude 42° 10' north, longitude 47° 19' west.

#### *Xystonella lanceolata* (Brandt) Brandt

*Xystonella lanceolata*, Kofoid and Campbell, 1929, p. 236, fig. 449.

The rather short, conical lorica, with thick, conical horn of moderate length, has a length of 5.35 oral diameters. The oral rim is low, and hidden by the higher sides of the outer edge of the outer wall of the suboral trough; the trough is concave, and the diameter of its outer edge is 1.28 oral diameters. The bowl flares (34°) within the upper 0.35 oral diameter, and the diameter at the lower end of the flare is 1.1 oral diameters. The bowl below the flare tapers (10°) for nearly 0.42 total length, the diameter at the lower end being 0.72 oral diameter. Below the taper the bowl becomes conical (32°) for 1.1 oral diameters. The lance is subuniformly thick (nearly 0.22 oral diameter) and its length is almost 0.35 total length. The free tip is acutely angular.

The wall reaches a thickness of about 0.07 oral diameter suborally, and thins rapidly to less than three-tenths that much in the lower bowl. There are thin laminae which enclose rectangular, subequal, radial secondary prisms. The surface has a mesh of small, rounded hexagons.

Length, 215 to 234 $\mu$ .

The character of the lance distinguishes this species from others, save *X. acus*. In *acus* the bowl is mildly swollen, and the lance laterally contracted.

Recorded from one station (131) in the California region, in a pump sample taken at 50 meters. Frequency, minimum.

Temperature, 13°98; salinity, 33.24; density, 25.00; pH, 8.39.

#### *Xystonella lohmanni* (Brandt) Brandt

*Xystonella lohmanni*, Kofoid and Campbell, 1929, pp. 236-237, fig. 448.

The large, rather thick-walled lorica, with long, pointed lance, has a length of 7.5 oral diameters. The oral cuff is submerged by the outer rim of the flattened suboral trough, which has a diameter of 1.33 oral diameters. The long bowl tapers (5°) with virtually no flare, or other more than strictly local and minor modification, for 0.48 total length, and then becomes conical (27°) for 0.22 total length. The concave, tapering lance (7°) has a length of 0.31 total length. Its upper end has a diameter of 0.3 oral diameter, and its free tip is sharply pointed.

The wall has a thickness of 0.06 oral diameter across the bowl and is thinner in the aboral cone and lance. There are thin laminae and radial secondary prisms. The surface hexagons are larger in the middle of the bowl than either above or below, where they are small. The wall is rather soft and easily deformed, the lance being much the more rigid part.

Length, 330 to 580 $\mu$ .

*Xystonella lohmanni* is distinctly more elongated than *X. acus*. It is also longer than *X. lanceolata*, and has a tapering lance, whereas *lanceolata* has a tubular one. The lance in the shorter *X. longicauda* is needle-like.

Recorded from seven stations, five in the Atlantic and two in the Pacific, as follows: one (16) in the Gulf Stream, two (19, 20) in the Sargasso Sea, two (24, 27) in the Atlantic equatorial region, one (70) in the Galápagos region, and one (136) in the California region.

There are 1 pump and 8 net samples, of which 4 were taken at 50 meters and 5 at 100 meters. Maximum frequency, 4 per cent at station 136; other records above minimum (2 to 3 per cent) from stations 19, 70; average in Pacific net samples, 3.3 per cent.

Temperature: Atlantic, pump sample 23°64, net samples 18°08-26°04 (22°92); Pacific, net samples 12°73-18°87 (15°80). Salinity: Atlantic, pump sample 36.41, net samples 36.00-37.15 (36.53); Pacific, net samples 34.76-35.02 (34.89). Density: Atlantic, pump sample 24.84, net samples 23.98-26.06 (25.12); Pacific, net samples 25.09-26.28 (25.68). pH: Atlantic, pump sample 8.23, net samples 8.09-8.30 (8.20); Pacific, net samples 7.68-8.39 (8.03).

#### *Xystonella minuscula* Kofoid and Campbell

*Xystonella minuscula* Kofoid and Campbell, 1929, p. 237, fig. 453.

The rather large lorica, with fairly short, conical bowl and long pedicel, skirt, and lance, has a length of 5.4 oral diameters. The thin oral cuff is submerged by the outer edge of the concave trough. The outer edge of the trough has a diameter of 1.42 oral diameters and is minutely serrate. The upper bowl is truncate conical (16°) with little trace of flare, local concavity, or swelling; the length of this cone is 0.4 total length, and its diameter at the lower end is nearly 0.67 oral diameter. The lower bowl is wider conical (within 24°), with a length of about 0.24 total length. The pedicel is laterally concave tubular, with a length of 0.23 total length, and with an expanded skirt with downward-projected prongs. The lance is spikelike, sharply pointed at the free tip, and 0.75 oral diameter in length.

The wall is thickest suborally, where it reaches 0.18 oral diameter; it rapidly thins in the lower bowl to much less. There are thin laminae and enclosed radial secondary prisms, which in their turn enclose small alveoles. The surface has a more or less uniform pattern of small hexagons. The lumen reaches to the lance.

Length, 268 to 350 $\mu$ .

*Xystonella minuscula* has a shorter, more conical bowl than *X. treforti*, with little or no suboral flare and concavity. It lacks the spiral shelf of *X. scandens*, but in other ways is similar. The remaining species lack a skirt.

Recorded from three stations, two in the Atlantic and one in the Pacific, as follows: two (27, 28) in the Atlantic equatorial region and one (112) in the North Pacific middle latitudes.

There are 1 pump and 4 net samples, of which 1 was taken at the surface, and 2 each at 50 and 100 meters. Fre-

quency, 2 per cent at station 27; other records minimum; average in Atlantic net samples, 1.3 per cent.

Temperature: Atlantic, net samples 18°08–26°79 (23°56); Pacific, pump sample 23°25. Salinity: Atlantic, net samples 36.03–36.63 (36.30); Pacific, pump sample 34.60. Density: Atlantic, net samples 23.79–26.06 (24.73); Pacific, pump sample 23.58. pH: Atlantic, net samples 8.09–8.30 (8.21); Pacific, pump sample 8.22.

*Xystonella treforti* (Daday) Laackmann

(Figure 68)

*Xystonella treforti*, Kofoid and Campbell, 1929, p. 238, fig. 452; Marshall, 1934, p. 651.

*Histonella treforti*, Hofker, 1931, p. 381.

The elongated, chalice-shaped lorica, with swollen skirt and lance, has a length of 4.9 oral diameters. The thin oral cuff is erect. The suboral trough surrounds the cuff, and its diameter at the outer edge is 1.38 oral diameters; the trough is deeply concave. The bowl flares (35°) within the anterior 0.45 oral diameter, the diameter at the lower end of the flare being 1.13 oral diameters. The bowl contracts steadily below this level within a cone (10°) with a length of 0.3 total length, then becomes steeper (22°) for 0.38 total length, and again below becomes narrower (5°) for 1.0 oral diameter. At the lower end is the skirt. This is swollen and knoblike, and has 4 to 8 downward-directed prongs. The short lance (0.31 oral diameter) is a pointed peg.

The wall is thickest below the suboral trough, where it reaches 0.17 oral diameter; it gradually thins so that just above the skirt it is only a third as much, or less. There are thin laminae which enclose subequal, rectangular, radial secondary prisms. Within these are minute primary alveoles. The surface is covered with a uniform hexagonal mesh. The oral cuff is hyaline, as is the lance. The skirt is denser than the rest of the bowl, and of a dirty brown hue. The lumen enters the lance as a cylindrical canal.

Length, 276 $\mu$ .

The loricae of this expedition do not have so long a bowl as that figured by Kofoid and Campbell, but they differ from *X. minuscula* in this regard. Marshall's (1934) loricae are much longer (405 to 469 $\mu$ ) than any of the *Carnegie* specimens.

*Xystonella treforti* has a longer, less directly conical bowl than *X. minuscula*. It lacks the spiral shelf of *X. scandens*, and none of the remaining species have skirts.

Recorded from fifty-seven stations, twenty in the Atlantic and thirty-seven in the Pacific, as follows: four (2, 14, 15, 16) in the Gulf Stream, five (17, 18, 19, 20, 21) in the Sargasso Sea, eight (22, 23, 24, 25, 26, 27, 29, 30) in the Atlantic equatorial region, three (31, 32, 34) in the Caribbean Sea, three (35, 35-36, 36) in the Pacific equatorial region, twelve (40, 41, 42, 43, 45, 46, 68, 69, 70, 71, 73, 77) in the Galápagos region, two (48, 49) in the region of South Pacific island fields, six (54, 55, 63, 64, 65, 67) in the South Pacific middle latitudes, four (132, 135, 137, 146) in the California region, five (138, 139, 140, 150, 151) in the North Pacific trade region, and five (112, 113, 143, 144, 145) in the North Pacific

middle latitudes. *Xystonella treforti* is one of the more widely distributed species of the warmer regions of the ocean, and avoids the cold areas.

There are 33 pump and 57 net samples, of which 20 were taken at the surface, 29 at 50 meters, and 41 at 100 meters. The increase with depth in this instance is possibly significant. Maximum frequency, 52 per cent between stations 35 and 36; other records above minimum (2 to 44 per cent) from stations 2, 14, 15, 16, 17, 19, 20, 22, 23, 24, 27, 32, 34, 35, 40, 41, 42, 45, 46, 48, 54, 63, 65, 69, 71, 77, 112, 113, 135, 145, 150; average in net samples in both Atlantic and Pacific, 8.1 per cent; in Atlantic pump samples, 3.3 loricae.

Temperature: Atlantic, pump samples 14°02–26°98 (23°32), net samples 14°60–25°56 (21°97); Pacific, 13°93–26°91 (18°94) and 14°33–26°05 (19°31), respectively. Salinity: Atlantic, pump samples 35.10–37.00 (36.25), net samples 35.59–37.15 (36.33); Pacific, 33.40–36.06 (34.93) and 34.30–36.44 (34.94), respectively. Density: Atlantic, pump samples 23.84–26.66 (24.72), net samples 24.25–26.66 (25.37); Pacific, 22.72–26.21 (24.23) and 22.89–26.17 (24.92), respectively. pH: Atlantic, pump samples 8.06–8.37 (8.23), net samples 7.93–8.37 (7.97); Pacific, 7.68–8.47 (8.17) and 7.87–8.34 (8.08), respectively.

UNDELLIDAE Kofoid and Campbell

Undellidae Kofoid and Campbell, 1929, p. 251.

The Undellidae include *Undella*, *Amplectella*, *Amplectellopsis*, *Cricundella*, *Proplectella*, and *Undellopsis*, six genera in all. All are present in the material of this expedition. Most of the genera are characteristic of warm water but are not limited to that region of the ocean; none is antarctic.

UNDELLINAE, new subfamily

The Undellinae include those genera of the Undellidae in which there is no suboral ledge and no inner collar, namely, *Undella*, *Amplectella*, *Amplectellopsis*, and *Cricundella*.

UNDELLA Daday emended

*Undella*, Kofoid and Campbell, 1929, p. 258.

*Undella* is better known than the genera which have been more recently established; in most instances more advanced species were formerly assigned to *Undella*. As a whole the members of *Undella* are simple, thimble-shaped forms with very little ornamentation or special elaboration in structure. The species are rather difficult to distinguish and sometimes intergrade.

Nearly all species of *Undella* occur in warm seas, and there seems to be little geographical limitation within the tropics.

Fifteen species are described here, of which two unusually interesting ones are new.

*Undella attenuata* Jörgensen emended Kofoid and Campbell

*Undella attenuata*, Kofoid and Campbell, 1929, p. 260, fig. 510.

The moderately elongated lorica, of general *hyalina* form, with biconical aboral region, has a length of 3.1 oral diameters. The oral margin is the thin, erect inner lamina. The

bowl is widened out within the anterior oral diameter to 1.25 oral diameters, and then contracts ( $10^\circ$ ) for 0.45 total length; the diameter at the lower end of this section is little more than 1.0 oral diameter. The aboral section is subconical ( $23^\circ$  in the upper four-fifths and  $120^\circ$  in the posterior fifth), the angles of change being marked. The aboral end is pointed.

The wall thickness is subuniformly 0.09 oral diameter. There are thin laminae with enclosed hyaline material. A pore rarely penetrates the aboral end.

Length, 173 $\mu$ .

*Undella attenuata* has a biconical, pointed aboral end unlike that of *U. bulla*; it has a longer bowl than *U. parva*; its proportions differ from those of *U. declivis*, and the angles of the aboral end are unlike those in *U. hyalina*.

Recorded from seven stations in the Pacific, as follows: two (51, 54) in the South Pacific middle latitudes, one (109) in the North Pacific trade region, three (142, 144, 145) in the North Pacific middle latitudes, and one (146) in the California region.

There are 9 pump and 2 net samples, of which 4 were taken at 50 meters and 7 at 100 meters. Frequency, 2 per cent at stations 54, 146; in pump samples, there were 4 loricae at station 145.

Temperature: pump samples  $16^\circ 90$ – $22^\circ 45$  ( $19^\circ 27$ ), net samples  $18^\circ 74$ – $20^\circ 07$  ( $19^\circ 40$ ). Salinity: pump samples 34.32–35.62 (34.76), net samples 34.32–35.35 (34.83). Density: pump samples 23.95–25.24 (24.72), net samples 24.24–25.37 (24.81). pH: pump samples 8.18–8.37 (8.29), net samples 8.16–8.26 (8.21).

#### *Undella californiensis* Kofoid and Campbell

*Undella californiensis* Kofoid and Campbell, 1929, p. 261, fig. 501.

The small lorica, shaped like a plump electric-light bulb, has a length of 2.6 oral diameters. The oral margin is abruptly thinned to a sharp edge. The upper bowl is a cylinder 0.35 total length in length, with posterior conical expansion ( $12^\circ$ ); the lower bowl is a subhemisphere with a maximum diameter of 2.0 oral diameters at 0.6 total length below the rim. The aboral end has a trace of flattening.

The wall is subuniformly 0.15 oral diameter in thickness except immediately below the suboral section. The laminae enclose homogeneous material.

Length, 71 $\mu$ .

*Undella californiensis* bears little likeness to other species of *Undella*. It is a little like *Amplectellopsis angularis* and *Proplectella exposita*, from which it differs in that its wall is subuniform in thickness, and in its lack of inner collar.

Recorded from one station (131) in the California region, in a net sample taken at 100 meters. Frequency, 2 per cent.

Temperature,  $12^\circ 12$ ; salinity, 33.36; density, 25.31; pH, 8.32.

#### *Undella carnegiei*, new species

(Plate 1, figure 13)

The elongated, tall lorica has a length of 8.86 oral diameters. The oral rim is thin, regular, and smoothed over. The

wall of the bowl immediately swells away from the margin, this upper section forming a collar-like region. This suboral segment is a truncated cone ( $23^\circ$ ), with a length of about 0.8 oral diameter. Its sides are full but not markedly convex. The diameter of its lower end is 1.2 oral diameters. The bowl may be subdivided conveniently into no less than three subdivisions. The anterior one is the longest; it has the general form of a cylinder and a length of approximately 3.3 oral diameters. Its diameter at its lower end is the same as that of the anterior end (1.2 oral diameters). The sides are full, barely convex, and regular. The second subdivision is below the first, and is a basal segment of a truncated cone ( $18^\circ$ ), with a length of 3.53 oral diameters. It has a slight tendency to be concavely contoured, especially in its aboral half. It reaches its least diameter at its lower end, where it is about 0.38 oral diameter. The third subdivision is a short, wide, inverted, hollow-sided cone (over  $70^\circ$ ), with a length of 0.46 oral diameter. It is asymmetrical, one side being nearly a third higher than the other. The aboral end is pointed, but not prolonged, and is closed off.

The wall is thin, about 0.01 oral diameter across, and is subuniform at all levels. Inner and outer laminae enclose clear interlaminar substance. The lumen follows exactly the outer contour.

Length, 443 $\mu$ ; diameter, oral 50 $\mu$ , maximum 65 $\mu$ .

*Undella carnegiei* is almost unique in the genus, and its closest relative is probably the other new species described in this report, *U. hawaiiensis*. These two species differ in size, proportions, and especially in aboral characters. In *hawaiiensis* the aboral cone is rounded rather than angular, there is an interpolated subcylindrical region above this cone, the conical region suborally from this section is flat-sided, and at the oral end there is no collar-like section, or rather a narrow one instead of a wide cone. It bears very little likeness to previously described species.

Recorded from two stations in the Pacific, as follows: one (151) in the North Pacific trade region and one (152) in the Pacific equatorial region.

There are 2 net samples, of which 1 each was taken at 50 and 100 meters. Frequency, 3 per cent at station 152; average, 2 per cent.

Temperature,  $11^\circ 48$ – $18^\circ 28$  ( $14^\circ 88$ ); salinity, 34.42–34.73 (34.57); density, 24.77–26.50 (25.63); pH, 7.76 at station 152.

Type locality, station 151, at 50 meters; latitude  $12^\circ 40'$  north, longitude  $137^\circ 32'$  west.

#### *Undella clevei* Jørgensen

*Undella clevei*, Kofoid and Campbell, 1929, p. 261, fig. 503.

The tiny lorica is phial-shaped, with a blunt aboral end, and has a length of 2.73 oral diameters. The oral margin is thin and erect. The bowl expands to 1.12 oral diameters at its middle, then contracts ( $15^\circ$  in the upper four-fifths and  $103^\circ$  in the lower part). The aboral end is blunted.

The wall has a thickness of almost 0.13 oral diameter at the most. There are thin laminae with enclosed hyaline material. The lumen is modified by slight suboral thickening.

Length, 55 to 71 $\mu$ .

*Undella clevei* resembles *U. ostenfeldi* closely, but is proportionately more slender, with greater median expansion. It is not so slender as *U. hyalinella* and lacks the suboral contraction and the angles of that species.

Recorded from one station (63) in the South Pacific middle latitudes, in a pump sample taken at 100 meters. Frequency, 5 loricae.

Temperature, 15°84; salinity, 34.58; density, 25.48; pH, 8.08.

#### *Undella declivis* Kofoid and Campbell

(Figure 108)

*Undella declivis* Kofoid and Campbell, 1929, pp. 261-262, fig. 507.

The fairly stout, moderately large lorica, of *parva*-like form but with cylindrical upper bowl, has a length of 2.66 oral diameters. The oral rim is sharp. The upper bowl (0.67 total length) is distinctly cylindrical. The lower bowl is biangular (30° in the upper four-fifths and 125° in the lower section). The aboral end is pointed.

The wall is subuniformly 0.09 oral diameter in thickness in the upper angular section, and thinner above and below. There are thin laminae which enclose finely alveolar material.

Length, 138 to 178 $\mu$ .

The lorica figured (fig. 108) is not typical, although assigned to this species.

*Undella declivis* resembles *U. parva*, but is shorter and stouter, with cylindrical rather than tapering upper bowl. *Undella dilatata* is saccular aborally, with some lateral concavity.

Recorded from six stations, two in the Atlantic and four in the Pacific, as follows: one (19) in the Sargasso Sea, one (23) in the Atlantic equatorial region, one (80) in the Galápagos region, two (109, 151) in the North Pacific trade region, and one (146) in the California region.

There are 3 pump and 4 net samples, of which 4 were taken at 50 meters and 3 at 100 meters. Maximum frequency, 20 per cent at station 23; 2 per cent each at stations 109, 146; average in Atlantic net samples, 1.7 per cent.

Temperature: Atlantic, net samples 20°99-25°31 (23°15); Pacific, net sample 19°81, pump samples 18°28-23°58 (21°74). Salinity: Atlantic, net samples 36.02-37.15 (36.40); Pacific, net sample 34.86, pump samples 34.42-36.21 (35.18). Density: Atlantic, net samples 24.89-25.30 (25.09); Pacific, net sample 24.72, pump samples 24.07-24.77 (24.51). pH: Atlantic, net samples 8.14-8.27 (8.19); Pacific, net sample 8.18, pump samples 8.18-8.30 (8.24).

#### *Undella dilatata* Kofoid and Campbell

*Undella dilatata* Kofoid and Campbell, 1929, p. 262, fig. 499.

*Undella dohrni*, Alzamora, 1929, p. 8, fig. 16.

The relatively stout, moderate-sized lorica, with saccular aboral region, has a length of 2.68 oral diameters. The oral rim is thin. The upper bowl forms an expanding, slightly concave cone (8°), with a length of 0.53 total length, then

swells evenly to 1.35 oral diameters at 0.73 total length from the rim. Below this level the lower bowl rounds broadly to the acutely pointed (125°) aboral end, which is also barely mammillate.

The wall is 0.1 oral diameter in thickness in the upper bowl, 0.15 in the bulge, and 0.05 aborally. There are thin laminae and homogeneous enclosed material.

Length, 130 to 160 $\mu$ .

*Undella dilatata* differs from *U. dohrni* in the greater width of the upper bowl, the less extensive swollen region, and the character of the aboral end. It lacks the squared-off aboral end of *U. pistillum*.

Recorded from two stations (25, 26) in the Atlantic equatorial region.

There are 1 pump and 1 net sample, taken at 50 and 100 meters, respectively. Frequency, net sample, 10 per cent; pump sample, 1 lorica.

Temperature: pump sample 24°10, net sample 14°60. Salinity: pump sample 36.14, net sample 35.70. Density: pump sample 24.49, net sample 26.62. pH: pump sample 8.21, net sample 7.93.

#### *Undella hawaiiensis*, new species

(Plate 1, figure 7)

The tall, cylindrical lorica, with narrowed posterior region and blunt aboral end, has a length of 5.98 oral diameters. The oral margin is even, inturned, thin, and not especially differentiated. Immediately below the rim is a very narrow region 0.2 oral diameter in width. This section is a low basal segment of a cone (55°), and there is a barely visible submedian constriction about it, although the sides are quite full. The diameter at the lower level of this cone is 1.16 oral diameters. The remaining part of the bowl may be subdivided into four sections. The first of these segments is a long cylinder of uniform diameter, with a length of 0.57 total length. Its sides are even, regular, and singularly free of local modification. The second subdivision is an inverted truncated cone (23°). Its length is 0.21 total length, and its diameter at the truncated aboral end is 0.72 oral diameter. The sides are flattened, and again without trace of irregularity. This cone is asymmetrical, with one of the sides somewhat higher than the other. The third subdivision is a short cylinder. Its upper end is continuous with the lower end of the cone above it, and it maintains approximately the same diameter throughout its length, which is more than 0.1 total length. Its sides are flattened and lack irregularity. The last of the subdivisions forms the aboral cone. This is a short, blunt, wide, inverted cone (70°). Its length is only 0.52 oral diameter. Its sides are broad arcs, and its tip is pointed and opens to the outside by means of a minute pore. The lateral contour of the bowl as a whole is, as may be judged from the above description, sinuous, and the changes from one subdivision to the other give it a hollow-sided, almost concave general appearance.

The wall is subuniformly thin at all levels, being about 0.02 oral diameter, or less, in thickness. Laminae and other wall structure appear to be lacking in the glass-clear lorica.

The cavity follows the outer contour almost exactly except at the aboral tip, where the wall thins down to the pore. The repeated subdivisions of the bowl suggest periodic behavior on the part of the animal at the time of formation of the lorica. They give the impression that there are five phases, pauses, or changes in a regular, orderly sequence of activity. The open aboral end, also, suggests that there was a connection between the protoplasm of the two daughter animals at the time of fission, when the lorica was formed. Such an explanation is in keeping with events and structures known in other genera of Tintinnoina.

Length, 298 $\mu$ ; oral diameter, 50 $\mu$ .

*Undella hawaiiensis* resembles *U. carnegiei* more closely than any other species. They differ in proportions, *carnegiei* being 8.86 oral diameters. The collar-like region is longer in the latter than in *hawaiiensis*, and the bowl is subdivided into more sections in *hawaiiensis* than in the other. The aboral region of *hawaiiensis* is laterally concave in contour; in *carnegiei* the lateral contour is hornlike, and the aboral end is a sharp, concave cone. These two species are unlike others of *Undella*.

Recorded from four stations in the Pacific, as follows: three (132, 133, 146) in the California region and one (145) in the North Pacific middle latitudes.

There are 2 pump and 2 net samples, of which 1 was taken at 50 meters and 3 at 100 meters. Frequency, 2 per cent at station 146; average in pump samples, 1.5 loricae.

Temperature: net sample 20°07', pump samples 18°38'–18°51' (18°44'). Salinity: net samples 34.32–34.71 (34.51), pump samples 33.89–34.76 (34.32). Density: net sample 24.24, pump samples 24.35–24.98 (24.66). pH: net samples 8.26–8.31 (8.28), pump samples 8.31–8.33 (8.32).

Type locality, station 145, at 100 meters; latitude 33° 27' north, longitude 145° 30' west.

#### *Undella hemispherica* Laackmann

*Undella hemispherica*, Kofoid and Campbell, 1929, p. 263, fig. 505.

The short, wide lorica, with cuplike bowl, wide-open oral opening, and thick walls, has a length of 1.0 oral diameter. The oral margin is sharp. The convex bowl rounds evenly from the oral rim to the pointed aboral end.

The wall is thick, about 0.07 oral diameter, and nearly twice as much aborally. There are thin laminae, and enclosed material is faintly alveolar. The lumen has an aboral dent at the point above the position at which the laminae bend.

Length, 60 $\mu$ .

*Undella hemispherica* has a form almost unique in the genus, but does have some likeness to *U. turgida*, from which it differs mainly in proportions, in character of oral margin, and in wall thickness.

Recorded from six stations in the Pacific, as follows: five (48, 86, 89, 90, 93) in the region of South Pacific island fields, and one (105) in the North Pacific trade region.

There are 5 pump and 1 net samples, of which 4 were taken at the surface and 2 at 100 meters. Frequency, 4 per

cent at station 48; in pump samples, not over 2 specimens.

Temperature: pump samples 25°11'–28°50' (27°51'), net sample 23°63'. Salinity: pump samples 34.92–36.22 (35.62), net sample 36.44. Density: pump samples 22.62–24.25 (23.10), net sample 24.86. pH: pump samples 8.23–8.27 (8.25), net sample 8.23.

#### *Undella hyalina* Daday

(Figure 102)

*Undella hyalina*, Kofoid and Campbell, 1929, p. 263, fig. 511.

The generally large lorica, with feebly angled and pointed aboral region, has a length of 2.57 oral diameters. The oral margin is a simple cuff formed by the upright inner lamina. The bowl is subcylindrical below this barely developed cuff; this section has a length of 0.77 total length. The aboral region contracts indefinitely (39° in the upper two-thirds and 125° in the lower part) to the blunted aboral end.

The wall has a subuniform thickness of nearly 0.07 oral diameter. There are thin laminae and dense enclosed material.

Length, 153 $\mu$ .

The *Carnegie* loricae are shorter and less definitely pointed than the more usual type.

*Undella hyalina* resembles *U. parva* closely, but the latter is usually more definitely angular. *Undella declivis* is also quite similar to *parva*, and differs from *hyalina* in the same ways. *Undella attenuata* is angular aborally and also more contracted.

Recorded from eight stations, five in the Atlantic and three in the Pacific, as follows: three (2, 15, 16) in the Gulf Stream, one (17) in the Sargasso Sea, one (25) in the Atlantic equatorial region, and three (45, 77, 79) in the Galápagos region.

There are 7 pump and 4 net samples, of which 8 were taken at 50 meters and 3 at 100 meters. Frequency, not above minimum except in a pump sample at station 25 at 50 meters, where there were 12 loricae.

Temperature: Atlantic, pump samples 14°60'–23°64' (19°72'), net samples 20°57'–23°64' (22°02'); Pacific, 23°69'–24°55' (24°12) and 21°69', respectively. Salinity: Atlantic, pump samples 35.70–36.48 (36.21), net samples 36.41–36.60 (36.46); Pacific, 36.04 and 35.21, respectively. Density: Atlantic, pump samples 24.84–26.62 (25.74), net samples 24.84–25.71 (25.34); Pacific, 24.28–24.54 (24.41) and 24.48, respectively. pH: Atlantic, pump samples 7.93–8.23 (8.15), net samples 8.16–8.27 (8.23); Pacific, 8.17–8.19 (8.18) and 8.12, respectively.

#### *Undella hyalinella* Kofoid and Campbell

*Undella hyalinella* Kofoid and Campbell, 1929, p. 263, fig. 506.

The small lorica, with *clevei*-like form and with nuchal constriction, has a length of 3.2 oral diameters. The oral rim is thin and sharp. The bowl contracts from the margin (12°) to a diameter of 0.8 oral diameter at 1.0 oral diameter below the rim, then widens to 1.0 oral diameter near 0.61 total length from the rim, below which level it again con-

tracts ( $23^\circ$  in the upper 0.28 and  $80^\circ$  in the remaining length). The angles at the levels of change are fairly sharp. The aboral end is pointed, but not prolonged.

The wall is subuniformly 0.12 oral diameter in thickness in the neck, and thins to nearly half as much below; in the lower bowl it thickens a bit. There are thin laminae and enclosed homogeneous material.

Length, 76 to 88 $\mu$ .

*Undella hyalinella* resembles *U. clevei* closely, but is proportionately thinner, and has pronounced nuchal contraction; in similar ways it differs from *U. ostensfeldi*. It is a distinct little form, not likely to be confused with others.

Recorded from five stations in the Pacific, as follows: three (115, 127, 128) in the North Pacific middle latitudes, one (118) in the East Asiatic marginal sea, and one (130) in the California region.

There are 4 pump and 1 net samples, of which 1 was taken at the surface, and 2 each at 50 and 100 meters. Frequency, 5 per cent at station 130; other records minimum.

Temperature: pump samples  $10^\circ.18$ – $15^\circ.85$  ( $11^\circ.82$ ), net sample  $12^\circ.91$ . Salinity: pump samples 32.75–34.63 (33.68), net sample 33.40. Density: pump samples 25.04–25.85 (25.47), net sample 25.19. pH: pump samples 8.06–8.21 (8.11), net sample 8.26.

#### *Undella ostensfeldi* Kofoid and Campbell

*Undella ostensfeldi* Kofoid and Campbell, 1929, p. 264, fig. 504.

The tiny lorica is stout, goblet-shaped, and 2.17 oral diameters in length. The oral margin is thin, simple, and erect. The suboral fifth forms a barely flaring collar-like region, below which the bowl expands to 1.1 oral diameters near 0.6 total length from the rim, and then becomes subconical ( $75^\circ$ ). The aboral end is obtusely pointed.

The wall reaches a maximum thickness of 0.15 oral diameter suborally, and thins down to less than half as much in the lower bowl. There are thin laminae with enclosed hyaline matter.

Length, 46 to 51 $\mu$ .

*Undella ostensfeldi* differs from both *U. hyalinella* and *U. clevei* in its stouter proportions, and has a much less constricted throat than *U. hyalinella*. In many ways it resembles a miniature *U. parva*, although not close to that species in that it has slight suboral differentiation.

Recorded from four stations in the Pacific, as follows: two (45, 78) in the Galápagos region, one (63) in the South Pacific middle latitudes, and one (97) in the region of South Pacific island fields.

There are 3 pump samples and 1 net sample, of which 2 were taken at the surface, and 1 each at 50 and 100 meters. Frequency, 5 per cent at station 78; 2 loricae in a pump sample at station 45; average, 1.3 loricae.

Temperature: pump samples  $15^\circ.84$ – $28^\circ.32$  ( $22^\circ.19$ ), net sample  $24^\circ.38$ . Salinity: pump samples 34.58–35.26 (35.01), net sample 36.03. Density: pump samples 22.45–25.48 (23.41), net sample 24.33. pH: pump samples 8.08–8.16 (8.12), net sample 8.14.

#### *Undella parva* Kofoid and Campbell

(Figure 103)

*Undella parva* Kofoid and Campbell, 1929, p. 264, fig. 508.

The fairly large lorica, of *hyalina*-like form, has an angled, pointed aboral end, and its length is 2.56 oral diameters. The oral margin is thin, erect, and inturned. The bowl is subcylindrical for 0.74 total length. The aboral region is subconical ( $52^\circ$  in the upper seven-tenths and  $112^\circ$  in the remainder), with distinct angles at the levels of change, and with a sharply pointed aboral end.

The wall is thickest suborally, where it is almost 0.09 oral diameter; it gradually thins down distally. There are thin laminae which enclose hyaline material.

Length, 145 to 205 $\mu$ .

*Undella parva* has an angular aboral end and point, unlike *U. hyalina*, and differs in these respects also from *U. declivis*, in which the aboral end is broader and the whole lorica generally shorter. It is stouter than *U. attenuata*, and is not saccular aborally as is *U. dilatata*.

Recorded from fourteen stations, three in the Atlantic and eleven in the Pacific, as follows: three (17, 18, 19) in the Sargasso Sea, three (46, 47, 80) in the Galápagos region, two (109, 138) in the North Pacific trade region, and six (132, 133, 135, 136, 145, 146) in the California region.

There are 5 pump and 15 net samples, of which 1 was taken at the surface, 9 at 50 meters, and 10 at 100 meters. Maximum frequency, 8 per cent at stations 17, 109; other records above minimum (2 to 6 per cent) from stations 18, 19, 46, 136, 145; averages in net samples, 5 and 2.8 per cent in the Atlantic and Pacific, respectively; in pump samples there were 1 to 3 loricae, average 2.5.

Temperature: Atlantic, net samples  $19^\circ.82$ – $25^\circ.31$  ( $22^\circ.30$ ); Pacific, pump samples  $18^\circ.51$ – $18^\circ.95$  ( $18^\circ.67$ ), net samples  $18^\circ.87$ – $26^\circ.06$  ( $22^\circ.30$ ). Salinity: Atlantic, net samples 36.60–37.15 (36.84); Pacific, pump samples 33.89–35.02 (34.63), net samples 34.32–35.96 (35.02). Density: Atlantic, net samples 24.89–26.05 (25.55); Pacific, pump samples 24.35–25.09 (24.84), net samples 22.89–25.09 (24.16). pH: Atlantic, net samples 8.23–8.27 (8.25); Pacific, pump samples 8.31–8.39 (8.34), net samples 8.16–8.39 (8.26).

#### *Undella peruana* Kofoid and Campbell

*Undella peruana* Kofoid and Campbell, 1929, p. 265, fig. 509.

The rather elongated lorica, with decided aboral expansion and angularity, has a length of 4.25 oral diameters. The oral rim is sharp. The bowl forms a cylinder with a length of 0.6 total length, then becomes flanged ( $43^\circ$ ) for about 0.1, contracted subconical ( $20^\circ$ ) for 0.24, and then inverted conical ( $93^\circ$ ) for less than 0.06 total length. The angles at the levels of change are marked. The aboral end is obtusely pointed.

The wall is subuniformly 0.09 oral diameter in thickness in the cylinder, 0.13 in the upper bowl, and much thinner (0.05) aborally. The laminae enclose homogeneous material.

Length, 163 to 215 $\mu$ .

*Undella peruana* has a flange, and also is more sharply angular than *U. attenuata*.

Recorded from four stations in the Pacific, as follows: one (67) in the South Pacific middle latitudes and three (75, 77, 78) in the Galápagos region.

There are 4 net samples, of which 1 was taken at the surface, 1 at 50 meters, and 2 at 100 meters. Frequency, 2 per cent at station 75; average, 1.2 per cent.

Temperature, 16°36–24°38 (20°71); salinity, 34.70–36.04 (35.56); density, 24.33–25.55 (24.96); pH, 8.09–8.19 (8.13).

#### *Undella pistillum* Kofoid and Campbell

*Undella pistillum* Kofoid and Campbell, 1929, p. 265, fig. 500.

The moderate-sized lorica, with wide, flattened aboral region, has a length of 2.5 oral diameters. The oral margin is sharp. The bowl increases evenly and constantly (15°) in diameter from the rim to the aboral end, where its diameter is 1.5 oral diameters. The aboral end is decidedly flattened, but rounds over from the widest level without angulation.

The wall has a thickness of 0.12 oral diameter a little (0.5 oral diameter) below the rim, and frequently thins in the lower bowl. There are thin laminae and enclosed hyaline material.

Length, 90 to 120 $\mu$ .

*Undella pistillum* bears slight resemblance to other species, although suggestive of *Amplectellopsis angularis* save that it has no suddenly swollen angular aboral region.

Recorded from one station (145) in the North Pacific middle latitudes, in a net sample taken at 50 meters. Frequency, 2 per cent.

Temperature, 19°16; salinity, 34.32; density, 24.48; pH, 8.34.

#### *Undella turgida* Kofoid and Campbell

*Undella turgida* Kofoid and Campbell, 1929, p. 266, fig. 502.

The extremely short, wide lorica, with convex-conical bowl and thick wall, has a length of 1.25 oral diameters. The oral rim is thin, and formed by the upward-directed inner lamina, so that there is a slight shoulder at the outer edge. The convex bowl swells evenly to a diameter equal to that of the length of the whole lorica at the ledge. Below this level it contracts evenly and regularly, being strongly globose. The aboral end is barely pointed.

The wall is thickest suborally (0.06 oral diameter), and thins evenly to the aboral end. The laminae are fairly thick and enclose homogeneous material.

Length, 41 to 45 $\mu$ .

*Undella turgida* resembles *U. hemispherica*, but its proportions are different, and its wall is thicker suborally and thins down rather than remaining thick. The lip is also different. In some ways it recalls some species of *Proplectella*, as *claparèdei*, but it never has an inner collar or a contracted oral opening.

Recorded from five stations in the Pacific, as follows: two (45, 46) in the Galápagos region and three (81, 84, 85) in the region of South Pacific island fields.

There are 2 pump and 3 net samples, of which 1 was taken at the surface and 4 at 50 meters. Frequency, 6 per

cent at station 84, 4 per cent at station 85; average in net samples, 3.6 per cent.

Temperature: pump samples 22°43–23°26 (22°84), net samples 26°42–27°89 (27°27). Salinity: pump samples 35.26–35.33 (35.29), net samples 35.85–36.42 (36.17). Density: pump samples 24.13–24.31 (24.22), net samples 23.38–23.64 (23.52). pH: pump samples 8.12–8.16 (8.14), net samples 8.19–8.22 (8.21).

#### AMPLECTELLA Kofoid and Campbell

*Amplectella* Kofoid and Campbell, 1929, p. 251.

*Amplectella* is a tropical genus of considerable differentiation. It is usually rather rare.

Four species are described here.

#### *Amplectella collaria* (Brandt) Kofoid and Campbell

(Figure 81)

*Amplectella collaria*, Kofoid and Campbell, 1929, p. 253, fig. 488.

The moderately tall, stout lorica, with two rings on the cylinder, and with hemispherical aboral end, has a length of 2.09 oral diameters. The oral margin is rounded over. The upper bowl is cylindrical, 0.76 total length in length, and with two rings. These rings, each with a diameter of 1.3 oral diameters, are at 0.3 and 0.48 total length from the rim; both are narrow angular. The wall between them is sweepingly concave. The lowermost of the three sections of the cylinder especially spreads. The diameter of the lower end of the cylinder is 1.57 oral diameters. The lower bowl is broadly rounded, its height being 0.4 its own diameter. The aboral end is unmodified.

The wall has a thickness of over 0.08 oral diameter in the cylinder and a trifle less aborally. There are thin laminae and enclosed hyaline material.

Length, 81 $\mu$ .

The *Carnegie* loricae are stouter than is usual for this species, and also somewhat shorter.

*Amplectella collaria* differs from *A. ampla* in longer cylinder, greater lateral concavities, and angular, shorter bowl. *Amplectella praeacuta* has a cordate bowl, and *A. monocollaria* has but one ring on the cylinder.

Recorded from fourteen stations, four in the Atlantic and ten in the Pacific, as follows: three (17, 18, 19) in the Sargasso Sea, one (23) in the Atlantic equatorial region, three (55, 65, 67) in the South Pacific middle latitudes, six (135, 136, 146, 147, 148, 149) in the California region, and one (150) in the North Pacific trade region. The distribution of *Amplectella collaria* and of *A. monocollaria* is much alike; there are seven stations at which they occur together, and the other stations are closely adjacent.

There are 3 pump samples and 14 net samples, of which 5 were taken at 50 meters and 12 at 100 meters. The absence of *A. collaria* at the surface is worthy of note. Maximum frequency, 8 per cent at station 147; other records above minimum (2 to 7 per cent) from stations 18, 19, 65, 67, 146, 148, 149, 150; averages, 1.0 lorica in Pacific pump samples,

and 1.7 and 5.1 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, net samples  $19^{\circ}82-25^{\circ}31$  ( $21^{\circ}83$ ); Pacific, pump samples  $18^{\circ}54-18^{\circ}95$  ( $18^{\circ}78$ ), net samples  $15^{\circ}03-20^{\circ}49$  ( $18^{\circ}65$ ). Salinity: Atlantic, net samples 36.04-37.15 (36.72); Pacific, pump samples 34.88-35.04 (34.98), net samples 36.04-37.04 (36.72). Density: Atlantic, net samples 24.89-26.07 (25.15); Pacific, pump samples 24.24-25.44 (25.30), net samples 24.96-25.18 (25.07). pH: Atlantic, net samples 8.14-8.27 (8.23); Pacific, pump samples 8.01-8.32 (8.20), net samples 8.18-8.39 (8.30).

*Amplectella monocollaria* (Laackmann) Kofoid  
and Campbell

*Amplectella monocollaria*, Kofoid and Campbell, 1929, p. 253,  
fig. 489.

The rather long lorica, with one ring on upper cylinder and wide, flattened lower bowl, has a length of 2.13 oral diameters. The oral margin is thin and sharp. The upper bowl or cylinder (0.79 total length in length) has a ring 1.64 oral diameters in diameter at 0.42 total length from the rim. The ring is sharply angular ( $90^{\circ}$ ), and the bowl flares widely ( $75^{\circ}$ ) below, until it meets the upper end of the lower bowl; the diameter at this level is 1.71 oral diameters. The lower bowl is low and panlike, with a height only 0.31 of the diameter. The aboral end is flattened.

The wall has a thickness of 0.18 oral diameter at the junction of upper and lower bowls, and elsewhere is much thinner. There are hyaline laminae and enclosed clear material. The lumen enters but little into the ring.

Length, 120 $\mu$ .

*Amplectella monocollaria* differs from *A. occidentalis* in the shape of the aboral region, and from all other species of the genus in the presence of but a single ring on the cylinder.

Recorded from fifteen stations, one in the Atlantic and fourteen in the Pacific, as follows: one (20) in the Sargasso Sea, four (54, 55, 56, 60-61) in the South Pacific middle latitudes, seven (133, 134, 136, 146, 147, 148, 149) in the California region, two (141, 142) in the North Pacific middle latitudes, and one (150) in the North Pacific trade region. This species is closely associated with *Amplectella collaria* in its distribution.

There are 6 pump and 10 net samples, of which 1 was taken at the surface and 15 at 100 meters. Maximum frequency, 6 per cent at stations 146, 147; other records above minimum (2 to 4 per cent) from stations 54, 55, 136, 141, 148; averages, 1.5 loricae in Pacific pump samples, and 3.1 and 1.0 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, net sample  $26^{\circ}56$ ; Pacific, net samples  $16^{\circ}75-20^{\circ}49$  ( $19^{\circ}17$ ), pump samples  $16^{\circ}90-20^{\circ}79$  ( $18^{\circ}43$ ). Salinity: Atlantic, net sample 36.73; Pacific, net samples 34.32-35.35 (34.38), pump samples 34.47-35.10 (34.78). Density: Atlantic, net sample 25.38; Pacific, net samples 24.24-25.48 (24.36), pump samples 24.46-25.37 (24.94). pH: Atlantic, net sample 8.19; Pacific, net samples 8.08-8.39 (8.27), pump samples 8.11-8.39 (8.29).

*Amplectella occidentalis* Kofoid and Campbell

*Amplectella occidentalis* Kofoid and Campbell, 1929, p. 254,  
fig. 487.

The moderate-sized lorica, with one ring and pointed lower bowl, has a length of 2.2 oral diameters. The oral margin is thin-edged. The upper bowl is a cylinder (0.77 total length in length) with one ring of 1.3 oral diameters at 0.36 total length below the rim. The lower end of the cylinder spreads ( $63^{\circ}$ ) with slightly convex sides to a diameter of 1.5 oral diameters at its lower end. The lower bowl is broad, short, and angled ( $110^{\circ}$ ), and the aboral end is bluntly pointed.

The wall reaches nearly 0.2 oral diameter in thickness in the upper part of the lower bowl, but is elsewhere thinner. There are thin laminae and included hyaline matter. The lumen fails to enter the ring.

Length, 101 to 107 $\mu$ .

*Amplectella occidentalis* resembles *A. praeacuta* in its pointed aboral end, but has only a single ring instead of two.

Recorded from one station (78) in the Galápagos region, in a pump sample taken at 100 meters. Frequency, minimum.

Temperature,  $22^{\circ}04$ ; salinity, 36.17; density, 25.11; pH, 8.14.

*Amplectella praeacuta* Kofoid and Campbell

*Amplectella praeacuta* Kofoid and Campbell, 1929, p. 254, fig.  
491.

The moderately tall lorica, with two rings and cordate lower bowl, has a length of 2.25 oral diameters. The oral margin is sharp. The upper bowl is a cylinder (0.64 total length in length), with the upper ring of 1.29 oral diameters at 0.26 total length below the margin, and the second ring of 1.33 at 0.47; both rings are angular ( $87^{\circ}$ ). The lower bowl has a length of 0.27 of its own maximum diameter (1.5 oral diameters), and is angled ( $150^{\circ}$ ) aborally.

The wall averages 0.1 oral diameter in thickness, being thickest above the lower bowl. There are thin laminae and enclosed dense matter.

Length, 106 $\mu$ .

*Amplectella praeacuta* has a pointed aboral end like that of *A. occidentalis*, but has two rings instead of one.

Recorded from one station (45) in the Galápagos region, in a net sample taken at 100 meters. Frequency, minimum.

Temperature,  $21^{\circ}69$ ; salinity, 35.21; density, 24.48; pH, 7.77.

*Amplectellopsis* Kofoid and Campbell

*Amplectellopsis* Kofoid and Campbell, 1929, p. 255.

This is a rare tropical genus, differing from *Amplectella* in lacking rings and internal bulge.

One species is described here.

*Amplectellopsis angularis* Kofoid and Campbell

*Amplectellopsis angularis* Kofoid and Campbell, 1929, pp. 255-  
256, fig. 493.

The moderate-sized lorica, without ring and with angled lower bowl, has a length of 2.2 oral diameters. The oral



margin is sharp-edged. The upper bowl is cylindrical, 0.6 total length in length, and slightly concave, and increases in diameter to 1.02 oral diameters aborally. The lower bowl is conical ( $32^\circ$ ) above, and expands to a blunt, angled ring at 0.87 total length from the rim; this ring has a diameter of 1.52 oral diameters. The aboral region is dishpan-shaped, with a trace of aboral flattening.

The wall reaches a thickness of 0.18 oral diameter near the ring, is less than 0.09 aborally, and in the upper bowl averages about 0.08. There are thin laminae and enclosed hyaline matter.

Length, 109 to 119 $\mu$ .

*Amplectellopsis angularis* differs from *A. biedermani* in lacking a ring on the cylinder.

Recorded from two stations, as follows: one (50) in the South Pacific middle latitudes, and one (87) in the region of South Pacific island fields.

Both records are from pump samples taken at 100 meters. Frequency, minimum.

Temperature,  $20.57$  in both; salinity, 35.73–36.02 (35.87); density, 24.41–25.18 (24.79); pH, 8.22–8.23 (8.225).

#### CRICUNDELLA Kofoid and Campbell

*Cricundella* Kofoid and Campbell, 1929, p. 256.

*Cricundella* is one of the more unusual genera of Tintinnina, being characterized especially by the numerous rings on the thimble-like bowl. The oral rim is simple, as in *Undella* and *Amplectella*. *Cricundella* is found close to the equator in mid-ocean.

One species is described here.

#### *Cricundella quadridivisa* Kofoid and Campbell

*Cricundella quadridivisa* Kofoid and Campbell, 1929, pp. 257–258, fig. 497.

The lorica has a length of 2.66 to 3.22 oral diameters, and is subcylindrical, with four rings and a contracted aboral cone. The oral margin is thin and smooth. The generally cylindrical bowl has rings at 0.11, 0.32, 0.47, and 0.63 total length below the margin. Of these rings, the first has a diameter of 1.19 oral diameters, and the others are wider, being respectively 1.29, 1.30, and 1.27 oral diameters. The cylinder itself has a subuniform diameter of less than 0.3 total length, or just a trifle greater than the diameter of the oral rim. The aboral two-fifths of the bowl contracts at once below the lowermost ring, at first as an inverted, somewhat convex conical section ( $60^\circ$ ) which is 0.18 total length in length; below this it again rather more abruptly contracts into a narrower, slender subconical ( $18^\circ$ ), more or less tube-like section, which has a length of about 0.19 to 0.29 total length and a diameter of 0.33 oral diameter. The aboral end is squarely truncated or imperceptibly convex.

The wall is hyaline, with thin laminae, and the lumen is cylindrical, not entering into the swollen rings.

Length, 108 to 133 $\mu$ .

*Cricundella quadridivisa* has four rings, instead of two like *C. tridivisa*, but otherwise bears a close resemblance to that species. Its aboral end is generally contracted subconical,

unlike that of *C. quadricincta*, which has a hemispherical aboral end.

Recorded from two stations (54, 64) in the South Pacific middle latitudes.

There are 1 pump and 1 net sample, taken at 50 and 100 meters respectively. Frequency, 2 per cent at station 54.

Temperature,  $17.51$ – $18.74$  ( $18.12$ ); salinity, 34.58–35.35 (34.96); density, 25.09–25.37 (25.23); pH, 8.12–8.16 (8.14).

#### PROPECTELLINAE, new subfamily

The Propectellinae include only the genus *Propectella*, in which there is an inner collar.

#### PROPECTELLA Kofoid and Campbell

*Propectella* Kofoid and Campbell, 1929, pp. 272–273.

The inner collar is an unusual and peculiar character which sets *Propectella* apart from other genera. The wall structure, general form, and oral and aboral ends show the relationship to the other genera.

*Propectella* extends its range from the warmer parts of the tropical ocean, where it often occurs in deeper than surface water, and reaches cooler seas to the northward, where a few species are found in distinctly cold water. It may be regarded as one of the dominant genera of Tintinnina, for one or more species seldom fail to occur in any temperate water.

Twenty-three species are described here, of which two are new.

#### *Propectella acuta* (Jørgensen) Kofoid and Campbell

*Propectella acuta*, Kofoid and Campbell, 1929, p. 273, fig. 545.

The short, conical lorica has a length of 1.95 oral diameters. The oral margin is sharp. The bowl expands ( $20^\circ$ ) to a diameter of 1.24 oral diameters at 0.39 total length below the rim, and then contracts ( $21^\circ$  anteriorly and  $43^\circ$  below, finally  $95^\circ$ ). The aboral end is pointed.

The wall reaches a maximum thickness of 0.14 oral diameter. The inner collar is funnel-like ( $35^\circ$ ), with a length of nearly 0.4 oral diameter, and the diameter at the lower end is 0.9 oral diameter. There are thin laminae and enclosed clear material.

Length, 57 to 65 $\mu$ .

*Propectella acuta* suggests *P. parva* and *P. grandis* in shape, but is less contracted aborally than the former, and smaller; from the latter species it differs in shortness, less width, and less aboral fullness. *Propectella cuspidata* is not so full below, and is longer.

Recorded from one station (19) in the Sargasso Sea, in a net sample taken at 50 meters. Frequency, minimum.

Temperature,  $25.31$ ; salinity, 37.15; density, 24.89; pH, 8.27.

#### *Propectella amphora* Kofoid and Campbell

*Propectella amphora* Kofoid and Campbell, 1929, pp. 273–274, fig. 530.

The moderate-sized lorica, with six subequal sides and flat aboral end, has a length of 1.9 oral diameters. The oral

margin is sharp. The bowl expands ( $50^\circ$ ) in the anterior 0.27 total length to a diameter of 1.87 oral diameters. The lower bowl contracts ( $42^\circ$ ) regularly to the flattened aboral end (diameter nearly that of the oral opening).

The wall reaches a thickness of 0.2 oral diameter in the thickest region, and is gradually reduced by two-thirds aborally. The inner collar contracts ( $25^\circ$ ); it has a length of 0.19 total length, and the lower end has a diameter of 0.82 oral diameter. The laminae are thin, and the enclosed material is clear.

Length, 57 to 60 $\mu$ .

*Proplectella amphora* is unique in the squarely flattened aboral end and in the general shape.

Recorded from one station (67) in the South Pacific middle latitudes, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 16 $^\circ$ 36; salinity, 34.70; density, 25.45; pH, 8.09.

#### *Proplectella angustior* (Jørgensen) Kofoid and Campbell

*Proplectella angustior*, Kofoid and Campbell, 1929, pp. 275-276, fig. 542.

The small, strongly ovate lorica has a length of 1.74 oral diameters. The oral margin is sharp. The bowl expands ( $48^\circ$ ) to a diameter of 1.47 oral diameters at 0.4 total length from the rim, and then contracts ( $14^\circ$  anteriorly, increasing to  $90^\circ$  and finally to  $116^\circ$ ). The whole lorica is distinctly convex. The aboral end is blunted.

The wall is as much as 0.24 oral diameter in thickness in the inner collar, and only 0.05 aborally. The inner collar is conical ( $36^\circ$ ), is 0.31 oral diameter in length, and has a diameter of 0.84 oral diameter at the lower end. There are thin, dark laminae and enclosed faintly prismatic material.

Length, 50 to 62 $\mu$ .

*Proplectella angustior* has a much narrower oral margin and a more pointed aboral end than *P. claparèdei*. Its bowl is less angular and its aboral end more pointed than in *P. fastigata*, and its proportions are different. It varies in length, perhaps in relation to its wide temperature range.

Recorded from eight stations, two in the Atlantic and six in the Pacific, as follows: one (18) in the Sargasso Sea, one (25) in the Atlantic equatorial region, two (69, 71) in the Galápagos region, and four (131, 132, 134, 135) in the California region.

There are 8 pump and 2 net samples, of which 3 were taken at the surface, 2 at 50 meters, and 5 at 100 meters. Frequency, 3 loricae at stations 132, 135 in pump samples; average in Pacific pump samples, 1.8.

Temperature: Atlantic, pump sample 20 $^\circ$ 32, net sample 14 $^\circ$ 60; Pacific, 14 $^\circ$ 42-23 $^\circ$ 46 (19 $^\circ$ 88) and 12 $^\circ$ 12, respectively. Salinity: Atlantic, pump sample 36.81, net sample 35.70; Pacific, 33.40-35.24 (34.56) and 33.36, respectively. Density: Atlantic, pump sample 26.07, net sample 26.62; Pacific, 23.75-24.96 (24.43) and 25.31, respectively. pH: Atlantic, pump sample 8.21, net sample 7.93; Pacific, 8.13-8.34 (8.24) and 8.32, respectively.

#### *Proplectella aulti*, new species

(Plate 1, figure 1)

The small, robust lorica has a truncated aboral region and a length of 1.6 oral diameters. The oral margin is sharp and thin, and the flattened inner rim dips toward the fundus at an angle ( $70^\circ$ ); the inner rim is approximately 0.12 total length in width, and its lower edge constricts the collar region to a diameter of 0.8 oral diameter at the level at which the bowl opens oralward. The inner wall of the bowl immediately below this level bends sharply and leaves the collar region merely a thickened area. In section, the wall is thus a distorted triangle, with the base formed by the collar region. The wall narrows quickly and reaches its minimum thickness at or near the ambitus of the lorica, and it maintains this thickness below. The wall has a minimum thickness of less than 0.02 oral diameter; it has distinct hyaline laminae, and the middle region between lacks prisms. The exterior of the lorica rounds evenly from the oral rim to the level of greatest diameter, which is somewhat above the upper 0.33 total length, roughly forming a truncated cone ( $60^\circ$ ). The diameter at the base of this cone is equal to the total length of the lorica. Below the level of maximum diameter the bowl decreases in diameter as a full, rounded, inverted truncated cone ( $23^\circ$ ). The aboral region is squarely truncated, and has a diameter equal to that of the oral aperture.

Length, 37 $\mu$ ; diameter, oral 23 $\mu$ , maximum 25 $\mu$ .

The amount of the curvature of the upper bowl toward the oral rim, the amount of contraction to the aboral end from the level of greatest diameter, and the diameter of the aboral end are among the main variable characters of this species.

*Proplectella aulti* differs from the described species of the genus in having a flattened aboral region, except from *P. amphora*, which it resembles more closely than any other. It differs from that species, however, in being tumid instead of sharply six-sided in outline; the anterior shoulder is also less emphatic in *aulti* than in *amphora*, in which latter it is pronounced. *Proplectella aulti* is unlike *P. pentagona*, the other angular species, in being truncated aborally instead of pointed, and in having the shoulder region anterior instead of posterior.

Recorded from one station (22) in the Atlantic equatorial region, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 17 $^\circ$ 50; other physical data are lacking.

Type locality, station 22, at 100 meters; latitude 13 $^\circ$  27' north, longitude 38 $^\circ$  00' west.

#### *Proplectella biangulata* Kofoid and Campbell

(Figure 98)

*Proplectella biangulata* Kofoid and Campbell, 1929, p. 276, fig. 532.

The large, angular lorica, with conical upper and aboral sections and cylindrical middle part, has a length of 3.5 oral diameters. The oral margin is angular. The upper

conical section ( $78^\circ$ ) has a length of 0.33 total length and a diameter at the lower end of 2.63 oral diameters. The middle 0.33 is cylindrical. The aboral 0.33 is again conical ( $75^\circ$ ), and the aboral end tends to be flattened (0.53 oral diameter).

The inner collar is cylindrical, nearly 0.52 oral diameter in length. The wall otherwise follows the outer contour; its maximum thickness is nearly 0.5 oral diameter, but it is quickly reduced to 0.1 in the middle and aboral sections. There are rather thick laminae and enclosed hyaline substance.

Length, 82 $\mu$ .

The *Carnegie* loricae are longer (82 as against 62 to 68 $\mu$ ) and more sharply angular than those previously reported.

*Proplectella biangulata* resembles *P. subangulata* in angularity and subdivisions. It differs, however, in the cylindrical rather than tapering middle section, and equality of cones. It differs from *P. amphora* in having three instead of two subdivisions.

Recorded from one station (64) in the South Pacific middle latitudes, in a net sample taken at the surface. Frequency, minimum.

Temperature, 20.61; salinity, 34.62; density, 24.33; pH, 8.12.

#### *Proplectella claparèdei* (Entz, Sr.) Kofoid and Campbell

*Proplectella claparèdei*, Kofoid and Campbell, 1929, p. 276, fig. 525.

The moderate-sized lorica, with general ovoid shape, has a length of 1.64 oral diameters. The oral margin is sharp. The bowl expands ( $32^\circ$ ) for nearly 0.45 total length, and reaches 1.32 oral diameters; it then contracts ( $26^\circ$  in the anterior section, then  $70^\circ$ , and finally  $132^\circ$ ). The aboral end is smoothly rounded.

The wall reaches a thickness of 0.1 oral diameter in the inner collar and decreases to 0.5 that amount aborally. The inner collar is funnel-like ( $42^\circ$ ) and only 0.1 oral diameter in length; its diameter at the lower end is 0.87 oral diameter. There are thin laminae with enclosed homogeneous material.

Length, 58 to 64 $\mu$ .

Some loricae are egg-shaped.

*Proplectella claparèdei* has a rounded aboral end, unlike *P. globosa* or *P. tenuis*. The aperture is wider than that of *P. tumida* or *P. praelonga*.

Recorded from thirty-seven stations, eleven in the Atlantic and twenty-six in the Pacific, as follows: one (3) in the Atlantic drift, three (18, 19, 20) in the Sargasso Sea, six (24, 25, 26, 27, 28, 30) in the Atlantic equatorial region, one (31) in the Caribbean Sea, two (39, 152) in the Pacific equatorial region, nine (41, 44, 45, 46, 47, 73, 77, 78, 80) in the Galápagos region, one (51) in the South Pacific middle latitudes, five (81, 93, 96, 157, 160) in the region of South Pacific island fields, one (117) in the North Pacific middle latitudes, one (118) in the East Asiatic marginal sea, six (130, 133, 137, 147, 148, 149) in the California region, and one (138) in the North Pacific trade region.

There are 23 pump and 24 net samples, of which 10 were taken at the surface, 19 at 50 meters, and 18 at 100 meters.

Maximum frequency, 10 per cent at station 130; other records above minimum (2 to 5 per cent) from stations 3, 18, 19, 20, 25, 27, 77, 78, 149, 160; averages in net samples, 2.3 and 2.4 per cent in the Atlantic and Pacific, respectively; in pump samples there were 1 to 8 loricae, averages 3.5 and 1.6, respectively.

Temperature: Atlantic, pump samples 14.60–27.61 (21.96), net samples 14.60–27.88 (21.75); Pacific, 8.96–28.57 (21.93) and 10.18–26.05 (19.94), respectively. Salinity: Atlantic, pump samples 35.70–37.15 (36.42), net samples 35.61–37.15 (36.34); Pacific, 33.61–35.99 (34.98) and 33.40–36.04 (35.10), respectively. Density: Atlantic, pump samples 23.32–26.62 (25.22), net samples 23.28–26.95 (25.23); Pacific, 21.95–26.50 (24.63) and 22.65–26.14 (24.03), respectively. pH: Atlantic, pump samples 7.93–8.30 (8.17), net samples 7.93–8.30 (8.27); Pacific, 7.76–8.47 (8.16) and 8.06–8.38 (8.21), respectively.

#### *Proplectella cuspidata* Kofoid and Campbell

(Figure 106)

*Proplectella cuspidata* Kofoid and Campbell, 1929, p. 277, fig. 540.

The fairly short lorica is slender conical and has a length of 3.2 oral diameters. The oral margin is rounded. The bowl is subcylindrical in the anterior 0.52. The lower bowl is slightly convex conical ( $35^\circ$ ). The aboral end is sharply pointed but not prolonged.

The wall is thickest suborally, where it reaches almost 0.09 oral diameter; it gradually thins aborally. There are extremely thin laminae and enclosed hyaline material.

Length, 80 to 106 $\mu$ .

*Proplectella cuspidata* is more slender than *P. grandis*, as well as less convex. It is larger and more convex than *P. parva*; the latter is more like *P. subcaudata*.

Recorded from eight stations in the Pacific, as follows: two (35, 37) in the Pacific equatorial region, four (41, 42, 68, 75) in the Galápagos region, and two (65, 67) in the South Pacific middle latitudes.

There are 1 pump and 8 net samples, of which 2 were taken at 50 meters and 7 at 100 meters. Frequency, 4 per cent at stations 41, 75; other records above minimum (2 per cent) from stations 35, 42; average in net samples, 2.3 per cent.

Temperature: pump sample 19.82, net samples 14.33–18.40 (15.74). Salinity: pump sample 34.53, net samples 34.30–35.47 (34.78). Density: pump sample 24.47, net samples 25.44–26.17 (25.73). pH: pump sample 8.00, net samples 7.88–8.13 (8.00).

#### *Proplectella ellipsoidea* Kofoid and Campbell

(Figure 93)

*Proplectella ellipsoidea* Kofoid and Campbell, 1929, p. 277, fig. 538.

The fairly short, elliptical lorica has a length of 1.65 oral diameters. The oral margin is sharp. The bowl expands ( $42^\circ$ ) for 0.37 total length, to 1.35 oral diameters, then con-

tracts ( $30^\circ$  anteriorly reaching  $95^\circ$  aborally) as a convex cone. The aboral end is pointed.

The wall thickness reaches 0.15 oral diameter at the lower end of the inner collar; it is a third as much in the bowl. The inner collar is wide, conical ( $40^\circ$ ), and 0.25 oral diameter in length, and the diameter at the lower end is 0.75 oral diameter. There are thin laminae with enclosed hyaline material.

Length, 55 to 70 $\mu$ .

*Proplectella ellipsoidea* is aborally pointed unlike *P. tumida* and *P. praelonga*, lacks the lateral angularity of *P. subangulata*, and is longer than *P. subacuta*, shorter than *P. ostensfeldi*, plumper and smaller than *P. grandis*, and wider aborally than *P. cuspidata*.

Recorded from twenty stations, eight in the Atlantic and twelve in the Pacific, as follows: one (16) in the Gulf Stream, two (19, 21) in the Sargasso Sea, four (23, 27, 29, 30) in the Atlantic equatorial region, one (34) in the Caribbean sea, four (41, 45, 46, 68) in the Galápagos region, five (55, 62-63, 64, 65, 67) in the South Pacific middle latitudes, two (136, 147) in the California region, and one (145) in the North Pacific middle latitudes.

There are 23 net samples, of which 4 were taken at the surface, 7 at 50 meters, 11 at 100 meters, and 1 at 1000 meters. Maximum frequency, 15 per cent at station 65; other records above minimum (2 to 10 per cent) from stations 19, 23, 27, 29, 45, 64, 67, 136, 145, 147; averages, 1.7 and 4.1 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic,  $22^\circ.42-27^\circ.42$  ( $24^\circ.67$ ); Pacific,  $3^\circ.98-23^\circ.30$  ( $19^\circ.27$ ). Salinity: Atlantic,  $36.02-37.05$  ( $36.39$ ); Pacific,  $34.19-35.32$  ( $35.04$ ). Density: Atlantic,  $23.26-25.67$  ( $24.55$ ); Pacific,  $24.06-27.25$  ( $25.00$ ). pH: Atlantic, 8.18-8.30 (8.24); Pacific, 7.76-8.39 (8.08).

#### *Proplectella expolita* Hada

*Proplectella expolita* Hada, 1932b, pp. 568-569, fig. 22.

The fairly short lorica is bottle-like and has a length of 2.00 to 2.58 oral diameters. The oral margin is sharp. The upper bowl is subcylindrical, 0.3 to 0.33 total length in length; it is angular in the suboral three-tenths. The lower bowl is spheroidal to ovate, and 1.5 to 2.0 oral diameters in diameter near the middle. The aboral end is widely rounded.

The wall reaches 0.15 oral diameter in thickness near the lower end of the upper bowl and is half as much aborally. The laminae are relatively thick and enclose hyaline material. The inner collar is cylindrical and has the same length as the upper bowl.

Length, 56 to 76 $\mu$ .

*Proplectella expolita* differs from other species of the genus in having a distinct cylindrical upper bowl. It resembles *Undella californiensis* in general form, but has a thicker wall at the base of the upper bowl.

Recorded from one station (116) in the North Pacific middle latitudes, in a net sample taken at 50 meters. Frequency, 2 per cent.

Temperature,  $11^\circ.18$ ; salinity, 33.79; density, 25.83; pH, 8.11.

#### *Proplectella fastigata* (Jørgensen) Kofoid and Campbell

(Figures 80, 96)

*Proplectella fastigata*, Kofoid and Campbell, 1929, p. 278, fig. 528.

The short, stout, ovate lorica, with thick wall, has a length of 1.94 oral diameters. The oral margin is rounded and thin. The upper 0.29 total length is conical ( $80^\circ$ ), the middle 0.49 tapers ( $23^\circ$ ), and the aboral region rounds off. The junctions between these sections are all rounded, the lowermost more than the upper. The aboral end is unmodified.

The wall reaches a thickness of almost 0.19 oral diameter in the upper section, but is reduced to a third as much lower down. The inner collar is funnel-shaped ( $20^\circ$ ) and almost 0.3 oral diameter in length. The laminae are rather thick.

Length, 69 to 82 $\mu$ .

*Proplectella fastigata* has a thicker collar wall than does *P. claparèdei*, has less aboral expansion than *P. perpusilla*, and is stouter than *P. tenuis*. It is not so long or so wide as *P. ovata*, and its aboral end is different.

Recorded from fifteen stations, fourteen in the Atlantic and one in the Pacific, as follows: three (3, 4, 5) in the Atlantic drift, two (14, 16) in the Gulf Stream, four (17, 19, 20, 20-21) in the Sargasso Sea, five (22, 23, 24, 27, 28) in the Atlantic equatorial region, and one (65) in the South Pacific middle latitudes.

There are 19 net samples, of which 2 were taken at the surface, 7 at 50 meters, and 10 at 100 meters. Frequency, 9 per cent at station 17; other records above minimum (2 to 6 per cent) from stations 3, 4, 14, 19, 20, 22, 23, 24, 27; average in the Atlantic, 3 per cent.

Temperature: Atlantic,  $14^\circ.02-26^\circ.79$  ( $19^\circ.45$ ); Pacific,  $15^\circ.03$ . Salinity: Atlantic,  $35.59-37.15$  ( $36.19$ ); Pacific, 34.30. Density: Atlantic,  $23.79-27.01$  ( $25.72$ ); Pacific, 25.44. pH: Atlantic, 7.96-8.27 (8.17); Pacific, 8.10.

#### *Proplectella globosa* (Brandt) Kofoid and Campbell

(Figures 95, 100)

*Proplectella globosa*, Kofoid and Campbell, 1929, pp. 278-279, fig. 541.

The small, globular lorica has a length of 1.6 oral diameters. The oral margin is sharp. The globose, convex bowl expands ( $40^\circ$ ) to a diameter of 1.55 oral diameters at 0.43 total length, and then contracts ( $36^\circ$  anteriorly, increasing to  $105^\circ$  and later to  $145^\circ$ ). The whole is distinctly convex. The aboral end is obscurely obtuse.

The wall reaches 0.27 oral diameter in thickness in the inner collar; it is gradually reduced to a minimum at the aboral end (0.07). There are thin laminae and enclosed homogeneous material. The inner collar is contracted ( $30^\circ$ ), the length being 0.17 oral diameter, and the diameter at the aboral end is 0.83 oral diameter.

Length, 62 to 95 $\mu$ .

The loricae of this expedition show considerable diversity. Some (fig. 100) are laterally compressed and narrow, and others (fig. 95) are rotund. The former suggest some loricae of *P. tenuis*, the others *P. claparèdei*. *Proplectella globosa* is much more rotund, in general, than either *P. claparèdei* or *P. ovata*, and is much less angular.

Recorded from forty-one stations, nine in the Atlantic and thirty-two in the Pacific, as follows: two (19, 20) in the Sargasso Sea, seven (22, 24, 25, 27, 28, 29, 30) in the Atlantic equatorial region, seven (45, 46, 47, 68, 75, 78, 80) in the Galápagos region, three (48, 81, 159) in the region of South Pacific island fields, five (62-63, 63, 64, 65, 67) in the South Pacific middle latitudes, five (100, 109, 110, 140, 150) in the North Pacific trade region, three (113, 141, 142) in the North Pacific middle latitudes, eight (133, 134, 135, 136, 137, 146, 148, 149) in the California region, and one (152) in the Pacific equatorial region.

There are 26 pump and 29 net samples, of which 4 were taken at the surface, 20 at 50 meters, and 21 at 100 meters. Frequency, 8 per cent at station 113; other records above minimum (2 to 7 per cent) from stations 19, 20, 24, 27, 28, 30, 68, 75, 78, 80, 146, 149, 152; averages in net samples, 2.2 and 2.3 per cent in the Atlantic and Pacific, respectively; in pump samples, maximum 7 loricae, average 2.2 in the Pacific.

Temperature: Atlantic, pump sample 24°44, net samples 14°60-27°88 (22°03); Pacific, 15°84-27°67 (21°22) and 11°48-28°60 (21°94), respectively. Salinity: Atlantic, pump sample 36.18, net samples 35.61-37.15 (36.25); Pacific, 34.47-36.41 (35.75) and 34.30-36.03 (35.22), respectively. Density: Atlantic, pump sample 24.42, net samples 23.26-26.62 (24.53); Pacific, 22.31-25.48 (24.48) and 22.77-26.50 (24.45), respectively. pH: Atlantic, pump sample 8.21, net samples 7.93-8.30 (8.17); Pacific, 8.08-8.39 (8.24) and 7.76-8.39 (8.25), respectively.

#### *Proplectella merriami*, new species

(Plate 1, figure 2)

The small, conelike lorica has a length of 4.4 oral diameters. The oral margin is thin, sharp, and smooth. The inner collar has a length of somewhat less than 0.75 oral diameter although it is not clearly differentiated; the upper half is a funnel (35°) and the lower section widens out below and meets the wall of the bowl. The wall of the bowl has a thickness of 0.1 oral diameter at this level and a little less posteriorly, reaching its minimum thickness at the aboral tip. The wall has very thin inner and outer laminae, between which is a nonprismatic thicker intermediate material. The lorica swells slightly away from the oral margin and reaches a maximum diameter of 1.13 oral diameters at 1.35 oral diameters below the rim. There is a barely appreciable suboral constriction at about the lower level of the inner collar. The bowl continues below the level of the greatest diameter as a moderately full cone (38°). The aboral end is sharply pointed.

Length, 65 $\mu$ ; diameter, oral 17 $\mu$ , maximum 23 $\mu$ .

*Proplectella merriami* resembles *P. cuspidata* in general form, but has different proportions (length 3.4 as against 2.2 to 2.6 oral diameters).

Recorded from one station (4) in the Atlantic drift, in a net sample taken at 50 meters. Frequency, minimum.

Temperature, 14°32; salinity, 36.00; density, 26.91; pH, 8.15.

Type locality, station 4, at 50 meters; latitude 44° 39' north, longitude 33° 06' west.

#### *Proplectella ostensfeldi* Kofoid and Campbell

*Proplectella ostensfeldi* Kofoid and Campbell, 1929, p. 279, fig. 537.

The very short, stout lorica, with wide aboral region, has a length of 1.61 oral diameters. The oral margin is sharp. The bowl gradually widens to 1.16 oral diameters at the middle, and contracts (33° anteriorly and 85° aborally) to the simple, pointed aboral end.

The wall is thickest suborally, where it is almost 0.08 oral diameter in the indistinctly differentiated inner collar; it diminishes regularly aborally. There are thin laminae and enclosed clear material.

Length, 43 to 55 $\mu$ .

*Proplectella ostensfeldi* is stouter, thinner-walled, and less contracted aborally than *P. acuta*. It does not bulge posteriorly like *P. subacuta*. It is wider and plumper than *Undella ostensfeldi*, but may be a form of that species under different physical conditions.

Recorded from five stations, two in the Atlantic and three in the Pacific, as follows: two (22, 23) in the Atlantic equatorial region, one (45) in the Galápagos region, and two (85, 95) in the region of South Pacific island fields.

There are 5 net samples, of which 1 was taken at the surface, 3 at 50 meters, and 1 at 100 meters. Frequency, 2 per cent at station 85; average in the Pacific, 1.3 per cent.

Temperature: Atlantic, 20°99-24°44 (22°71); Pacific, 22°43-28°74 (26°35). Salinity: Atlantic, 36.04-36.18 (36.11); Pacific, 35.26-36.84 (35.61). Density: Atlantic, 24.42-25.30 (24.85); Pacific, 22.43-24.31 (23.37). pH: Atlantic, 8.14-8.21 (8.17); Pacific, 8.12-8.22 (8.18).

#### *Proplectella ovata* (Jørgensen) Kofoid and Campbell

(Figure 101)

*Proplectella ovata*, Kofoid and Campbell, 1929, p. 280, fig. 529.

The large, wide, baggy, somewhat angular lorica has a length of 1.77 oral diameters. The oral margin is angular. The bowl expands at the middle to 1.39 oral diameters and then contracts (34° increasing to 90° and finally to 121° near the aboral end). The bowl as a whole is clearly convex. The aboral end is minutely prolonged as a point.

The wall is thickest suborally, where it reaches 0.14 oral diameter; it is reduced in the lower bowl to about three-quarters as much, and is much less again aborally. The inner collar is nearly cylindrical, and 0.28 oral diameter in length. There is a sharp angle where the wall thins at the junction with the bowl. There are rather thick laminae which enclose radial secondary prisms; this is almost unique in the genus.

Length, 63 to 75 $\mu$ .

*Proplectella ovata* is more angular aborally than *P. globosa*, and is without the aboral pointing of *P. angustior*. *Proplectella tenuis* is shaped more like an olive pit than this species.

Recorded from thirty-eight stations, sixteen in the Atlantic and twenty-two in the Pacific, as follows: two (15, 16) in the Gulf Stream, four (18, 19, 20, 21) in the Sargasso Sea, seven (23, 25, 26, 27, 28, 29, 30) in the Atlantic equatorial region, three (31, 33, 34) in the Caribbean Sea, three (35, 99, 152)

in the Pacific equatorial region, five (45, 46, 47, 77, 80) in the Galápagos region, two (54, 58) in the South Pacific middle latitudes, six (81, 82, 89, 92, 158, 159) in the region of South Pacific island fields, two (100, 151) in the North Pacific trade region, one (113) in the North Pacific middle latitudes, and three (131, 146, 148) in the California region.

There are 23 pump and 32 net samples, of which 12 were taken at the surface, 19 at 50 meters, and 24 at 100 meters. Maximum frequency, 12 per cent at station 29; other records above minimum (2 to 11 per cent) from stations 25, 27, 28, 31, 33, 34, 113, 131, 151, 152, 158, 159; averages in net samples, 4.2 and 2.7 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, pump samples 18°08–26°57 (22°07), net samples 14°60–27°56 (23°31); Pacific, 22°04–27°99 (26°03) and 11°48–28°60 (21°98), respectively. Salinity: Atlantic, pump samples 36.03–36.81 (36.39), net samples 35.70–37.15 (36.36); Pacific, 34.39–36.46 (35.64) and 33.36–36.04 (34.28), respectively. Density: Atlantic, pump samples 23.84–26.26 (25.23), net samples 23.47–26.62 (24.84); Pacific, 21.95–25.11 (23.44) and 22.31–26.50 (24.27), respectively. pH: Atlantic, pump samples 8.09–8.32 (8.20), net samples 7.93–8.32 (8.20); Pacific, 8.14–8.29 (8.19) and 7.76–8.39 (8.17), respectively.

#### *Proplectella parva* Kofoid and Campbell

*Proplectella parva* Kofoid and Campbell, 1929, p. 280, fig. 544.

The short, conical lorica, with thickened wall, has a length of 2.2 oral diameters. The oral margin is sharp-edged. The upper half of the bowl is cylindrical, although there is a little expansion (1.04 oral diameters) in the middle region of a few individuals. The aboral section is conical (50°) and slightly concave, and has a sharply pointed free tip.

The wall reaches 0.18 oral diameter in thickness in the inner collar; it thins down a little in the anterior part and becomes distinctly, but not suddenly, thinner aborally. The inner collar is diffused, 0.1 total length in length, funnel-like (40°), and 0.9 oral diameter in diameter at the lower end. There are thin laminae and enclosed hyaline matter; rarely are there coccoliths.

Length, 44 to 63 $\mu$ .

*Proplectella parva* differs from both *P. acuta* and *P. grandis*, not only in decided shortness, but also in the thickened wall. In *P. subcaudata* the thickening is not continued to the lower bowl.

Recorded from eight stations, one in the Atlantic and seven in the Pacific, as follows: one (2) in the Gulf Stream, two (40, 43) in the Galápagos region, two (64, 65) in the South Pacific middle latitudes, two (116, 117) in the North Pacific middle latitudes, and one (136) in the California region.

There are 2 pump and 9 net samples, of which 1 was taken at the surface, 4 at 50 meters, and 6 at 100 meters. Maximum frequency, 22 per cent at station 117; other records above minimum (2 to 9 per cent) from stations 64, 65, 116, 136; average in Pacific net samples, 10.8 per cent.

Temperature: Atlantic, net sample 20°35; Pacific, pump samples 15°90–16°53 (16°21), net samples 8°93–18°87

(13°33). Salinity: Atlantic, net sample 36.41; Pacific, pump samples 34.54–34.95 (34.74), net samples 34.02–35.02 (34.49). Density: Atlantic, net sample 25.76; Pacific, pump samples 25.43–25.60 (25.51), net samples 24.41–26.41 (25.24). pH: Atlantic, net sample 8.21; Pacific, pump samples 7.93–8.10 (8.01), net samples 7.87–8.39 (8.09).

#### *Proplectella pentagona* (Jørgensen) Kofoid and Campbell

*Proplectella pentagona*, Kofoid and Campbell, 1929, p. 281, fig. 531.

The moderate-sized lorica, with pentagonal outline, has a length of 2.14 oral diameters. The oral margin is thin. The bowl expands regularly (20°) to a diameter of 1.5 oral diameter at 0.75 total length below the rim. The posterior section is a short, wide cone (105°). The angles are all blunted, as is the aboral end.

The wall attains a maximum thickness of 0.14 oral diameter and then thins down to at least a third as much aborally. The inner collar contracts (32°) to a diameter of 0.82 oral diameter, its length being 0.4 oral diameter. The laminae enclose hyaline substance.

Length, 51 to 53 $\mu$ .

*Proplectella pentagona* differs from *P. amphora* in the lower level of the expansion, and the conical, pointed aboral region. It lacks the subcylindrical middle section of *P. biangulata* and the aboral narrowness of *P. subangulata*. It is most distinctive.

Recorded from eleven stations, two in the Atlantic and nine in the Pacific, as follows: two (25, 26) in the Atlantic equatorial region, two (45, 46) in the Galápagos region, four (135, 146, 147, 148) in the California region, two (144, 145) in the North Pacific middle latitudes, and one (150) in the North Pacific trade region.

There are 11 pump and 2 net samples, of which 2 were taken at the surface, 4 at 50 meters, 6 at 100 meters, and 1 at 150 meters. Frequency, 2 per cent at stations 45, 147, 148; other records minimum; average in Pacific pump samples, 1.2 loricae.

Temperature: Atlantic, pump samples 14°60–24°10 (19°35), net sample 14°60; Pacific, 14°73–23°41 (20°16) and 19°27, respectively. Salinity: Atlantic, pump samples 35.70–36.14 (35.92), net sample 35.70; Pacific, 34.27–35.32 (34.89) and 35.04, respectively. Density: Atlantic, pump samples 24.49–26.62 (25.55), net sample 26.62; Pacific, 23.96–25.48 (24.60) and 25.00, respectively. pH: Atlantic, pump samples 7.93–8.21 (8.07), net sample 7.93; Pacific, 8.12–8.34 (8.24) and 8.29, respectively.

#### *Proplectella perpusilla* Kofoid and Campbell

*Proplectella perpusilla* Kofoid and Campbell, 1929, p. 281, fig. 524; Marshall, 1934, p. 653, fig. 32.

The short, ovate lorica, with wide-open aperture, has a length of 1.59 oral diameters. The oral margin is sharp. The bowl is subcylindrical in its upper tenth, then expands rather suddenly (38°) to a diameter of 1.35 oral diameters near 0.47 total length from the rim. The lower bowl contracts

(30° increasing to 79°, and finally to 130° in the aboral section). The aboral end is rounded over.

The wall reaches a thickness of nearly 0.12 oral diameter in the middle of the bowl. The inner collar is diffused. There are thin laminae and enclosed hyaline material.

Length, 41 to 50μ.

*Proplectella perpusilla* differs from *P. subacuta* in lacking an aboral point, and from *P. praelonga* in its lesser suboral narrowness; it is also shorter than the latter. *Proplectella claparèdei* is longer, and has a thicker wall in the more defined inner collar. *Proplectella columbiana* has an aboral mammilla, but is otherwise rather similar.

Recorded from two stations in the Pacific, as follows: one (38) in the Pacific equatorial region, and one (106) in the North Pacific trade region.

There are 1 pump and 1 net sample, the former taken at 100 meters and the latter at the surface. Frequency, 10 per cent at station 38 in the net sample.

Temperature: pump sample 25°8.2, net sample 26°4.8. Salinity: pump sample 35.05, net sample 32.88. Density: pump sample 23.15, net sample 21.31. pH: pump sample 8.23, net sample 8.33.

#### *Proplectella praelonga* Kofoid and Campbell

*Proplectella praelonga* Kofoid and Campbell, 1929, p. 282, fig. 527.

The moderately tall, stout, bag-shaped lorica has a length of 2.5 oral diameters. The oral margin is sharp. The bowl expands (28°) to 1.67 oral diameters at 0.53 total length below the rim, then contracts (32° anteriorly and 102° aborally). The aboral end is broadly rounded.

The wall reaches 0.15 oral diameter in thickness near the lower end of the inner collar. The inner collar is diffused, 0.21 total length in length, and funnel-shaped (26°), with a diameter at the lower end of 0.8 oral diameter. There are thin laminae and enclosed hyaline material.

Length, 56 to 76μ.

*Proplectella praelonga* is longer than *P. tumida* and more prolonged in the upper bowl. *Proplectella perpusilla* is less contracted suborally, and, like *P. claparèdei*, has a relatively wider oral opening.

Recorded from five stations in the Pacific, as follows: one (80) in the Galápagos region, three (81, 82, 84) in the region of South Pacific island fields, and one (100) in the North Pacific trade region.

There are 5 net samples, all taken at 50 meters. Frequency, 6 per cent at station 81; 2 per cent at station 100; average, 2.5 per cent.

Temperature, 26°0.6–27°6.7 (26°9.9); salinity, 34.71–36.42 (35.85); density, 22.31–23.75 (23.38); pH, 8.19–8.21 (8.20).

#### *Proplectella subacuta* (Cleve) emended Kofoid and Campbell

*Proplectella subacuta*, Kofoid and Campbell, 1929, p. 282, fig. 543.

The small lorica is amphora-shaped and has a length of 2.36 oral diameters. The oral margin is sharp. The generally ovate bowl expands (38°) to a maximum diameter of

1.57 oral diameters at approximately 0.46 total length, then contracts (14° increasing to 68°, finally 119°). The aboral end is broadly rounded.

The wall reaches 0.21 oral diameter in thickness across the inner collar, and thins down gradually to the aboral end. The inner collar is funnel-shaped (43°), 0.43 oral diameter in length, and 0.93 oral diameter at its lower end. The laminae are thin and enclose hyaline material.

Length, 50μ.

*Proplectella subacuta* is shorter than *P. claparèdei*, and has a narrower oral opening and is more pointed than *P. perpusilla*.

Recorded from eight stations, five in the Atlantic and three in the Pacific, as follows: one (14) in the Gulf Stream, one (18) in the Sargasso Sea, two (23, 25) in the Atlantic equatorial region, one (32) in the Caribbean Sea, and three (69, 71, 74) in the Galápagos region.

There are 9 net samples, of which 2 were taken at the surface, 1 at 50 meters, and 6 at 100 meters. Maximum frequency, 22 per cent at station 69; other records above minimum (2 to 14 per cent) from stations 14, 32, 74; averages in net samples, 2.5 and 13.3 per cent in the Atlantic and Pacific, respectively.

Temperature: Atlantic, 14°6.0–23°3.0 (18°5.1); Pacific, 14°7.7–23°4.6 (18°9.7). Salinity: Atlantic, 35.59–36.82 (36.10); Pacific, 34.83–35.24 (35.11). Density: Atlantic, 24.91–26.66 (25.94); Pacific, 24.00–25.91 (25.08). pH: Atlantic, 7.93–8.24 (8.11); Pacific, 7.86–8.13 (8.00).

#### *Proplectella subcaudata* (Jørgensen) Kofoid and Campbell

(Figure 99)

*Proplectella subcaudata*, Kofoid and Campbell, 1929, p. 283, fig. 539.

The small, vase-like lorica, with thin wall and decidedly conical aboral end, has a length of 1.92 oral diameters. The oral rim is rounded and thin. The bowl rounds over to a maximum diameter of 1.25 oral diameters at 0.3 total length below the rim. The middle region tapers (16°), and the aboral section is conical (95°). The aboral end is a blunted cone (44°) the length of which is only 0.25 oral diameter.

The wall reaches nearly 0.09 oral diameter in thickness in the inner collar, the length of which is 0.25 oral diameter; the wall thins down to a membrane in the aboral cone. There are thin laminae and hyaline enclosed material.

Length, 60 to 94μ.

*Proplectella subcaudata* is much like *P. parva*, but differs in being wider, longer, and more bluntly conical aborally, and in its thinner wall. It is narrowed down suborally, and has a more definite aboral cone than *P. cuspidata*, besides being shorter.

Recorded from eleven stations, six in the Atlantic and five in the Pacific, as follows: one (3) in the Atlantic drift, one (14) in the Gulf Stream, one (20) in the Sargasso Sea, three (23, 25, 27) in the Atlantic equatorial region, one (42) in the Galápagos region, three (63, 64, 65) in the South Pacific middle latitudes, and one (109) in the North Pacific trade region.

There are 5 pump and 9 net samples, of which 1 was taken at the surface, 3 at 50 meters, and 10 at 100 meters. Maximum frequency, 8 per cent at station 64; other records above minimum (2 to 4 per cent) from stations 14, 42, 63; average in Atlantic net samples, 2 per cent.

Temperature: Atlantic, pump sample 26°04, net samples 14°02–36°02 (21°04); Pacific, 15°03–16°96 (15°93) and 14°33–19°81 (17°07), respectively. Salinity: Atlantic, pump sample 36.25, net samples 35.59–36.73 (36.02); Pacific, 34.30–34.58 (34.44) and 34.86–35.04 (34.95), respectively. Density: Atlantic, pump sample 23.98, net samples 25.30–26.66 (26.00); Pacific, 25.14–25.48 (25.37) and 24.72–26.17 (25.44), respectively. pH: Atlantic, pump sample 8.30, net samples 7.93–8.19 (8.10); Pacific, 8.08–8.10 (8.09) and 7.91–8.18 (8.04), respectively.

#### *Proplectella tenuis* Kofoid and Campbell

(Figure 94)

*Proplectella tenuis* Kofoid and Campbell, 1929, pp. 283–284, fig. 536; Marshall, 1934, p. 653, fig. 33.

The moderate-sized lorica, with wide aboral region and general rotundity, has a length of 1.78 oral diameters. The oral margin is sharp. The globose bowl expands (50°) in the anterior half, where the bowl reaches 1.67 oral diameters, and then it contracts (22°, increasing to 89°, and finally to 148°). The aboral end is widely and obtusely pointed.

The wall reaches 0.28 oral diameter in thickness in the inner collar, but is reduced in the bowl to one-fourth as much, or less, aborally. The inner collar is funnel-like (24°), and the diameter at the lower end is 0.83 oral diameter. The laminae are thin and there is a faint prismatic structure.

Length, 63 to 76 $\mu$ .

The *Carnegie* loricae are not much like either of those recorded by others. The lorica figured by Marshall is flatter-sided than that of the earlier authors, and the *Carnegie* specimens (fig. 94) are more globose than either.

*Proplectella tenuis* is less pointed and has a more flaring collar than *P. ostensfeldi*, and differs from *P. ellipsoida* in being wider aborally. It is longer than *P. globosa*.

Recorded from sixteen stations, three in the Atlantic and thirteen in the Pacific, as follows: one (18) in the Sargasso Sea, two (23, 24) in the Atlantic equatorial region, two (41, 45) in the Galápagos region, two (63, 64) in the South Pacific middle latitudes, four (139, 140, 150, 151) in the North Pacific trade region, two (142, 145) in the North Pacific middle latitudes, and three (146, 147, 148) in the California region.

There are 19 pump and 5 net samples, of which 3 were taken at the surface, 8 at 50 meters, 12 at 100 meters, and 1 at 150 meters. Maximum frequency, 11 per cent at station 23; average in Atlantic net samples, 7.6 per cent.

Temperature: Atlantic, net samples 15°55–22°12 (19°55); Pacific, net sample 21°69, pump samples 14°55–26°72 (23°12). Salinity: Atlantic, net samples 35.61–36.82 (36.14); Pacific, net sample 35.21, pump samples 34.27–35.18 (34.82). Density: Atlantic, net samples 25.30–26.34 (25.74); Pacific,

net sample 24.48, pump samples 22.80–26.11 (24.37). pH: Atlantic, net samples 7.96–8.24 (8.13); Pacific, net sample 8.12, pump samples 7.92–8.34 (8.31).

#### *Proplectella tumida* Kofoid and Campbell

*Proplectella tumida* Kofoid and Campbell, 1929, p. 284, fig. 526.

The fairly small, bottle-shaped lorica has a length of 2.54 oral diameters. The oral margin is thinly rounded. The generally ovate bowl expands (30°) to 1.76 oral diameters at 0.53 total length below the rim, then contracts in a rather narrow ellipse (35°, increasing to 89°) to the rounded aboral end.

The wall hardly reaches 0.1 oral diameter in thickness at the inner collar. The inner collar is ill defined; it is 0.1 oral diameter in length, and the diameter at the lower end is 0.85 oral diameter. The laminae are extremely thin, and enclose hyaline material.

Length, 60 to 61 $\mu$ .

*Proplectella tumida* is rather like *P. praelonga*, but has an ill defined anterior extension, and a thinner wall in the inner collar. It is also shorter. It is only vaguely like *P. claparèdei*.

Recorded from four stations, one in the Atlantic and three in the Pacific, as follows: one (18) in the Sargasso Sea, and three (51, 54, 65) in the South Pacific middle latitudes.

There are 2 pump and 2 net samples, all taken at 100 meters. Frequency, 4 per cent at station 54; other records 2 to 3 per cent.

Temperature: Atlantic, net sample 20°32; Pacific, pump samples 15°03–20°07 (17°55), net sample 18°74. Salinity: Atlantic, net sample 36.81; Pacific, pump samples 34.30–35.62 (34.96), net sample 35.35. Density: Atlantic, net sample 26.07; Pacific, pump samples 25.24–25.44 (25.34), net sample 26.07. pH: Atlantic, net sample 8.21; Pacific, pump samples 8.10–8.22 (8.16), net sample 8.16.

#### *Proplectella urna* Kofoid and Campbell

*Proplectella urna* Kofoid and Campbell, 1929, p. 284, fig. 533.

The small lorica, of urnlike form, has a length of 4.4 oral diameters. The oral margin is thin and sharp. The bowl expands (48°) to a diameter of 2.46 oral diameters at 0.44 total length below the rim, continues with a subcylindrical section, and then contracts (97°) to the distinctly pointed aboral end.

The wall reaches the extraordinary thickness of 0.23 oral diameter at the base of the inner collar. The inner collar occupies the upper 0.12 total length and its inside face is practically upright. There are exceedingly thin laminae and homogeneous enclosed material.

Length, 46 to 48 $\mu$ .

*Proplectella urna* bears a little likeness to *P. tumida*, but is pointed instead of rounded; also, it is expanded more anteriorly.

Recorded from one station (67) in the South Pacific middle latitudes, in a net sample taken at 100 meters. Frequency, minimum.



Temperature, 16°36; salinity, 34.70; density, 25.45; pH, 8.09.

#### UNDELLOPSINAE, new subfamily

This subfamily includes only the genus *Undellopsis*, in which there is a suboral ledge.

#### UNDELLOPSIS Kofoid and Campbell

*Undellopsis* Kofoid and Campbell, 1929, pp. 266-267, 271.

This genus has a suboral ledge, which is lacking in *Amplectella*, but otherwise has a rather great diversity of form. All the species are distinctly tropical.

Seven species are described here.

#### *Undellopsis cubitum* Kofoid and Campbell

(Figure 97)

*Undellopsis cubitum* Kofoid and Campbell, 1929, p. 268, fig. 517.

The moderate-sized lorica, of rectangular optical section, has a length of 2.5 oral diameters. The oral margin is thin. There is a concave suboral ledge with almost no posterior contraction (1.3 oral diameters in diameter). The bowl is subcylindrical (0.87 total length in length), with a posterior diameter of 1.11 oral diameters. Below the lower end it contracts (30°) subconically to the nearly flat (160°) aboral end. The aboral end is introverted and umbilicated after the manner of *umbilicata*.

The wall has a thickness of 0.04 oral diameter in the middle of the bowl; it is thicker suborally and thinner aborally. There are extremely thin laminae and enclosed hyaline matter.

Length, 115 to 123 $\mu$ .

The lorica of this expedition has an umbilicated aboral end unlike those described earlier.

*Undellopsis cubitum* resembles *U. subangulata*, but is more slender, with much less suboral expansion, longer aboral cone, and a different aboral end. The remaining species are very different.

Recorded from one station (45) in the Galápagos region, in a net sample taken at 100 meters. Frequency, 5 per cent.

Temperature, 21°69; salinity, 35.21; density, 24.48; pH, 8.12.

#### *Undellopsis entzi* Kofoid and Campbell

(Figure 105)

*Undellopsis entzi* Kofoid and Campbell, 1929, p. 268, fig. 516.

The moderate-sized lorica, with salt-cellar shape, has a length of 2.56 oral diameters. The oral margin is sharp-edged. There is a sharp-angled (80°) suboral ledge (1.28 oral diameters in diameter) which occupies the anterior 0.36 oral diameter. The bowl below the ledge is subcylindrical (1.08 oral diameters at the lower end), and its length is 0.47 total length. The lower bowl expands subconically (60°) to the base, which has a diameter of 1.6 oral diameters, then contracts again subconically (60°) for nearly 0.38 total length

to the flattened (0.68 oral diameter) aboral end. All levels of change are sharply angular, and the sides are all planes.

The wall is subuniformly 0.08 oral diameter in thickness except in the ledge and in the truncated aboral end, where it is thicker. There are thin laminae and enclosed hyaline material.

Length, 125 $\mu$ .

The *Carnegie* loricae are longer than those recorded earlier (108 to 115 $\mu$ ), chiefly in the longer cylindrical section. The truncated aboral end is also less than an oral diameter.

*Undellopsis entzi* bears some resemblance to *U. insignata*, but is truncated instead of rounded aborally, and has a cylindrical rather than concave upper bowl. It has no ring on the cylinder like *U. annularius*.

Recorded from two stations (55, 67) in the South Pacific middle latitudes, in 1 net and 1 pump sample, both taken at 100 meters. Frequency, 4 per cent at station 55.

Temperature: net sample 16°36, pump sample 16°75. Salinity: net sample 34.70, pump sample 34.86. Density: net sample 25.45, pump sample 25.48. pH: net sample 8.09, pump sample 8.17.

#### *Undellopsis insignata* Kofoid and Campbell

*Undellopsis insignata* Kofoid and Campbell, 1929, pp. 268-269, fig. 519.

The moderate-sized lorica, with *entzi*-like form but with an angled division between upper and lower bowl, has a length of 2.48 oral diameters. The oral margin is sharp-edged. The suboral ledge is angular (108°), with a diameter of 1.22 oral diameters at 0.3 oral diameter below the rim. The upper bowl is 0.52 total length in length, with the upper part cylindrical and the lower section widely flaring, so that the whole is sweepingly concave. The diameter at the lower end is 1.29 oral diameters. The lower bowl is potlike, the sides contracting (35°), and the truncated aboral end having a diameter of almost 1.0 oral diameter; the angles of change are sharp in the upper region but rounded posteriorly.

The wall reaches 0.1 oral diameter in thickness in many places, although commonly a trifle less. There are thin laminae with enclosed hyaline material. The lumen does not enter the angular transition between upper and lower bowls.

Length, 105 $\mu$ .

*Undellopsis insignata* differs from *U. entzi* in the rounded, rather than squarely truncated, aboral end. It lacks the ring of *U. annularius*, and its aboral end is not hemispherical as in that species.

Recorded from two stations in the Pacific, as follows: one (137) in the California region and one (140) in the North Pacific trade region.

There are 2 pump samples and 1 net sample, of which 2 were taken at 50 meters and 1 at 100 meters. Frequency, 6 per cent at station 137.

Temperature: pump samples 24°84-25°94 (25°39), net sample 24°84. Salinity: pump samples 35.02-35.12 (35.07), net sample 35.12. Density: pump samples 23.09-25.50 (24.29), net sample 23.50. pH: 8.34 in all samples.

*Undellopsis lineata* Kofoid and Campbell

(Figure 110)

*Undellopsis lineata* Kofoid and Campbell, 1929, p. 269, fig. 514.*Undella marsupialis*, Alzamora, 1929, p. 8, fig. 17.

The moderate-sized lorica, of general *marsupialis*-like form, has an expanded, saccular aboral region, a rounded aboral end, and a length of 2.0 oral diameters. The oral rim is rounded. There is a low suboral cuff with a narrow shelf at the junction of cuff and bowl (1.16 oral diameters in diameter). The upper bowl (0.79 total length in length) has sweepingly concave sides; it reaches 0.9 oral diameter at 0.39 total length. The lower bowl is low and panlike (anterior diameter the same as that of the suboral shelf), with a broadly rounded bottom, and with little angle at the line of junction with the upper bowl.

The wall thickness averages 0.06 oral diameter save suborally, where it is more. There are thin laminae and enclosed hyaline material.

Length, 108 to 120 $\mu$ .

The *Carnegie* loricae are longer (120 $\mu$ ) than usual, and show sharper distinction between upper and lower bowls.

*Undellopsis lineata* differs from its near relative *U. marsupialis* in the more swollen aboral region, rounded aboral end, and less developed suboral shelf.

Recorded from one station (25) in the Atlantic equatorial region, in a net sample taken at 100 meters. Frequency, 7 per cent.

Temperature, 14°60; salinity, 35.70; density, 26.62; pH, 7.93.

*Undellopsis marsupialis* (Brandt) emended Kofoid and Campbell

(Figure 104)

*Undellopsis marsupialis*, Kofoid and Campbell, 1929, p. 269, fig. 515.

The moderate-sized lorica, with strong suboral ledge, concave sides, some aboral expansion, and pointed aboral end, has a length of 2.43 oral diameters. The oral rim is sharp-edged. There is a fairly high suboral cuff and a flat ledge at the junction of cuff and bowl (1.23 oral diameters). The upper bowl, with a length of 0.81 total length, is concave; its minimum diameter of 1.0 oral diameter is reached at 0.28 total length below the rim. The lower bowl is pan-shaped, with its greatest diameter of 1.23 oral diameters at its upper edge. The bottom is broadly rounded, save that the aboral end itself is obscurely pointed. The angle of junction of the two parts of the bowl is rounded.

The wall thickness is subuniformly 0.07 oral diameter save near the aboral end, where it is thinner. There are thin laminae and enclosed hyaline material.

Length, 138 $\mu$ .

The *Carnegie* loricae are longer than is usual for this species.

*Undellopsis marsupialis* differs from *U. lineata* in greater suboral development, less concave sides, less aboral expansion, and presence of an aboral point.

Recorded from four stations (22, 23, 25, 27) in the Atlantic equatorial region.

There are 2 pump and 4 net samples, of which 1 was taken at 50 meters and 5 at 100 meters. Frequency, 4 per cent at station 22; average, 3 per cent.

Temperature: pump samples 14°60–26°04 (20°32), net samples 14°60–18°08 (16°67). Salinity: pump samples 36.25–37.70 (36.97), net samples 35.70–36.10 (35.88). Density: pump samples 23.90–26.62 (25.26), net samples 26.06–26.62 (26.32). pH: pump samples 7.93–8.30 (8.11), net samples 7.93–8.18 (8.04).

*Undellopsis pacifica* Kofoid and Campbell

(Figures 107, 109)

*Undellopsis pacifica* Kofoid and Campbell, 1929, p. 270, fig. 513.

The short lorica, of *marsupialis*-like form but with little lateral concavity, and with aboral inflation and rounded aboral end, has a length of 1.9 oral diameters. The oral margin is thin. There is a low cuff with outer concavity, below which the bowl rounds off. The bowl tapers (10°) for 0.84 total length, and has a diameter at its lower end of 0.9 oral diameter. The aboral region (0.16 total length) is soup-bowl shaped. The aboral end is nearly flat, and its diameter is about 0.67 oral diameter.

The wall has a thickness of nearly 0.14 oral diameter at the anterior shoulder, and thins down to half as much in the posterior region. There are relatively thick laminae (which fuse in the suboral cuff) and enclosed homogeneous matter.

Length, 113 $\mu$ .

One of the loricae figured (fig. 107) has distinct lateral concavity and aboral expansion much as in *U. marsupialis*. The other lorica (fig. 109) has scarcely any lateral concavity, and no inflation. Both are extremes.

*Undellopsis pacifica* resembles *U. marsupialis*, but lacks the sweeping lateral concavity, the distinct aboral swelling, and the aboral point. *Undellopsis linearis* has pronounced aboral swelling and no point. *Undellopsis cubitum* and *U. subangulata* are more rectangular in optical section than the above species.

Recorded from five stations in the Pacific, as follows: three (41, 42, 75) in the Galápagos region, one (67) in the South Pacific middle latitudes, and one (136) in the California region.

There are 5 net samples, all taken at 100 meters. Frequency, 5 per cent at station 75; average, 2.5 per cent.

Temperature, 14°33–18°87 (16°50); salinity, 34.70–35.47 (35.05); density, 25.09–26.17 (25.67); pH, 7.91–8.39 (8.08).

*Undellopsis tricollaria* (Laackmann) emended Kofoid and Campbell*Undellopsis tricollaria*, Kofoid and Campbell, 1929, p. 272, fig. 522.

The short, wide lorica, with two rings on the anterior cylinder, inflated lower bowl, and rounded aboral end, has a length of 2.2 oral diameters. The oral margin is sharp-edged. The suboral ledge is angular (120°) at 0.18 total length below the rim, and has a diameter of 1.13 oral diameters. The upper bowl is subcylindrical (10°) and nearly 0.73 total length in length; it has two rings, the upper 1.14

and the lower 1.15 oral diameters in diameter, at 0.8 and 1.1 oral diameters below the rim; the upper bowl itself has a diameter, at the lower end, of 1.16 oral diameters, and decidedly concave sides between each of the three divisions. The lower bowl is pan-shaped, with a broadly rounded aboral end.

The wall has a thickness of nearly 0.2 oral diameter in the upper, but much less than half as much in the lower, bowl. There are thin laminae which enclose gray material.

Length, 110 $\mu$ .

*Undelopsis tricollaria* resembles *U. bicollaria* except that there are two rings instead of one on the upper bowl. It is not unlike *Amplectella collaria* save for the suboral ledge.

Recorded from three stations in the Pacific, as follows: one (145) in the North Pacific middle latitudes, one (146) in the California region, and one (151) in the North Pacific trade region.

There are 3 net samples, of which 1 was taken at 50 meters and 2 at 100 meters. Frequency, 4 per cent at station 151; all other records 2 per cent; average, 2.6 per cent.

Temperature, 18°28–20°07 (19°17); salinity, 34.35–34.71 (34.46); density, 24.24–24.77 (24.50); pH, 8.26–8.31 (8.28).

#### TINTINNIDAE Claparède and Lachmann emended

Tintinnidae, Kofoid and Campbell, 1929, p. 302; 1939, pp. 310–312.

Twenty-two genera are included in this family, namely, *Tintinnus*, *Bursaopsis*, *Proamphorella*, *Canthariella*, *Amphorella*, *Steenstrupiella*, *Amphorellopsis*, *Odontophorella*, *Albatrossiella*, *Dadayiella*, *Ormosella*, *Brandtiella*, *Prosteli-diella*, *Steli-diella*, *Eutintinnus*, *Daturella*, *Salpingella*, *Salpingelloides*, *Rhabdosella*, *Epirhabdosella*, *Salpingacantha*, and *Epicranella*. Of these twenty-two genera, eleven are present in the material of this expedition, namely, *Canthariella*, *Amphorella*, *Steenstrupiella*, *Dadayiella*, *Ormosella*, *Brandtiella*, *Eutintinnus*, *Daturella*, *Salpingella*, *Epirhabdosella*, and *Salpingacantha*. The family is widely spread in most seas and reaches its greatest development in the tropics. A few species enter both northern and antarctic seas, these showing clear relationships to those of warmer areas. The family is the most highly differentiated in the Tintinnoida.

#### TINTINNINAE Kofoid and Campbell

Amphorellinae Kofoid and Campbell, 1929, p. 303.

Tintinninae Kofoid and Campbell, 1939, pp. 312–313.

Included in this report are *Canthariella*, *Amphorella*, *Steenstrupiella*, and *Dadayiella*.

#### CANTHARIELLA Kofoid and Campbell

*Canthariella* Kofoid and Campbell, 1929, pp. 305–306.

*Canthariella* is one of the primitive species of the Tintinnidae in form and wall structure. All the species save one are first reported from the Pacific. All are tropical.

Three species are described here.

#### *Canthariella brevis* Kofoid and Campbell

*Canthariella brevis* Kofoid and Campbell, 1929, p. 306, fig. 584.

The tiny, rather slender lorica, with upright collar and sharply angular aboral end, has a length of 2 to 2.2 oral diameters. The thin oral margin is sharp-edged and entire. The collar is an inverted truncated cone (42°) with a length of 0.16 total length, and its diameter at the lower end is 0.8 oral diameter. The conical bowl (7°) contracts within the aboral fifth to form an angular aboral end (56°).

The exceedingly thin wall is hyaline.

Length, 47 to 54 $\mu$ .

*Canthariella brevis* differs from *C. truncata* in the shape of the aboral end, which in the latter species is squarely truncated. *Canthariella brevis* has a stouter bowl than either *C. truncata* or *C. septinaria*. It is shorter than *C. pyramidata*; its bowl is shorter, its collar relatively longer, and the aboral end is not shaped as in the latter. Had it a suborally thickened wall, it might have been confused with *Steenstrupiella gracilis*.

Recorded from four stations in the Pacific, as follows: one (35) in the Pacific equatorial region, one (44) in the Galápagos region, one (64) in the South Pacific middle latitudes, and one (136) in the California region.

There are 1 pump and 3 net samples, all taken at 100 meters. Frequencies, minimum.

Temperature: pump sample 14°33, net samples 14°55–18°87 (16°44). Salinity: pump sample 34.91, net samples 34.54–35.02 (34.86). Density: pump sample 26.06, net samples 25.09–26.11 (25.54). pH: pump sample 7.88, net samples 7.92–8.39 (8.13).

#### *Canthariella septinaria* Kofoid and Campbell

*Canthariella septinaria* Kofoid and Campbell, 1929, p. 307, fig. 582.

The minute lorica has wide collar and short, stout, faceted bowl, and its length is 1.72 to 1.79 oral diameters. The thin oral margin is entire, and the conical collar (37°) has a length of nearly 0.3 total length. Its diameter at its lower end is 0.67 oral diameter. The stocky bowl is subcylindrical for about 0.67 of its own length, contracting below that level about 35°, and has a flattened aboral end about 0.25 oral diameter in diameter.

The thin wall is hyaline. The lower bowl has 8 subequal short facets, and the neck region is barely thickened.

Length, 50 to 52 $\mu$ .

*Canthariella septinaria* differs from the others of the genus in aboral faceting.

Recorded from three stations, two in the Atlantic and one in the Pacific, as follows: two (24, 30) in the Atlantic equatorial region and one (45) in the Galápagos region.

There are 4 net samples, of which 1 was taken at the surface, 1 at 50 meters, and 2 at 100 meters. Frequency, minimum.

Temperature: Pacific, 22°43; Atlantic, 15°55–27°88 (22°99). Salinity: Pacific, 35.26; Atlantic, 35.61–36.40 (36.03). Density: Pacific, 24.31; Atlantic, 23.20–26.92 (26.34). pH: Pacific, 8.12; Atlantic, 7.96–8.30 (8.18).

**Canthariella truncata** Kofoid and Campbell

*Canthariella truncata* Kofoid and Campbell, 1929, p. 307, fig. 583.

The slender little lorica, with short collar, narrow bowl, and squarely truncated aboral end, has a length of 1.75 to 1.92 oral diameters. The thin oral margin is entire. The collar is an inverted truncated cone ( $38^\circ$ ) with a length of 0.36 total length, and a diameter at the throat of 0.6 oral diameter. The cylindrical bowl has a slight median bulge, and the aboral end is squarely flattened, the diameter being 0.45 oral diameter.

The thin, subuniform wall is hyaline, and the cavity neatly conforms to the outer contour.

Length, 42 to 54 $\mu$ .

*Canthariella truncata* differs from all others of the genus in the squarely truncated aboral end.

Recorded from one station (65) in the South Pacific middle latitudes, in a net sample taken at 100 meters. Only 1 lorica was found.

Temperature, 15.03; salinity, 34.30; density, 25.44; pH, 8.10.

**AMPHORELLA** Daday emended

*Amphorella*, Kofoid and Campbell, 1929, pp. 307-308.

*Amphorella* is an old genus of relatively simple character but of larger size than *Canthariella*, with fins, and with a peculiar aboral end. The genus is widely distributed in warm and cool seas, although never arctic.

Three species are described here.

**Amphorella amphora** (Claparède and Lachmann) Kofoid and Campbell

*Amphorella amphora*, Kofoid and Campbell, 1929, p. 309, fig. 586.

*Amphorella brandti* Kofoid and Campbell, 1929, p. 309, fig. 588; Marshall, 1934, p. 655, fig. 36.

The elongated, vasselike lorica has a length of 3.73 oral diameters. The oral margin is thin and smooth. The collar is widely flaring and funnel-shaped, sometimes reaching to  $93^\circ$ , and has a length of 0.23 oral diameter. Its sides are plane. The bowl is generally cylindrical and is 0.6 oral diameter in diameter just below the collar. The aboral region is convex conical ( $33^\circ$ ). The aboral end is concavely flattened and is less than 0.3 oral diameter in diameter. There are 3 flat, bladelike fins which reach 0.5 total length in length.

The wall is subuniformly thin, being 0.05 oral diameter in thickness. The lorica has a greenish cast and is almost transparent. Primary and secondary prismatic structure is recorded. The cavity of the lorica adheres to the outer contour.

Length, 145 to 190 $\mu$ .

Marshall (1934) had loricae of 107 to 190 $\mu$  from off the Barrier Reef of Australia. These loricae had long fins and *Amphorella* thickening, and otherwise conformed to the type of *amphora*.

*Amphorella amphora* is a species which is difficult to place. It resembles, and is commonly confused with, *A. quadri-*

*lineata*. It differs, however, in the length of the fins, which are typically longer in *quadrilineata*. The collar is quite different in shape in the two species, having, for one thing, a distinct constriction in *quadrilineata*, whereas in *amphora* it is more definitely a funnel. *Amphorella amphora* is somewhat like *A. minor*, but is larger and less stout. *Amphorella laackmanni* is smaller and unlike it in form, as are also the peculiar *A. calida* and *A. infundibulum* from the Atlantic collections of the *National*.

The confused history of this species is recorded by Kofoid and Campbell (1929). These authors, however, created the species *brandti*, which is here treated as part of *amphora*. The reasons for this inclusion are these: (1) Claparède and Lachmann's original figure is generalized; (2) this figure agrees better with *amphora* of Brandt (1906, p. 69, fig. 6) than with *quadrilineata*; and (3) loricae from off Japan, which the writer has examined, as well as those of this collection, can be readily differentiated from *quadrilineata*. The elimination of *brandti* thus better clears up the history of this division of the genus.

Recorded from one station (45) in the Galápagos region, in a pump sample taken at the surface. Frequency, 2 per cent.

Temperature, 22.43; salinity, 35.26; density, 24.31; pH, 8.12.

**Amphorella minor** Jörgensen

(Figures 112, 115)

*Amphorella minor*, Kofoid and Campbell, 1929, p. 310, fig. 590; Marshall, 1934, p. 655, fig. 37.

*Amphorella quadrilineata*, Alzamora, 1929, p. 6, fig. 11.

The tiny, short, thick lorica, with low, flaring collar, wide, convex bowl, and narrowed aboral end with truncated tip, has a length of 1.92 to 1.95 oral diameters. The oral margin is thin and smooth. The collar is a low, widely flaring basal segment of an inverted truncated cone ( $74^\circ$  to  $89^\circ$ ) with a length of 0.23 to 0.25 oral diameter. Its sides are plane to slightly convex, and evenly contoured. The throat has a diameter of about 0.73 oral diameter. The convex bowl increases in diameter to the level of greatest diameter, which is 0.75 to 0.85 oral diameter, and is at 0.85 to 0.90 oral diameter below the rim. This section forms a segment of a truncated cone ( $9^\circ$ ), and its sides are full. The aboral part of the bowl occupies about 1.1 oral diameters, and contracts from about  $8^\circ$  in the upper half to  $55^\circ$  in the lower half. The sides of the upper section are nearly plane; those of the lower are distinctly convex. The aboral end is concavely truncate, and has a diameter of 0.16 oral diameter. The fins are low, more or less suberect in their lower three-fourths, and curved in the upper part. They have a length ranging from 1.6 oral diameters up to the full length of the bowl.

The wall is thickest in the neck, where the *Amphorella*-like thickening occurs. It is 0.08 oral diameter at this level. It thins out steadily to the rim, and quickly below in the bowl, where, at the aboral end, it is little more than a membrane. Thin laminae with homogeneous interlamellar matter occur. The wall is glass-clear and without trace of even the

finest prisms. The lumen is constricted in the throat, and the fins are solid; the aboral end is always closed.

There are 2 macronuclei.

Length, 93 to 94 $\mu$ .

Marshall (1934) figures a lorica assigned to *Amphorella minor* much like that of the original figure. Kofoid and Campbell (1929) figure another from the California Current which is rather intermediate between the former and the *Carnegie* specimens. The sum total of figures indicates considerable variability. The fact should not be overlooked that dwarfed *A. quadrilineata* may occur, and that these might be confused with *minor* on account of their dimensions.

*Amphorella minor* is much shorter than other species which have the same general form. It bears some likeness to *A. amphora* in having a low collar and in fins, but is always shorter and typically has a biconvex bowl. The shape of the bowl, and the lower collar and longer fins distinguish it from *A. quadrilineata*. The general shape and character of the fins serve to mark it off from *A. laackmanni*.

Recorded from twenty-five stations, seven in the Atlantic and eighteen in the Pacific, as follows: one (3) in the Atlantic drift, one (16) in the Gulf Stream, three (18, 20, 21) in the Sargasso Sea, two (23, 30) in the Atlantic equatorial region, three (42, 45, 69) in the Galápagos region, one (65) in the South Pacific middle latitudes, three (95, 96, 97) in the region of South Pacific island fields, two (99, 152) in the Pacific equatorial region, three (100, 109, 140) in the North Pacific trade region, two (111, 117) in the North Pacific middle latitudes, and four (134, 136, 146, 149) in the California region.

There are 20 pump and 11 net samples, of which 10 were taken at the surface, 8 at 50 meters, and 13 at 100 meters. Maximum frequency, 8 per cent at station 42; other records above minimum (2 to 3 per cent) from stations 3, 30, 96, 97, 99, 134, 152; averages, 1.0 and 1.4 loricae in Atlantic and Pacific pump samples, and 2.7 and 2.8 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump samples 19°62–25°92 (22°70), net samples 14°66–27°88 (22°16); Pacific, 15°03–29°30 (24°64) and 8°93–21°13 (15°07), respectively. Salinity: Atlantic, pump samples 35.90–36.80 (36.31), net samples 36.16–36.73 (36.45); Pacific, 34.06–35.24 (34.79) and 34.30–35.63 (34.98), respectively. Density: Atlantic, pump samples 23.95–26.01 (25.11), net samples 23.26–26.81 (25.11); Pacific, 22.14–25.09 (23.37) and 24.60–26.50 (25.86), respectively. pH: Atlantic, pump samples 8.17–8.24 (8.20), net samples 8.14–8.32 (8.22); Pacific, 8.10–8.37 (8.23) and 7.76–8.12 (8.03), respectively.

*Amphorella quadrilineata* (Claparède and Lachmann) Daday  
(Figures 111, 113)

*Amphorella quadrilineata*, Kofoid and Campbell, 1929, p. 311, fig. 587; Hofker, 1931, pp. 384–385, fig. 80; Marshall, 1934, p. 654, fig. 35.

*Amphorella brandti*, Hada, 1932b, pp. 569–570, fig. 23.

The elongated, tubular lorica, with widely flaring collar and broad, more or less angular, truncated aboral end with

4 fins, has a length of 2.63 to 3.43 oral diameters. The oral margin is thin and entire. The flaring collar, with usually concave sides, is a truncated, inverted basal segment of a cone (45° to 84°) with a length of 0.27 to 0.37 oral diameter and with a diameter at its lower end of 0.56 to 0.75 oral diameter. The bowl increases in diameter regularly and evenly to a diameter of 0.66 to 1.00 oral diameter at about 2 oral diameters below the rim. This upper section of the bowl is, thus, a truncated cone (7°) with plane or barely convex sides; sometimes the sides are plane on one side and convex on the other. The aboral section of the bowl is more or less angular and its length is 0.87 to 1.45 oral diameters. It contracts at 10° in the upper half and at 60° to 87° in the aboral part. The aboral end itself is truncated concave. There are 4 long fins which reach up on the bowl as far as 0.75 total length, or rarely higher.

The wall is thickest in the neck, where, in the *Amphorella*-like thickening, it reaches 0.095 oral diameter. Below and above, the wall is less than half as thick, and in the aboral region it is reduced to a membrane; this latter region is not infrequently crushed and distorted as a result of its extreme thinness. The wall is glassy or grayish, without trace of either primary or secondary prisms. There are, however, thin laminae between which is homogeneous matter.

There are 8 large, oval macronuclei, arranged in a spiral line drawn through the length of the animal, and 2 or more micronuclei. The frontal field is tipped at a pronounced angle to the axis of the body. There are 18 membranelles, and the body has 8 rows of vertical ciliary lines.

Length, 109 to 145 $\mu$ .

Hofker's generalized (1931) sketch is, perhaps, intended only to show the characters of the nuclei. Marshall (1934) figures a lorica 2.83 oral diameters in length which has a wider neck and narrower funnel than the loricae of this collection; its fins are short, being only 1.3 oral diameters in length. Hada (1932b) figures another lorica 2.82 oral diameters in length, with long fins and narrow neck; its throat is also narrow and the laminae are thick. The *Carnegie* loricae vary among themselves in length, proportions, shape of collar and bowl, and length of fins. Two rather extreme individuals are figured (figs. 111, 113) from this collection.

Hada (1932b) figures his lorica as *A. brandti*, but it appears best to register it as *quadrilineata*, with which it agrees in form, size, and proportions.

*Amphorella quadrilineata* is separated with some difficulty from *A. amphora*. Its fins are usually longer, and the collar is longer and more funnel-like instead of being a simple low flare. The bowl is not narrowed down near the middle and there is greater thickening in the throat. It is distinguished from *A. minor* by its larger size and more tubular bowl. It is not likely to be confused with other species of *Amphorella*. The presence of 4 fins is a rather uncertain diagnostic character and not always easy to determine.

Recorded from thirty-three stations, fourteen in the Atlantic and nineteen in the Pacific, as follows: three (2, 15, 16) in the Gulf Stream, two (3, 4) in the Atlantic drift, three (18, 20, 21) in the Sargasso Sea, three (22, 23, 27) in the Atlantic equatorial region, three (31, 33, 34) in the

Caribbean Sea, three (35-36, 38, 154) in the Pacific equatorial region, nine (40, 44, 45, 69, 71, 73, 78, 79, 80) in the Galápagos region, three (48, 84, 98) in the region of South Pacific island fields, and four (115, 142, 144, 145) in the North Pacific middle latitudes.

There are 21 pump and 20 net samples, of which 13 were taken at the surface, 14 at 50 meters, and 14 at 100 meters. Maximum frequency, 25 per cent at stations 35-36, 115; other records above minimum (2 to 20 per cent) from stations 15, 16, 18, 33, 38, 40, 44, 45, 69, 71, 80, 144, 154; averages, 3.5 and 1.6 loricae in Atlantic and Pacific pump samples, and 1.1 and 10.2 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, pump samples 19°27-28°49 (24°12), net samples 14°32-26°46 (20°87); Pacific, 15°33-27°52 (22°49) and 16°58-28°71 (21°76), respectively. Salinity: Atlantic, pump samples 36.25-37.00 (36.42), net samples 35.96-38.37 (36.81); Pacific, 34.47-36.29 (35.28) and 32.88-36.42 (33.16), respectively. Density: Atlantic, pump samples 22.73-26.12 (24.66), net samples 23.89-26.91 (25.11); Pacific, 23.88-25.30 (24.44) and 21.31-25.83 (24.04), respectively. pH: Atlantic, pump samples 8.21-8.30 (8.23), net samples 8.14-8.32 (8.19); Pacific, 8.04-8.31 (8.21) and 7.77-8.33 (8.05), respectively.

#### STEENSTRUPIELLA Kofoid and Campbell

*Steenstrupiella* Kofoid and Campbell, 1929, pp. 311-312.

The elongated loricae of this genus are related to *Amphorella*, and are tropical.

Three species are described here.

#### *Steenstrupiella gracilis* (Jørgensen) Kofoid and Campbell

*Steenstrupiella gracilis*, Kofoid and Campbell, 1929, p. 313, fig. 597.

The short, plump lorica, with little-flaring collar and tubular bowl with blunt aboral end, has a length of 2.66 oral diameters. The thin oral margin is merely the upper end of the low collar. The collar is a basal segment of an inverted truncated, slightly rounded cone (46°) with a length of 0.5 oral diameter and with a diameter at the lower end of 0.84 oral diameter. The tubular bowl, with the same diameter as at the throat, reaches 0.75 total length, then suddenly becomes conical (42°) for a short distance, and finally becomes bluntly angular (110°), although without distinct pointing.

There are 4 (or 6) short, ridgelike fins, the length of which reaches nearly 0.67 oral diameter, and which are located within the lower part of the tubular section of the bowl and the upper part of the blunt, closed aboral end. The wall reaches 0.16 oral diameter in thickness in the neck and is elsewhere decidedly thinner. It is hyaline.

Length, 79µ.

The lorica figured by Jørgensen (1924) is not the same as that figured by Kofoid and Campbell (1929), although the latter credit it to the former. The *Carnegie* loricae are of the latter type, and it is not unlikely that Kofoid and Camp-

bell's specimen actually was from the eastern tropical Pacific rather than the Mediterranean. The species may later require a new name.

*Steenstrupiella gracilis* is shorter and relatively thicker than the other species. Its aboral end is not swollen as is that of *S. robusta*, nor is it saccular to pointed as in the much longer *S. steenstrupii*. It has no median swelling as in the greatly elongated *S. intumescens*. Were it shorter and without nuchal thickening, it would be close to *Canthariella septinaria*.

Recorded from eleven stations, one in the Atlantic and ten in the Pacific, as follows: one (20) in the Sargasso Sea, two (38, 153) in the Pacific equatorial region, three (49, 85, 89) in the region of South Pacific island fields, one (77) in the Galápagos region, two (110, 150) in the North Pacific trade region, and two (142, 144) in the North Pacific middle latitudes.

There are 8 pump and 3 net samples, of which 4 were taken at the surface, 3 at 50 meters, and 4 at 100 meters. Maximum frequency, 10 per cent at station 38; other records all minimum.

Temperature: Atlantic, net sample 25°72; Pacific, pump samples 17°46-28°38 (22°88), net samples 23°72-26°48 (25°10). Salinity: Atlantic, net sample 36.60; Pacific, pump samples 34.20-36.24 (35.08), net samples 32.88-36.04 (34.46). Density: Atlantic, net sample 24.34; Pacific, pump samples 21.78-25.11 (23.98), net samples 21.31-24.53 (22.92). pH: Atlantic, net sample 8.26; Pacific, pump samples 8.14-8.47 (8.29), net samples 8.19-8.33 (8.26).

#### *Steenstrupiella robusta* Kofoid and Campbell

(Figure 114)

*Steenstrupiella robusta* Kofoid and Campbell, 1929, p. 313, fig. 595; Marshall (part), 1934, pp. 655-656 (see also *S. steenstrupii*).

The phial-shaped lorica, with blunt, swollen pyramidal aboral end, has a length of 2.8 oral diameters. The oral margin is thin, and there is a low, widely spread collar below it. The collar is a basal segment of a truncated cone (80°) with barely concave sides, with a length of only 0.43 oral diameter, and with a diameter at the lower end of 0.62 oral diameter. The longer, tubelike anterior part of the bowl extends with uniform diameter (the same as the throat) for 1.58 oral diameters; the aboral region is swollen angular and generally pyramidal. It begins, at the lower end of the tubular section, to expand as a basal segment of a smooth cone (25°); this subdivision has a length of 0.33 oral diameter and reaches a diameter at the lower end of nearly 0.63 oral diameter. Below this level the wall contracts evenly as a segment of an inverted truncated cone (20°) with a length of 0.54 oral diameter, and with a diameter of about 0.4 oral diameter at its lowermost end. At the aboral end is an inverted, plane, bluntly pointed pyramid (92°) with a length of about 0.2 oral diameter. There are 6 low, line-like, convex, erect fins with length of approximately 0.67 oral diameter.

The wall thickens at the neck to over 0.16 oral diameter,

and rapidly thins to a minimum of 0.07 just above the aboral expansion. It is glass-clear, and though laminae are present, the enclosed material is without clear-cut prisms.

Length, 107 to 133 $\mu$ .

Marshall (1934) includes this species with *Steenstrupiella steenstrupii* because of size, striae, and thickness, but these characters are of less importance than the swollen pyramidal aboral end. The two species were readily distinguishable in the Carnegie material. The figured lorica (fig. 114) is extreme, however, in this regard.

*Steenstrupiella robusta* differs from *S. steenstrupii* and *S. gracilis* in the shape of the aboral end.

Recorded from five stations, two in the Atlantic and three in the Pacific, as follows: one (3) in the Atlantic drift, one (21) in the Sargasso Sea, one (48) in the region of South Pacific island fields, one (59) in the South Pacific middle latitudes, and one (145) in the North Pacific middle latitudes.

There are 6 net samples, of which 3 were taken at the surface, 1 at 50 meters, and 2 at 100 meters. Frequency, 2 per cent at station 3; other records minimum; average in the Atlantic, 1.5 per cent.

Temperature: Atlantic, 13°52–26°57 (18°25); Pacific, 16°33–23°63 (19°98). Salinity: Atlantic, 35.85–36.28 (36.03); Pacific, 34.71–36.44 (35.37). Density: Atlantic, 23.84–26.96 (25.87); Pacific, 24.86–24.90 (24.88). pII: Atlantic, 8.10–8.31 (8.23); Pacific, 8.10–8.32 (8.20).

*Steenstrupiella steenstrupii* (Claparède and Lachmann)  
Kofoid and Campbell

*Steenstrupiella steenstrupii*, Kofoid and Campbell, 1929, p. 314, fig. 596; Marshall (part), 1934, pp. 655–656 (see also *S. robusta*).

*Steenstrupiella entzi* Kofoid and Campbell, 1929, pp. 312–313, fig. 593.

The moderately elongated lorica, with very low, flaring collar, long, tubular bowl, and saccular aboral end, has a length of 4.5 oral diameters. The oral margin is thin. The widely flaring collar is a basal segment of a full-sided inverted cone (60°), with a length of nearly 0.4 oral diameter and with a diameter of 0.75 oral diameter at the lower end. The elongated tubular section of the bowl has a length of 0.89 total length, and it maintains approximately the same diameter as at the throat throughout. The aboral end is rounded off, saccular, without a point, and a little expanded. Above the rounded part extend 6 very short (hardly 0.75 oral diameter) ridges or fins, on the lower end of the tubular bowl.

The hyaline wall is thickened at the throat to nearly 0.16 oral diameter, but is less than half as much at other levels.

There are 2 round macronuclei.

Length, 117 to 200 $\mu$ .

This extensively distributed species is remarkably variable in its length, in possible correlation with temperature.

The inclusion of *Steenstrupiella entzi* with the present species must, of course, be only tentative, but does not seem impossible. *Steenstrupiella entzi* is comparable with those

loricae of *Tintinnopsis*, such as *Tintinnopsis dadayi*, in which repeated collars occur at fission.

*Steenstrupiella steenstrupii* is much like *S. robusta*, but lacks the aboral expansion. Its low fins are relatively shorter, and its collar is more flaring. It is not so long as *S. intumescens*, and is never swollen in the middle as is that species.

Recorded from thirteen stations, six in the Atlantic and seven in the Pacific, as follows: one (3) in the Atlantic drift, four (17, 18, 19, 20) in the Sargasso Sea, one (33) in the Caribbean Sea, one (35–36) in the Pacific equatorial region, one (45) in the Galápagos region, one (62) in the South Pacific middle latitudes, one (96) in the region of South Pacific island fields, one (148) in the California region, and two (150, 151) in the North Pacific trade region.

There are 6 pump and 12 net samples, of which 5 were taken at the surface, 6 at 50 meters, and 7 at 100 meters. Maximum frequency, 11 per cent at station 3; 8 per cent at station 35–36; average in net samples, 5 per cent in the Atlantic and 3.3 per cent in the Pacific.

Temperature: Atlantic, net samples 14°66–25°31 (21°13); Pacific, pump samples 12°44–28°41 (22°05), net samples 18°28–21°69 (19°98). Salinity: Atlantic, net samples 35.96–37.15 (36.58); Pacific, pump samples 34.02–35.63 (34.71), net samples 34.42–35.21 (34.81). Density: Atlantic, net samples 24.89–26.81 (25.68); Pacific, pump samples 22.34–26.22 (23.89), net samples 24.89–26.81 (25.68). pH: Atlantic, net samples 8.15–8.27 (8.20); Pacific, pump samples 8.10–8.39 (8.22), net sample 8.12.

*DADAYIELLA* Kofoid and Campbell

*Dadayiella* Kofoid and Campbell, 1929, p. 319.

*Dadayiella* is a specialized tropical genus with a few species that occur in the Mediterranean.

Four species are described here.

*Dadayiella acutiformis* Kofoid and Campbell

*Dadayiella acuta*, Kofoid and Campbell, 1929, p. 320, fig. 609.  
*Dadayiella acutiformis* Kofoid and Campbell, 1939, pp. 341–342, pl. 29, fig. 4.

The tall, chalice-shaped lorica, with fairly long aboral horn, has a length of 3.45 oral diameters. The oral margin is exceedingly thin and its sides are bounded by 9 plane facets. The 9 facets extend for nearly 0.5 oral diameter below the rim. The narrow, bell-shaped bowl flares (50°) as a basal segment of a cone with a length of only 0.2 oral diameter, forming a collar-like region. Below this collar the bowl is a long segment of an inverted cone (6°) with a length of nearly 1.46 oral diameters, and aborally it becomes one of 30° with a length of 1.19 oral diameters, the truncated end of which segment has a diameter of 0.11 oral diameter. The conical (5°) aboral horn has a length of 0.29 total length and has a minutely blunted tip.

The wall is exceedingly thin and clear, and the cavity, which exactly follows the outer contour, continues to the aboral tip.

Length, 75 $\mu$ .

*Dadayiella acutiformis* has longer and fewer suboral facets than either *D. ganymedes* or *D. bulbosa*. Its horn is stockier than that of *ganymedes* and lacks the bulb of *bulbosa*. The bowl is taller and bell-like, in contrast with that of *D. curta*. The remaining species are decidedly dissimilar.

Recorded from two stations (19, 20) in the Sargasso Sea. There were 2 loricae, taken in net samples, one from 50 and the other from 100 meters.

Temperature, 22.56–25.31 (23.93); salinity, 36.73–37.15 (36.94); density, 24.89–25.38 (25.13); pH, 8.19–8.27 (8.23).

#### *Dadayiella bulbosa* (Brandt) Kofoid and Campbell

*Dadayiella bulbosa*, Kofoid and Campbell, 1929, p. 320, fig. 611.  
*Amphorella ganymedes*, Hofker, 1931, p. 384, fig. 79a, b.

The tall, narrow, bell-shaped lorica, with aboral horn with swollen knob, has a length of 3.53 oral diameters. The thin, membrane-like oral margin is faceted with 20 facets. These facets are supported by vertical riblets; alternate stays are stronger and longer than intercalary ones. The riblets occupy most of the upper 1.0 oral diameter of the bowl. There is hardly any suboral flare, and the bowl is virtually subcylindrical for a little over half its length; at the lower end it contracts as an inverted convex cone (40°) with a diameter at its truncate end of less than 0.24 oral diameter. The aboral horn below the conical part is cylindrical, with a length of 0.61 oral diameter. Its lateral contour is decidedly concave, and toward the tip it swells into a knob with a flattened tip. From the tip there frequently extends a short spike, and there are 4 tiny vertical finlets on the knob.

The wall is distinctly hyaline; especially is it difficult to examine the oral region adequately because of its transparency; it is not thick, and the lumen probably extends into the knob as a minute canal.

Length, 93 to 125 $\mu$ .

In the presence or absence of the posterior spikelet, in the length of the finlets, in the extent of bulbosity, in the number of facets, and in the degree of lateral concavity of the bowl, these loricae vary among themselves.

The aboral bulb is the character which immediately distinguishes *Dadayiella bulbosa* from other species; some forms of *D. curta* also have a bulb, but the latter species is always smaller and shorter, with a different bowl. From *D. jorgensenii*, *bulbosa* may be distinguished by the lack of lateral spikes on the bulb.

Hofker's loricae (1931) clearly have bulbs and cannot be assigned to *D. ganymedes*.

Recorded from twenty stations, five in the Atlantic and fifteen in the Pacific, as follows: two (2, 14) in the Gulf Stream, two (25, 27) in the Atlantic equatorial region, one (32) in the Caribbean Sea, seven (43, 69, 71, 77, 78, 79, 80) in the Galápagos region, seven (110–111, 112, 113, 114, 116, 117, 128) in the North Pacific middle latitudes, and one (146) in the California region.

There are 9 pump and 14 net samples, of which 7 were taken at the surface, 9 at 50 meters, and 7 at 100 meters. Maximum frequency, 11 per cent at station 112; other records

above minimum (2 to 10 per cent) from stations 2, 14, 32, 113, 114, 116, 117; averages, 1.7 per cent in Atlantic net samples, 1.2 loricae and 3.8 per cent in Pacific pump and net samples, respectively.

Temperature: Atlantic, pump sample 26.04, net samples 14.02–26.64 (21.00); Pacific, 11.88–24.55 (19.11) and 8.93–26.06 (18.08), respectively. Salinity: Atlantic, pump sample 36.25, net samples 35.59–36.40 (36.07); Pacific, 33.07–36.04 (34.84) and 33.79–36.04 (34.90), respectively. Density: Atlantic, pump sample 23.98, net samples 23.55–26.66 (25.40); Pacific, 23.58–25.89 (24.69) and 23.75–26.41 (24.77), respectively. pH: Atlantic, pump sample 8.30, net samples 8.06–8.30 (8.24); Pacific, 8.09–8.22 (8.11) and 7.98–8.26 (8.16), respectively.

#### *Dadayiella cuspis* Kofoid and Campbell

*Dadayiella cuspis* Kofoid and Campbell, 1929, pp. 320–321, fig. 614.

The very small lorica, with facets extending to the aboral region and with short horn, has a length of 2.91 to 3.10 oral diameters. The oral margin is thin, erect, and smooth, and is formed by the edges of about 12 subequal vertical facets. These facets are long planes and form the bowl. The bowl as a whole flares 12° in the upper tenth and becomes a cone (5°) for about 0.8 the length, finally becoming a broader cone (50°) in the aboral 0.2. The conical (10°), pointed aboral horn has a length of 0.12 to 0.18 total length.

The exceedingly thin wall is hyaline; there is no prismatic structure and laminae are not differentiated.

Length, 67 to 93 $\mu$ .

The facets of *Dadayiella cuspis* extend to the very end of the bowl, unlike those of *D. pachytoecus*, which die away near the aboral end. In all the other species facets are limited to the suboral region. The general form is much like that of *D. ganymedes*, but size and facets serve to distinguish the two species.

Recorded from two stations in the Pacific, as follows: one (65) in the South Pacific middle latitudes, and one (147) in the California region.

Both records are from 100 meters, in net samples. Frequency, 2 per cent at station 147.

Temperature, 15.03–19.27 (17.15); salinity, 34.30–35.04 (34.67); density, 25.00–25.44 (25.22); pH, 8.10–8.29 (8.19).

#### *Dadayiella ganymedes* (Entz, Sr.) Kofoid and Campbell

(Figure 128)

*Dadayiella ganymedes*, Kofoid and Campbell, 1929, p. 321, fig. 610; Marshall, 1934, p. 657.

Not *Amphorella ganymedes*, Hofker, 1931, p. 384, fig. 79 (see *D. bulbosa*).

The elongate, chalice-shaped lorica, with simple, pointed aboral horn, has a length of 4.0 oral diameters. The oral margin is regularly faceted with 7 to 12 facets, and exceedingly thin-edged. The suboral facets extend from the margin for a distance of 0.21 total length, and there are thin vertical



stays which apparently support the membrane-like, almost transparent wall between them. This faceted region is laterally concave, but the diameter of the bowl at the lower end reaches 1.15 oral diameters, so that there is general swelling up to that level. Below this level the bowl continues to expand, reaching, at 1.54 oral diameters below the rim, a diameter of 1.23 oral diameters. As the bowl continues aborally it gradually contracts within a moderately convex cone ( $28^\circ$ ) and reaches a diameter at the lower end of the cone of about 0.5 oral diameter. The aboral horn is a narrow cone ( $18^\circ$ ) with a length of slightly over 1.0 oral diameter, and its free tip is pointed.

The wall is exceedingly thin and clear, being hardly visible at all except in rather dim illumination. The lumen strictly follows the outer contour.

Length, 75 to 102 $\mu$ .

A few loricae have inserted riblets standing between the main ribs, and in some others subsidiary riblets occur.

Hofker's loricae (1931) have bulbous aboral ends and hence do not belong to the clearly defined *Dadayiella ganymedes*, but to *D. bulbosa*. As the aboral characters are wholly unlike those of *Amphorella*, there is no reason to assign these loricae to that genus, which is distinct.

*Dadayiella ganymedes* differs from *D. acutiformis* in having fewer facets, a more cylindrical aboral horn, and a more sharply set-off bowl. There is no bulb as in *D. bulbosa*, nor spikes as in *D. jorgenseni*. The facets are not so long as those of either *D. cuspidis* or *D. pachytoecus*, and the bowl is not short and plump as in *D. curta*.

Recorded from twenty-seven stations, nine in the Atlantic and eighteen in the Pacific, as follows: one (14) in the Gulf Stream, one (21) in the Sargasso Sea, five (22, 23, 25, 29, 30) in the Atlantic equatorial region, two (31, 33) in the Caribbean Sea, ten (40, 41, 43, 47, 69, 71, 72, 73, 78, 80) in the Galápagos region, two (108, 110) in the North Pacific trade region, three (111, 114, 117) in the North Pacific middle latitudes, one (118) in the East Asiatic marginal sea, one (149) in the California region, and one (152) in the Pacific equatorial region. *Dadayiella ganymedes* is a hardy, widely distributed species, absent mainly from the coldest waters.

There are 16 pump and 19 net samples, of which 8 were taken at the surface, 16 at 50 meters, and 11 at 100 meters. Maximum frequency, 60 per cent at station 114; other records above minimum (2 to 10 per cent) from stations 14, 29, 69, 110, 114, 117, 149, 152; averages, 1.4 loricae in Pacific pump samples, and 2.3 and 10.2 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, net samples  $14^\circ 60' - 27^\circ 88' (22^\circ 09')$ ; Pacific, pump samples  $10^\circ 18' - 26^\circ 96' (19^\circ 24')$ , net samples  $8^\circ 93' - 26^\circ 06' (18^\circ 39')$ . Salinity: Atlantic, net samples 35.59-36.51 (36.09); Pacific, pump samples 33.61-35.95 (34.85), net samples 34.06-36.03 (35.97). Density: Atlantic, net samples 23.26-26.66 (25.00); Pacific, pump samples 23.20-26.11 (24.10), net samples 23.75-26.50 (24.98). pH: Atlantic, net samples 7.93-8.31 (8.17); Pacific, pump samples 7.92-8.34 (8.12), net samples 7.76-8.38 (8.10).

#### STELIDIPELLINAE Kofoid and Campbell

Stelidiellinae Kofoid and Campbell, 1929, p. 321.

This subfamily includes four genera, namely, *Ormosella*, *Brandtiella*, *Prostelidiella*, and *Stelidiella*. Only the first two are found in the material of this expedition.

#### ORMOSELLA Kofoid and Campbell

*Ormosella* Kofoid and Campbell, 1929, p. 322.

This is an unusual tropical genus, often rare in the plankton.

One species is described here.

#### *Ormosella apsteini* Kofoid and Campbell

*Ormosella apsteini* Kofoid and Campbell, 1929, p. 323, fig. 620.

The tall, narrow lorica, with conical collar, thin bowl, and long, sharp aboral horn, has a length of 2.38 to 3.21 oral diameters. The oral margin is thin and sharp. The conical, sleeve-like collar is sharply set off from the bowl; it is 0.38 oral diameter in width, flares ( $15^\circ$ ), and has flat sides. The bowl has a maximum diameter, just below the collar, of 0.56 oral diameter. It decreases steadily in diameter as a truncated basal segment of a pyramid ( $3^\circ$ ) in the upper 2.0 oral diameters, and then  $35^\circ$  in the lower 1.0 oral diameter. The bowl is faceted with 7 subequal, plane sides. The aboral horn is a narrow, sharply pointed cone ( $4^\circ$ ) with a length of 0.77 oral diameter in some instances.

The wall is glassy, without prismatic structure but with thin laminae and homogeneous enclosed substance. It thickens from the oral margin to the lower end of the collar, being there nearly 0.1 oral diameter across, and is somewhat less thick in the bowl. The aboral horn is solid.

Length, 100 to 136 $\mu$ .

*Ormosella apsteini* has a narrower, more elongated bowl than the other species. It is somewhat like *O. schweyeri* in all characters save the elongation and the differently shaped bowl. It has fewer facets than *O. trachelium*, has a less stout bowl than *O. bresslaui* as well as a longer horn, and hardly resembles the remaining species.

Recorded from one station (74) in the Galápagos region, in a net sample taken at 100 meters. Frequency, minimum.

Temperature,  $16^\circ 52'$ ; salinity, 35.14; density, 25.75; pH, 7.89.

#### BRANDTIELLA Kofoid and Campbell

*Brandtiella* Kofoid and Campbell, 1929, p. 325.

*Brandtiella* is often very common in the tropical ocean.

There is but a single species.

#### *Brandtiella palliata* (Brandt) Kofoid and Campbell

(Figures 126, 127)

*Brandtiella palliata*, Kofoid and Campbell, 1929, p. 325, fig. 623.

The elongate, amphora-like lorica, with spool-shaped collar, complexly folded aboral end, and outer gelatinous sac, has a length of 3.53 to 4.12 oral diameters. The oral margin is thin-edged, erect, and entire. The narrow, grooved, wheel-

like collar has a length of 0.23 to 0.30 oral diameter. The upper half is a basal segment of an inverted truncated cone (as much as  $58^\circ$ ). The diameter of the lower end of this section is about 0.8 oral diameter, and the sides are plane. The lower half of the collar is a somewhat convex-sided basal segment of a cone (reaching to  $78^\circ$ ). The long, amphora-shaped bowl begins at once below the collar and narrows down below it to the minimum diameter of 0.8 oral diameter at 1.00 to 1.32 oral diameters below the oral rim. The bowl swells below the level of least diameter and increases evenly and gradually until it is 1.04 to 1.20 oral diameters at 2.30 to 2.71 oral diameters below the oral rim. The upper bowl is thus narrow-waisted and concavely contoured. The aboral section of the bowl is convex conical ( $50^\circ$ ). The aboral end has 3 narrow, linelike fins as much as 2.0 oral diameters in length, and a purselike character is given this region by their arrangement. The aboral end is concavely truncated. The whole lorica save the oral opening is enclosed in a jelly-like outer lorica or sac which is 1.6 oral diameters in diameter across the middle. The sac extends out from the oral margin with plane sides, and reaches its greatest diameter at the lower end of the spool-like collar. This diameter it more or less retains until it reaches the level of the greatest diameter of the bowl, then it narrows and blends into the truncated aboral end. The sac is beset with minute circular bodies which are irregularly scattered in its substance. These are possibly coccoliths.

The wall is exceedingly thin, and hyaline with slight greenish cast; there are distinct inner and outer laminae. The cavity follows the contour of the outer surface and enters into the angles of the collar and aboral region.

The animal has 2 macronuclei.

Length, 156 to 203 $\mu$ .

The *Carnegie* loricae differ in length and proportions from those recorded elsewhere.

*Brandtiella palliata* is so unlike other Tintinnoina that there is little opportunity to compare it with others. Rarely is there an outer sac in other species save as in *Petalotricha entzi* and in one or two *Rhabdonella*; in these instances it is strictly confined to the suboral region. The inner lorica resembles that of *Amphorella quadrilineata*, especially the bowl, but the collars are utterly different. This species appears to be without close relatives in the suborder.

Recorded from sixteen stations, five in the Atlantic and eleven in the Pacific, as follows: one (20) in the Sargasso Sea, four (22, 23, 25, 30) in the Atlantic equatorial region, two (83, 98) in the region of South Pacific island fields, four (102, 103, 109, 151) in the North Pacific trade region, one (113) in the North Pacific middle latitudes, three (136, 148, 149) in the California region, and one (153) in the Pacific equatorial region.

There are 9 pump and 11 net samples, of which 10 each were taken at 50 and 100 meters. The absence of this species at the surface is significant. Maximum frequency, 4 per cent at stations 113, 153; all other records minimum; averages, 1.0 and 1.5 loricae in Atlantic and Pacific pump samples, and 1.0 and 3.3 per cent in Atlantic and Pacific net samples, respectively.

Temperature: Atlantic, net samples  $14^\circ.60$ – $24^\circ.44$  ( $19^\circ.01$ ), pump samples  $25^\circ.72$ – $27^\circ.88$  ( $26^\circ.80$ ); Pacific,  $18^\circ.28$ – $21^\circ.74$  ( $19^\circ.88$ ) and  $18^\circ.28$ – $27^\circ.46$  ( $23^\circ.87$ ), respectively. Salinity: Atlantic, net samples  $35.70$ – $36.73$  ( $36.15$ ), pump samples  $36.08$ – $36.60$  ( $36.34$ ); Pacific,  $34.42$ – $35.02$  ( $34.78$ ) and  $34.42$ – $36.49$  ( $35.14$ ), respectively. Density: Atlantic, net samples  $24.42$ – $26.62$  ( $25.60$ ), pump samples  $23.26$ – $24.34$  ( $23.80$ ); Pacific,  $24.06$ – $25.18$  ( $24.75$ ) and  $22.97$ – $24.77$  ( $23.76$ ), respectively. pH: Atlantic, net samples  $7.93$ – $8.21$  ( $8.09$ ), pump samples  $8.26$ – $8.30$  ( $8.28$ ); Pacific,  $8.12$ – $8.39$  ( $8.26$ ) and  $8.16$ – $8.28$  ( $8.23$ ), respectively.

#### SALPINGELLINAE Kofoid and Campbell

Tintinnineae Kofoid and Campbell, 1929, p. 327.

Salpingellinae Kofoid and Campbell, 1939, pp. 314–317.

This subfamily includes *Daturella*, *Epicranella*, *Epirhabdosella*, *Eutintinnus*, *Rhabdosella*, *Salpingacantha*, *Salpingella*, and *Salpingelloides*. Two of these are new genera.

#### EUTINTINNUS Kofoid and Campbell

*Eutintinnus* Kofoid and Campbell, 1939, pp. 358–363.

The tubular loricae of this genus have long been known under the familiar name *Tintinnus*. There are, however, a number of reasons why the name *Tintinnus* cannot be used for these species. These have been treated by Kofoid and Campbell (1939).

*Eutintinnus* is widely distributed. Most of the species are tropical and are often by far the most abundant of all Tintinnoina in the plankton. In most cases they are few in actual numbers but distinctly the most widely spread over great areas. A few species are limited to small regions of the ocean. Most of the tropical species cling to currents originating near the equator, and are spread north and south by them. In the north there are a few species limited to that region, but none is found in the Antarctic.

Twenty-one species are described here, of which one is new.

#### *Eutintinnus apertus* Kofoid and Campbell

*Tintinnus apertus* Kofoid and Campbell, 1929, p. 331, fig. 648; Marshall, 1934, p. 659.

The short lorica, with strong brim, tapering upper shaft, subcylindrical lower section, and rimless contracted aboral end, has a length of 3.12 oral diameters. The strong, horizontal brim surrounds the oral margin. The upper shaft flares ( $56^\circ$ ) concavely within 0.1 oral diameter below the rim, then tapers ( $15^\circ$ ) evenly for 0.67 total length; its diameter at the lower end is 0.76 oral diameter. Below this level it becomes inverted, truncated convex conical ( $33^\circ$ ) for a short distance (0.15 total length), and the diameter of this section at the lower end is only 0.5 oral diameter. The lowest section of the shaft is a cylinder which continues, with a diameter of 0.5 oral diameter, for a length of 0.85 oral diameter. The open aboral end is rimless.

The exceedingly thin wall is hyaline. Attached *Chaetoceros* occur, one or two of these diatom cells being fastened on the side of the lorica.

Length, 89 to 108 $\mu$ .

The *Carnegie* loricae are rather longer than the usual run and more tubular in the upper shaft.

*Eutintinnus apertus* has a wider aboral cylinder than does *E. angustatus*, its closest relative. *Eutintinnus tubus* lacks the intermediate subconical section and is a brackish-water form. *Eutintinnus tubulosus* tapers throughout, and *E. pinguis* and *E. pacificus* have median bulge and wider aboral ends.

Recorded from ten stations, two in the Atlantic and eight in the Pacific, as follows: one (18) in the Sargasso Sea, one (22) in the Atlantic equatorial region, two (41, 44) in the Galápagos region, one (60) in the South Pacific middle latitudes, one (109) in the North Pacific trade region, two (113, 145) in the North Pacific middle latitudes, one (132) in the California region, and one (153) in the Pacific equatorial region.

There are 11 pump and 7 net samples, of which 2 were taken at the surface, 5 at 50 meters, and 11 at 100 meters. Maximum frequency, 8 per cent at station 113; other records above minimum (2 to 3 per cent) from stations 44, 109, 153; average in Pacific net samples, 3.5 per cent.

Temperature: Atlantic, pump samples 20°32–22°12 (21°22), net samples 17°50–20°32 (18°91); Pacific, 13°62–24°19 (20°97) and 19°81–27°21 (22°33), respectively. Salinity: Atlantic, pump samples 36.81–36.82 (36.81), net sample 36.81; Pacific, 33.40–35.02 (34.50) and 34.66–36.33 (35.25), respectively. Density: Atlantic, pump samples 25.58–26.07 (25.82), net sample 26.07; Pacific, 23.25–26.11 (24.67) and 23.83–24.72 (24.16), respectively. pH: Atlantic, pump samples 8.21–8.24 (8.22), net sample 8.21; Pacific, 7.92–8.34 (8.26) and 8.18–8.28 (8.22), respectively.

#### *Eutintinnus birictus* Kofoid and Campbell

*Tintinnus birictus* Kofoid and Campbell, 1929, p. 332, fig. 634.

The long, slender lorica, with suboral and aboral flares, with both ends having brims, and with tapering shaft, has a length of 7.65 oral diameters. The oral margin has a thin, molded brim. There is some suboral flare (23°) within the upper 0.1 total length. The long shaft tapers (3°), its diameter just below the flare being 0.53 oral diameter. The aboral flare (10°) occupies about 0.67 oral diameter. Near its lower end it flares a bit more (48°). The wide-open aboral end (0.8 oral diameter) has a narrow, molded brim.

The hyaline wall is thin.

Length, 377 to 650 $\mu$ .

*Eutintinnus birictus* is much longer than *E. elongatus* and has more suboral flare. It is wider open and less tapering below than that species.

Recorded from one station (66) in the South Pacific middle latitudes, in a pump sample taken at 50 meters. Frequency, minimum.

Temperature, 17°86; salinity, 34.78; density, 25.16; pH, 8.10.

#### *Eutintinnus brandti* Kofoid and Campbell

(Figure 122)

*Tintinnus brandti* Kofoid and Campbell, 1929, pp. 332–333, fig. 628.

The tall, stout lorica, with flaring ends and swollen shaft,

has a length of 5.05 oral diameters. The thin oral margin has a low, scarcely evident, molded brim. The suboral flare (43°) is within 0.39 oral diameter, and its diameter at the lower end is nearly 0.7 oral diameter. The long shaft swells gradually from the neck and reaches 0.72 oral diameter near 0.37 total length from the rim. The swollen region occupies approximately 0.6 total length. At the lower level its diameter is 0.57 oral diameter, and again below it contracts (6°) for 0.85 oral diameter, with a diameter at the lower end of about 0.48 oral diameter. The concave aboral flare (42°) is brimless, and of a length of about 0.33 oral diameter; its own diameter is 0.69 oral diameter.

The uniformly thin wall (0.02 oral diameter) is hyaline.

Length, 331 $\mu$ .

The *Carnegie* loricae lack the aboral brim usual in most specimens.

*Eutintinnus brandti* is smaller than *E. latus* (353 to 404 $\mu$ ) and bulges somewhat more. It has submedian bulge, lacking in *E. fraññóii*, and aboral flare, lacking in *E. turgescens*. *Eutintinnus medius* is shorter, with less abrupt flare.

Recorded from eighteen stations, four in the Atlantic and fourteen in the Pacific, as follows: three (18, 19, 20) in the Sargasso Sea, one (23) in the Atlantic equatorial region, five (44, 71, 72, 73, 80) in the Galápagos region, four (85, 90, 93, 97) in the region of South Pacific island fields, two (101, 110) in the North Pacific trade region, two (137, 146) in the California region, and one (142) in the North Pacific middle latitudes.

There are 17 pump and 7 net samples, of which 8 were taken at the surface, 7 at 50 meters, and 9 at 100 meters. Maximum frequency, 13 per cent at station 18; in pump samples there were 1 to 11 loricae, average 2.7.

Temperature: Atlantic, net samples 20°32–25°31 (22°54); Pacific, net sample 20°07, pump samples 16°90–28°74 (24°34). Salinity: Atlantic, net samples 36.02–37.15 (36.76); Pacific, net sample 34.32, pump samples 34.47–36.24 (35.26). Density: Atlantic, net samples 24.89–26.07 (25.51); Pacific, net sample 24.24, pump samples 21.95–25.30 (23.70). pH: Atlantic, net samples 8.18–8.27 (8.22); Pacific, net sample 8.26, pump samples 8.03–8.34 (8.24).

#### *Eutintinnus colligatus* Kofoid and Campbell

*Tintinnus colligatus* Kofoid and Campbell, 1929, p. 333, fig. 652.

The moderately long, tall, slender lorica, with abrupt aboral constriction, has a length of 5.0 oral diameters. The thin oral margin has a narrow, molded brim. The suboral funnel flares (38°) within the anterior 0.5 oral diameter; its aboral diameter is 0.6 oral diameter. The long shaft tapers (4°) regularly. At 0.2 oral diameter above the aboral end is a narrow constriction of somewhat less than 0.3 oral diameter. There is an aboral flare (45°) directly posterior to the peculiar constriction. The rimless aboral end has a diameter of 0.35 oral diameter.

The hyaline wall is uniformly thin.

Length, 260 to 295 $\mu$ .

No other species has the unique aboral constriction.

Recorded from thirteen stations in the Pacific, as follows: two (37, 152) in the Pacific equatorial region, two (68, 78) in the Galápagos region, three (96, 158, 159) in the region of South Pacific island fields, and six (103, 104, 105, 107, 108, 151) in the North Pacific trade region.

There are 11 pump and 7 net samples, of which 10 were taken at the surface, 7 at 50 meters, and 1 at 100 meters. Maximum frequency, 5 per cent at station 151; other records above minimum (2 to 3 per cent) from stations 152, 159; average in net samples, 2.1 per cent; in pump samples there were 2 loricae at station 151, the frequency in all others being minimum.

Temperature: pump samples 18°60–29°30 (25°43), net samples 11°48–28°60 (22°88). Salinity: pump samples 34.02–35.95 (34.98), net samples 31.68–36.03 (34.78). Density: pump samples 21.95–25.15 (24.08), net samples 20.20–26.50 (23.06). pH: pump samples 8.14–8.25 (8.21), net samples 7.76–8.39 (8.38).

#### *Eutintinnus elegans* (Jørgensen) Kofoid and Campbell

*Tintinnus elegans*, Kofoid and Campbell, 1929, p. 333, fig. 630.

The rather short, slender lorica, with median bulge and flaring ends, has a length of 6.0 oral diameters. The thin oral margin has a narrow, molded brim. The suboral funnel flares (22°) within 0.67 oral diameter, and its aboral diameter is 0.73 oral diameter. The shaft gradually swells to a diameter of 1.0 oral diameter within a rather lengthy region (0.64 total length), with the maximum diameter at 0.43 total length from the rim. The posterior region contracts (12°) for approximately 0.12 oral diameter, with a diameter of 0.73 oral diameter at the lower end. Below the lower end the aboral flare (28°) expands to the rimless aboral end, the diameter of which is 0.9 oral diameter.

The exceedingly thin wall is hyaline.

Length, 147 to 190 $\mu$ .

*Eutintinnus elegans* is shorter than *E. brandti* and longer than *E. medius*. It is much more contracted aborally than either of these species, but has a median bulge unlike *E. macilentus*.

Recorded from three stations in the Pacific, as follows: one (47) in the Galápagos region, one (49) in the region of South Pacific island fields, and one (53) in the South Pacific middle latitudes.

There were 3 pump samples, of which 2 were taken at the surface and 1 at 50 meters. Frequency, 2 loricae at station 53; average, 1.3.

Temperature, 21°44–23°88 (22°83); salinity, 35.76–36.17 (35.96); density, 24.42–24.96 (24.70); pH, 8.20–8.27 (8.23).

#### *Eutintinnus elongatus* (Jørgensen) Kofoid and Campbell

*Tintinnus elongatus*, Kofoid and Campbell, 1929, p. 334, fig. 631.

The elongated lorica, with both ends flaring, the oral end with brim, and with gradual even contraction in the shaft, has a length of 7.5 oral diameters. The oral margin is thin and has a narrowed, molded brim. The concave suboral

flaring (15°) region is well within the upper tenth of the contracted (5°) shaft. The diameter of the shaft at its lower end is nearly 0.43 oral diameter. Below this level it flares (35°) more widely than suborally, and the lower, open, brimless aboral end has a diameter of 0.57 oral diameter.

The thin, hyaline wall is uniformly 0.01 oral diameter in thickness.

Length, 493 to 500 $\mu$ .

Some of the *Carnegie* loricae are a little longer than usual for this species.

*Eutintinnus elongatus* lacks an aboral brim. It is less wide aborally than *E. birictus*.

Recorded from fourteen stations, two in the Atlantic and twelve in the Pacific, as follows: one (3) in the Atlantic drift, one (34) in the Caribbean Sea, two (45, 77) in the Galápagos region, three (48, 49, 89) in the region of South Pacific island fields, three (52, 54, 55) in the South Pacific middle latitudes, one (109) in the North Pacific trade region, one (137) in the California region, and two (141, 145) in the North Pacific middle latitudes.

There are 6 pump and 11 net samples, of which 8 were taken at the surface, 4 at 50 meters, and 5 at 100 meters. Maximum frequency, 18 per cent at station 48; other records above minimum (2 to 4 per cent) from stations 34, 54, 109, 141; average in Pacific net samples, 3.5 per cent; in pump samples, 1.6 loricae.

Temperature: Atlantic, net samples 24°08–36°06 (30°34); Pacific, net samples 16°75–23°72 (21°59), pump samples 20°79–28°38 (23°67). Salinity: Atlantic, net sample 36.53; Pacific, net samples 34.86–36.44 (35.48), pump samples 34.62–35.64 (35.10). Density: Atlantic, net sample 24.52; Pacific, net samples 23.74–25.37 (24.67), pump samples 22.77–24.64 (23.81). pH: Atlantic, net samples 8.15–8.21 (8.18); Pacific, net samples 8.16–8.27 (8.19), pump samples 8.21–8.30 (8.27).

#### *Eutintinnus fraknóii* (Daday) Kofoid and Campbell

(Figure 123)

*Tintinnus fraknóii*, Kofoid and Campbell, 1929, p. 334, fig. 638; Hofker, 1931, pp. 385–386, fig. 81.

The tall, slender lorica, with flaring ends and tapering shaft, has a length of 5.6 oral diameters. The oral margin is thin, with a narrow, horizontal brim. The suboral funnel flares (21°) within the anterior 0.16 total length; its diameter at the lower end is 0.6 oral diameter. The tapering (5°) shaft decreases evenly in diameter to within 0.2 oral diameter above the aboral end, where its diameter reaches 0.44 oral diameter. The flaring (40°), open aboral end is brimless and its diameter is 0.56 oral diameter.

The thin (0.04 oral diameter), uniform wall is glassy. Rare coccoliths are scattered along the shaft.

There are 4 (8) macronuclei.

Length, 278 $\mu$ .

*Eutintinnus fraknóii* is much shorter and less slender than *E. birictus* and *E. elongatus*. These two species also have less suboral flare. *Eutintinnus medius* has median swelling

lacking in *fraknóii*; the latter has aboral flare lacking in *E. lusus-undae*.

Recorded from fifty-nine stations, nineteen in the Atlantic and forty in the Pacific, as follows: three (2, 14, 16) in the Gulf Stream, one (3) in the Atlantic drift, five (17, 18, 19, 20, 21) in the Sargasso Sea, eight (22, 23, 24, 25, 26, 28, 29, 30) in the Atlantic equatorial region, two (33, 34) in the Caribbean Sea, four (35, 35-36, 37, 99) in the Pacific equatorial region, nine (40, 44, 45, 68, 71, 72, 75, 77, 78) in the Galápagos region, three (49, 90, 93) in the region of South Pacific island fields, nine (50, 52, 54, 59, 61, 62-63, 63, 64, 65) in the South Pacific middle latitudes, nine (100, 101, 102, 104, 105, 106, 140, 150, 151) in the North Pacific trade region, two (112, 145) in the North Pacific middle latitudes, and four (132, 133, 148, 149) in the California region. Like *Eutintinnus lusus-undae*, this species is seldom excluded in warm or temperate seas.

There are 48 pump and 39 net samples, of which 43 were taken at the surface, 26 at 50 meters, and 18 at 100 meters. This species progressively diminishes in deeper levels. Maximum frequency, 24 per cent at station 61; other records above minimum (2 to 20 per cent) from stations 2, 14, 17, 18, 20, 35, 35-36, 45, 59, 62-63, 65, 68, 71, 77, 78, 145; averages, 1.4 and 5.8 per cent in Atlantic and Pacific net samples, respectively; in pump samples there were 1 to 7 loricae.

Temperature: Atlantic, pump samples 17°50–28°57 (25°32), net samples 14°60–27°88 (22°09); Pacific, 16°33–27°84 (23°05) and 10°92–24°93 (18°87), respectively. Salinity: Atlantic, pump samples 35.22–37.00 (36.10), net samples 35.23–37.18 (36.39); Pacific, 31.68–36.17 (35.81) and 33.97–36.04 (34.83), respectively. Density: Atlantic, pump samples 22.73–25.38 (23.84), net samples 23.26–26.81 (25.22); Pacific, 20.20–24.96 (23.75) and 23.64–26.06 (25.00), respectively. pH: Atlantic, pump samples 8.18–8.32 (8.25), net samples 7.93–8.37 (8.20); Pacific, 8.04–8.42 (8.21) and 7.87–8.34 (8.05), respectively.

#### *Eutintinnus latus* (Jørgensen) Kofoid and Campbell

*Tintinnus latus*, Kofoid and Campbell, 1929, p. 334, fig. 636.

The large, stout lorica, with flaring suboral and aboral ends and median swelling, has a length of 4.92 oral diameters. The thin oral margin has a narrow, molded brim. The suboral flare (12°) extends nearly 0.27 total length; the diameter of the shaft at its lower end is 0.73 oral diameter. Below this level the shaft swells regularly and gradually, reaching 0.8 oral diameter near 0.57 total length from the brim. The swollen region occupies a band approximately 0.47 total length. Below its lower end the shaft continues for almost 0.23 total length, the diameter at the lower end being about 0.67 oral diameter. The aboral end flares (28°) within 0.4 oral diameter. There is no aboral brim, and the diameter reaches 0.8 oral diameter.

The wall is hyaline and thin (0.01 oral diameter).

Length, 355 to 404 $\mu$ .

*Eutintinnus latus* resembles *E. medius* in general shape, but is much broader and longer. It may be only a form of the other, developed under special physical conditions.

Recorded from two stations in the Atlantic, as follows: one (30) in the Atlantic equatorial region, and one (31) in the Caribbean Sea.

There are 3 net samples, of which 1 was taken at 50 meters and 2 at 100 meters. Frequency, minimum.

Temperature, 22°56–27°88 (25°32); salinity, 36.08–36.51 (36.33); density, 23.26–25.22 (24.24); pH, 8.19–8.30 (8.25).

#### *Eutintinnus lusus-undae* (Entz, Sr.) Kofoid and Campbell

(Figure 125)

*Tintinnus lusus-undae*, Kofoid and Campbell, 1929, p. 335, fig. 656; Alzamora, 1929, pp. 5–6, fig. 10; Marshall, 1934, pp. 657–658, fig. 39; Hofker (part), 1931, p. 387 (for fig. 84 see *E. tubulosus*).

The moderately tall lorica, with widely flaring funnel, oral brim, tapering shaft, and brimless wide aboral end, has a length of 3.02 oral diameters. The oral margin has a horizontal brim and a diameter of 0.93 oral diameter. The shaft flares as a wide funnel (38°) with a length of only 0.5 oral diameter, and with a diameter at the lower end of 0.88 oral diameter. The shaft is a tapering cylinder (4°), the length of which is nearly 0.84 total length, and the aboral diameter of which is about 0.4 oral diameter. The wide-open aboral end has neither flare nor brim.

The wall is hyaline, not over 0.01 oral diameter in thickness, with laminae that enclose homogeneous matter.

There are 8 macronuclei.

Length, 169 $\mu$ .

Marshall's (1934) loricae are longer than those of this expedition (176 to 298 $\mu$ ), and have taller funnels. Hofker's material apparently includes *E. tubulosus*, and possibly other species.

*Eutintinnus lusus-undae* is not swollen in the middle of the shaft as is *E. turgescens*, and its shaft is stouter and has a wider funnel than in *E. tenuis*. *Eutintinnus tubulosus* is shorter and more slender, with little suboral flare.

Recorded from seventy-three stations, sixteen in the Atlantic and fifty-seven in the Pacific, as follows: four (2, 14, 15, 16) in the Gulf Stream, one (4) in the Atlantic drift, four (17, 18, 20-21, 21) in the Sargasso Sea, five (23, 24, 25, 26, 28) in the Atlantic equatorial region, two (32, 33) in the Caribbean Sea, six (35, 35-36, 36, 37, 152, 153) in the Pacific equatorial region, fourteen (40, 41, 42, 43, 44, 45, 46, 47, 69, 71, 73, 77, 78, 80) in the Galápagos region, three (50, 54, 59) in the South Pacific middle latitudes, four (87, 98, 157, 158) in the region of South Pacific island fields, eleven (101, 102, 103, 104, 105, 106, 107, 108, 109, 138, 151) in the North Pacific trade region, eight (111, 112, 113, 141, 142, 143, 144, 145) in the North Pacific middle latitudes, and eleven (130, 131, 132, 133, 134, 135, 136, 137, 146, 148, 149) in the California region. This virile, dominant species is to be expected in all warm and temperate seas, and is lacking only in the coolest waters of the Arctic.

There are 79 pump and 46 net samples, of which 44 were taken at the surface, 43 at 50 meters, and 38 at 100 meters. *Eutintinnus lusus-undae* is most frequent in the upper levels of the sea, progressively diminishing in numbers at the

deeper levels. Maximum frequency, 36 per cent at station 112; other records above minimum (2 to 15 per cent) from stations 15, 23, 24, 33, 35, 35-36, 37, 40, 41, 42, 45, 46, 47, 69, 77, 78, 109, 113, 131, 136, 148, 152, 157; averages, 2.1 and 5.2 per cent in Atlantic and Pacific net samples, respectively; in pump samples there were 1 to 13 loricae.

Temperature: Atlantic, pump samples  $14^{\circ}95-28^{\circ}49$  ( $24^{\circ}35$ ), net samples  $14^{\circ}02-26^{\circ}79$  ( $20^{\circ}54$ ); Pacific,  $8^{\circ}96-27^{\circ}85$  ( $20^{\circ}90$ ) and  $11^{\circ}48-28^{\circ}14$  ( $20^{\circ}49$ ), respectively. Salinity: Atlantic, pump samples 35.63-36.75 (36.08), net samples 35.23-36.81 (36.10); Pacific, 33.40-36.09 (34.36) and 31.62-36.04 (34.83), respectively. Density: Atlantic, pump samples 23.14-26.12 (24.31), net samples 23.79-26.91 (25.39); Pacific, 21.97-26.19 (24.04) and 22.80-26.50 (24.45), respectively. pH: Atlantic, pump samples 8.18-8.29 (8.22), net samples 7.93-8.32 (8.15); Pacific, 7.87-8.39 (8.30) and 7.76-8.39 (8.09), respectively.

*Eutintinnus macilentus* (Jørgensen) emended Kofoid  
and Campbell

*Tintinnus macilentus*, Kofoid and Campbell, 1929, p. 335, fig. 637.

The rather short, decidedly concave, tapering lorica, with both ends flaring, has a length of 3.62 oral diameters. The thin oral margin has a thickened brim. The suboral 0.48 of the shaft flares ( $12^{\circ}$ ) and reaches at the lower end a diameter of 0.5 oral diameter. Below this level it again flares ( $8^{\circ}$ ) less widely and reaches a diameter of 0.37 oral diameter at 0.5 oral diameter above the aboral end. The aboral flare ( $20^{\circ}$ ) is short and wide. The open aboral end has no brim; its diameter is 0.56 oral diameter.

The uniformly thin wall is hyaline.

Length, 136 to 290 $\mu$ .

Considerable variation in length and amount of aboral constriction occurs.

*Eutintinnus macilentus* is much smaller than *E. fraxnöii* and its shaft has much more pronounced constriction. It is decidedly shorter and stouter than *E. elongatus*. *Eutintinnus attenuatus* has a short, wide suboral funnel, lacks aboral flare, and is much longer; similarly, *E. colligatus* has a funnel but has a specially contracted region aborally. Had *macilentus* teeth, it would be close to *E. turris*.

Recorded from seven stations, five in the Atlantic and two in the Pacific, as follows: four (17, 18, 19, 21) in the Sargasso Sea, one (22) in the Atlantic equatorial region, and two (49, 85) in the region of South Pacific island fields.

There are 4 pump and 7 net samples, of which 4 were taken at the surface, 5 at 50 meters, and 2 at 100 meters. Maximum frequency, 5 per cent at station 21; other records in net samples, minimum; in pump samples there were 1 to 4 loricae; average, 2.2.

Temperature: Atlantic, pump samples  $21^{\circ}85-26^{\circ}57$  ( $24^{\circ}98$ ), net samples  $17^{\circ}50-26^{\circ}57$  ( $22^{\circ}36$ ); Pacific, net samples  $23^{\circ}38-27^{\circ}89$  ( $25^{\circ}63$ ). Salinity: Atlantic, pump samples 36.28-37.15 (36.60), net samples 36.28-37.15 (36.76); Pacific, net samples 36.07-36.24 (36.21). Density: Atlantic, pump

samples 23.84-25.49 (24.60), net samples 23.84-26.07 (25.09); Pacific, net samples 23.38-24.72 (24.05). pH: Atlantic, pump samples 8.27-8.32 (8.28), net samples 8.21-8.32 (8.26); Pacific, net samples 8.22-8.27 (8.24).

*Eutintinnus magnificus*, new species

(Plate 1, figure 10; figure 124)

The elongated, tubular lorica, with flaring, rimmed oral margin, has a length of 8.57 oral diameters. The oral margin has a rim 0.09 oral diameter in width; this rim extends like a rounded, almost recurved flange about the aperture. The shaft arches concavely from its inner edge and reaches a diameter of 0.64 oral diameter at 0.58 oral diameter below the opening, forming a collar-like section. The long shaft narrows continuously until it reaches its least diameter at 8.3 oral diameter below the rim; this minimum diameter is 0.28 oral diameter, or about 0.3 diameter of the shaft at its upper end. The shaft as a whole forms a straight-sided inverted truncated cone ( $3^{\circ}$ ). Below the narrowest place the lorica again flares outward, as a wide, truncated cone ( $60^{\circ}$ ) with barely concave sides. The aboral aperture, which forms the base of the aboral cone, has a diameter of 0.84 oral diameter. There is no aboral flange.

The wall is exceedingly thin, shows no trace of laminae, and is glass-clear. There are no exterior markings.

Length, 300 $\mu$ ; diameter, oral 35 $\mu$ , aboral 32 $\mu$ , minimum diameter of shaft 13 $\mu$ .

*Eutintinnus magnificus* resembles *E. birictus* in general form and proportions, being 8.57 as against 6.3 to 10.6 oral diameters in length. It is unlike that species, however, in having an oral brim, and in its greater suboral and aboral flares, as well as in being narrowed posteriorly to a greater extent. It is unlike *E. attenuatus* in that that species has no pronounced brim or aboral flare; *attenuatus* is also stouter, being 5.4 to 5.6 oral diameters in length. *Eutintinnus latus* is much stouter, and so is *E. fraxnöii*. There is no aboral constriction in *magnificus* as in *E. colligatus*.

Recorded from four stations (19, 20, 20-21, 21) in the Sargasso Sea.

There are 5 net samples, of which 1 was taken at the surface, 2 at 50 meters, and 2 at 100 meters. Frequency, minimum.

Temperature,  $22^{\circ}42-25^{\circ}31$  ( $23^{\circ}68$ ); salinity, 36.24-37.15 (36.79); density, 24.47-25.67 (25.10); pH, 8.19-8.27 (8.24).

Type locality, station 19, at 50 meters; latitude  $24^{\circ} 00'$  north, longitude  $39^{\circ} 36'$  west.

*Eutintinnus medius* Kofoid and Campbell

*Tintinnus medius* Kofoid and Campbell, 1929, p. 336, fig. 629.

The stout, moderately bulging lorica, with both ends flaring, has a length of 4.35 oral diameters. The oral margin has a narrow, molded brim. The suboral funnel ( $23^{\circ}$ ) has a length of nearly 0.64 oral diameter and a diameter of 0.73 oral diameter at the lower end. The shaft is a truncated conical ( $3^{\circ}$ ) section, with submedian (0.53 total length) bulge (0.82 oral diameter). Below the long bulging region,

which occupies approximately 0.37 total length, the shaft contracts to a diameter of 0.55 oral diameter at 0.36 oral diameter above the aboral end. The aboral flare ( $18^\circ$ ) meets the thin, brimless, open aboral end.

The wall is thin and hyaline.

Length, 192 to 254 $\mu$ .

*Eutintinnus medius* differs from *E. turgescens* in having aboral flare. It is stouter and longer than *E. elegans* and has less constriction toward the aboral end of the shaft. It is much like *E. latus*, but is smaller and narrower.

Recorded from seventeen stations, three in the Atlantic and fourteen in the Pacific, as follows: one (16) in the Gulf Stream, two (18, 21) in the Sargasso Sea, two (45, 46) in the Galápagos region, one (48) in the region of South Pacific island fields, six (103, 104, 109, 138, 150, 151) in the North Pacific trade region, two (142, 144) in the North Pacific middle latitudes, and three (146, 147, 148) in the California region.

There are 14 pump and 6 net samples, of which 5 were taken at the surface, 6 at 50 meters, and 9 at 100 meters. Maximum frequency, 2 per cent at stations 45, 46, 48; in pump samples there were 1 to 8 loricae; average in Pacific net samples 1.6 per cent, in pump samples 1.4 loricae.

Temperature: Atlantic, net sample  $23^\circ 64$ , pump samples  $22^\circ 12$ – $26^\circ 57$  ( $24^\circ 34$ ); Pacific,  $19^\circ 27$ – $23^\circ 63$  ( $21^\circ 55$ ) and  $17^\circ 46$ – $25^\circ 45$  ( $21^\circ 82$ ), respectively. Salinity: Atlantic, net sample 36.41, pump samples 36.28–36.82 (36.55); Pacific, 34.63–36.44 (35.29) and 34.42–35.32 (34.88), respectively. Density: Atlantic, net sample 23.64, pump samples 22.12–26.57 (24.34); Pacific, 24.11–24.86 (24.57) and 22.89–25.11 (24.17), respectively. pH: Atlantic, net sample 8.23, pump samples 8.24–8.32 (8.28); Pacific, 8.12–8.32 (8.20) and 8.18–8.37 (8.28), respectively.

#### *Eutintinnus pacificus* Kofoid and Campbell

*Tintinnus pacificus* Kofoid and Campbell, 1929, p. 337, fig. 632; Marshall, 1934, p. 659, fig. 41.

The short, truncate subconical lorica, with little brim and wide-open aboral end, has a length of 2.3 oral diameters. The thin oral margin has only a thickened, molded brim. The shaft tapers ( $6^\circ$ ) and in some loricae is contracted in the postmedian half. The aboral end has a diameter of nearly 0.67 oral diameter. It is rimless.

The wall is nearly transparent and of exceeding thinness.

Length, 67 to 71 $\mu$ .

Marshall's (1934) loricae are posteriorly contracted and also longer (108 to 120 $\mu$ ) than the Carnegie specimens.

*Eutintinnus pacificus* is shorter than *E. pinguis* (114 to 161 $\mu$ ) and also stouter (length 2.3 as against 2.6 to 3.8 oral diameters); it lacks the median bulge which characterizes *pinguis*. Both species differ from *E. tubulosus* in being relatively stouter.

Recorded from one station (45) in the Galápagos region, in a net sample taken at the surface. Frequency, 2 per cent.

Temperature,  $22^\circ 43$ ; salinity, 35.26; density, 24.31; pH, 8.12.

#### *Eutintinnus perminutus* Kofoid and Campbell

*Tintinnus perminutus* Kofoid and Campbell, 1929, p. 337, fig. 649.

The fairly short lorica, with tapering shaft, bare median bulge, and both ends flaring, has a length of 4.37 oral diameters. The oral margin has a narrow, molded brim. The upper end of the shaft flares ( $38^\circ$ ) well within 0.1 oral diameter, then tapers ( $4^\circ$ ) for over half its length. Below this level it contracts very slightly to the aboral end, which, like the upper end, flares ( $38^\circ$ ) within 0.1 oral diameter. The open aboral end has no brim and is 0.65 oral diameter in diameter.

The wall is uniformly thin and clear.

Length, 140 to 183 $\mu$ .

*Eutintinnus perminutus* resembles *E. macilentus*, but that species is sweepingly concave laterally. It is also close to *E. tubulosus*, but in that species there are no oral and aboral flares. Other smaller species are not likely to be confused with it.

Recorded from seven stations, one in the Atlantic and six in the Pacific, as follows: one (19) in the Sargasso Sea, two (77, 80) in the Galápagos region, one (81) in the region of South Pacific island fields, two (112, 141) in the North Pacific middle latitudes, and one (135) in the California region.

There are 3 pump and 4 net samples, of which 2 were taken at the surface, 3 at 50 meters, and 2 at 100 meters. Frequency, 3 per cent at station 77; other records above minimum (2 per cent) from stations 80, 81; average in Pacific net samples, 2.3 per cent.

Temperature: Atlantic, net sample  $23^\circ 31$ ; Pacific, net samples  $23^\circ 72$ – $26^\circ 42$  ( $25^\circ 50$ ), pump samples  $18^\circ 95$ – $23^\circ 25$  ( $20^\circ 99$ ). Salinity: Atlantic, net sample 37.15; Pacific, net samples 35.85–36.04 (35.94), pump samples 34.60–35.10 (34.86). Density: Atlantic, net sample 24.89; Pacific, net samples 23.56–24.53 (23.94), pump samples 23.58–24.06 (24.06). pH: Atlantic, net sample 8.27; Pacific, net samples 8.19, pump samples 8.22–8.34 (8.29).

#### *Eutintinnus pinguis* Kofoid and Campbell

*Tintinnus pinguis* Kofoid and Campbell, 1929, p. 338, fig. 640.

The small, stout lorica has a median bulge, an indefinite suboral flare, and a length of 3.0 oral diameters. The thin oral margin has a narrow, molded brim. There is a bare suboral flare. The shaft tapers ( $10^\circ$ ), but has some bulge (0.87 oral diameter) near its middle. Below the bulge it contracts regularly to the open aboral end; the aboral diameter is 0.63 oral diameter. The aboral end is brimless.

The hyaline wall is exceedingly thin.

Length, 114 to 161 $\mu$ .

*Eutintinnus pinguis* differs from *E. pacificus* in being longer and more slender, and in having a median bulge. It lacks the aboral cylinder of *E. apertus* and the flare of *E. procurrerens*.

Recorded from four stations, two each in the Atlantic and the Pacific, as follows: one (21) in the Sargasso Sea, one

(24) in the Atlantic equatorial region, one (145) in the North Pacific middle latitudes, and one (146) in the California region.

There are 4 net samples, of which 2 were taken at 50 meters and 2 at 100 meters. Frequency, 2 per cent at station 145; other records minimum.

Temperature: Atlantic, 15°55–24°44 (19°99); Pacific, 19°16–20°07 (19°61). Salinity: Atlantic, 36.24–36.61 (36.42); Pacific, 34.32. Density: Atlantic, 24.47–26.34 (25.40); Pacific, 24.24–24.48 (24.36). pH: Atlantic, 7.96–8.25 (8.10); Pacific, 8.26–8.34 (8.30).

#### *Eutintinnus procurrerens* Kofoid and Campbell

*Tintinnus procurrerens* Kofoid and Campbell, 1929, p. 338, fig. 653.

The small, stout lorica, with wide-flaring aboral end, has a length of 3.3 oral diameters. The thin oral margin has a low, molded brim. The suboral funnel (30°) has a length of 0.47 oral diameter and a diameter at its lower end of 0.59 oral diameter. The wide shaft tapers (2°) for approximately 2 oral diameters, then contracts (18°) for 0.59 oral diameter and again flares (30°) in the lowermost section, the length of which is about equal to that of the section just above it. The wide-open aboral end is brimless.

The hyaline wall is thin.

Length, 138 to 206 $\mu$ .

*Eutintinnus procurrerens* differs from *E. turgescens* in having aboral flare, and from *E. medius* in the greater degree of aboral flare as well as in aboral contraction above the flare. Although contracted aborally, it does not resemble *E. colligatus*, which is distinctly different.

Recorded from nine stations in the Pacific, as follows: one (63) in the South Pacific middle latitudes, one (80) in the Galápagos region, one (84) in the region of South Pacific island fields, three (105, 109, 139) in the North Pacific trade region, and three (132, 136, 147) in the California region.

There are 8 pump and 2 net samples, of which 3 were taken at the surface, 3 at 50 meters, and 4 at 100 meters. Maximum frequency, 4 per cent at station 147; 2 per cent at station 136; in pump samples there were 1 to 2 loricae; average in net samples, 3 per cent.

Temperature: net samples 18°95–19°27 (19°11), pump samples 17°01–27°52 (23°39). Salinity: net samples 34.88–35.04 (34.96), pump samples 33.91–36.42 (35.34). Density: net samples 24.96–25.00 (24.98), pump samples 22.71–25.22 (23.95). pH: net samples 8.29–8.34 (8.31), pump samples 8.08–8.34 (8.21).

#### *Eutintinnus stramentus* Kofoid and Campbell

*Tintinnus stramentus* Kofoid and Campbell, 1929, p. 339, fig. 635; Marshall, 1934, p. 659, fig. 40.

The short lorica, with tapering shaft and rather strong brim, has a length of 4.9 oral diameters. The oral margin has a horizontal brim. The shaft lacks flare and tapers (5°) throughout its whole length without any local modification. The aboral end is brimless and its diameter is only 0.56 oral diameter.

The wall is exceedingly thin and almost transparent.

Length, 115 to 176 $\mu$ .

*Eutintinnus stramentus* lacks the suboral flare of *E. lusus-undae* and is also shorter and more slender. *Eutintinnus attenuatus* is much longer and more slender, with a wide suboral funnel and much narrower aboral end. Among the smaller species *stramentus* has no counterpart.

Recorded from ten stations, four in the Atlantic and six in the Pacific, as follows: two (18, 19) in the Sargasso Sea, two (24, 25) in the Atlantic equatorial region, one (45) in the Galápagos region, one (63) in the South Pacific middle latitudes, one (99) in the Pacific equatorial region, one (110) in the North Pacific trade region, and two (147, 149) in the California region.

There are 6 pump and 5 net samples, of which 3 were taken at the surface, 3 at 50 meters, and 5 at 100 meters. Frequency, minimum.

Temperature: Atlantic, net samples 14°60–25°31 (18°94); Pacific, net sample 22°43, pump samples 15°84–23°86 (22°02). Salinity: Atlantic, net samples 35.61–37.15 (36.31); Pacific, net sample 35.26, pump samples 34.58–35.28 (34.87). Density: Atlantic, net samples 24.89–26.62 (25.98); Pacific, net sample 24.31, pump samples 22.43–25.48 (24.07). pH: Atlantic, net samples 7.93–8.27 (8.04); Pacific, net sample 8.12, pump samples 8.08–8.34 (8.20).

#### *Eutintinnus tenuis* Kofoid and Campbell

*Tintinnus tenuis* Kofoid and Campbell, 1929, p. 339, fig. 655; Hada, 1932b, p. 571, fig. 25; Nie, 1934, pp. 79–80, fig. 16.

The lorica is a tapering tube with slight brim, and has a length of 4.9 oral diameters. The oral opening has a narrow, molded brim. The shaft tapers (3°) without local modification. The aboral end is rimless and its diameter is 0.69 oral diameter.

The hyaline wall is uniformly thin.

Length, 179 to 312 $\mu$ .

There is some variation in length, proportions, and aboral contraction.

*Eutintinnus tenuis* lacks the aboral flare of *E. frañónii* and is more slender than *E. lusus-undae*.

Recorded from four stations, one in the Atlantic and three in the Pacific, as follows: one (19) in the Sargasso Sea, one (117) in the North Pacific middle latitudes, one (130) in the California region, and one (140) in the North Pacific trade region.

There are 1 pump and 3 net samples, of which 1 was taken at 50 meters and 3 at 100 meters. Maximum frequency, 4 per cent at station 130; 2 per cent at station 117; other records minimum; average in Pacific net samples, 3 per cent.

Temperature: Atlantic, net sample 25°31; Pacific, net samples 8°93–8°96 (8°94), pump sample 25°94. Salinity: Atlantic, net sample 37.15; Pacific, net samples 33.72–34.06 (33.89), pump sample 35.02. Density: Atlantic, net sample 24.89; Pacific, net samples 26.14–26.41 (26.27), pump sample 23.09. pH: Atlantic, net sample 8.27; Pacific, net samples 7.98–8.05 (8.02), pump sample 8.34.



**Eutintinnus tubiformis** Kofoid and Campbell

*Tintinnus tubiformis* Kofoid and Campbell, 1929, p. 340, fig. 654.

The tall, stout lorica, with abrupt suboral and aboral flares and dense, rugose wall, has a length of 3.64 oral diameters. The oral margin is thick but nearly brimless. There is wide suboral flare ( $42^\circ$ ) within the anterior 0.1 oral diameter. The shaft tapers slightly ( $2^\circ$ ) without local modification, the diameter being nearly 0.58 oral diameter just above the aboral flare. The aboral flare ( $60^\circ$ ) is within 0.1 oral diameter, and the brimless aboral end has a diameter of 0.63 oral diameter.

The wall is dense but thin (0.02 oral diameter). Its surface has short, linear, irregular rugae.

Length, 323 to 414 $\mu$ .

*Eutintinnus tubiformis* has no oral teeth, but does have suboral flare, unlike *E. rugosus*, which latter species is also shorter (275 $\mu$ ). It is unique and not likely to be confused with others.

Recorded from five stations in the Pacific, as follows: two (81, 84) in the region of South Pacific island fields, one (105) in the North Pacific trade region, one (146) in the California region, and one (156) in the Pacific equatorial region.

There are 1 pump and 4 net samples, of which 1 was taken at the surface and 2 each at 50 and 100 meters. Frequency, 8 per cent at station 81; other records above minimum (2 to 4 per cent) from stations 105, 156; average in net samples, 4.3 per cent.

Temperature: pump sample  $26^\circ 91$ , net samples  $20^\circ 07$ – $27^\circ 52$  ( $25^\circ 15$ ). Salinity: pump sample 34.92, net samples 34.32–36.42 (35.41). Density: pump sample 22.71, net samples 22.90–24.24 (23.58). pH: pump sample 8.23, net samples 8.19–8.34 (8.22).

**Eutintinnus tubulosus** (Ostenfeld) Kofoid and Campbell

*Tintinnus tubulosus*, Kofoid and Campbell, 1929, pp. 340–341, fig. 651.

*Tintinnus lusus-undae*, Hofker, 1931, p. 387, fig. 84 (see also *E. lusus-undae*).

The short, contracted, tubular lorica, with almost no brim, has a length of 2.72 oral diameters. The oral margin is thin and is surrounded by a weak sort of molding which forms a slight brim. The shaft tapers ( $5^\circ$ ) uniformly to the simple, rimless aboral end, the diameter of which is 0.75 oral diameter.

The wall is almost transparent and of exceeding thinness.

Length, 111 $\mu$ .

For an account of the complex history of this species see Kofoid and Campbell (1929).

*Eutintinnus tubulosus* differs from *E. perminutus* in lack of suboral flare, smaller size, and less stout proportions. It is much shorter than *E. lusus-undae*, and not so stout: it is not so contracted as *E. sramentus*.

Recorded from six stations, three each in the Atlantic and the Pacific, as follows: two (3, 3-4) in the Atlantic drift, one (22) in the Atlantic equatorial region, one (72) in the Galá-

pagos region, one (128) in the North Pacific middle latitudes, and one (130) in the California region.

There are 4 pump and 5 net samples, of which 4 were taken at the surface, 3 at 50 meters, and 2 at 100 meters. Maximum frequency, 4 per cent at station 3; 2 per cent at station 3-4; other records minimum; average in net samples, 2 per cent.

Temperature: Atlantic, net samples  $13^\circ 52$ – $17^\circ 34$  ( $15^\circ 17$ ); Pacific, pump samples  $11^\circ 88$ – $24^\circ 93$  ( $18^\circ 05$ ). Salinity: Atlantic, net samples 35.85–36.10 (35.99); Pacific, pump samples 33.07–35.40 (34.30). Density: Atlantic, net samples 26.29–26.96 (26.68); Pacific, pump samples 23.64–25.30 (24.63). pH: Atlantic, net samples 7.99–8.19 (8.10); Pacific, pump samples 8.11–8.34 (8.18).

**Eutintinnus turgescens** Kofoid and Campbell

*Tintinnus turgescens* Kofoid and Campbell, 1929, p. 341, fig. 650.

The moderately tall lorica, with brim, suboral flare, and median expansion, has a length of 4.0 oral diameters. The oral opening has a thin, molded brim. The shaft flares ( $34^\circ$ ) within its upper tenth, the lower end of the flaring section having a diameter of 0.75 oral diameter. The shaft slowly swells from the neck to a diameter of 0.81 oral diameter near 0.47 total length below the brim, and then contracts with equal slowness to the simple, rimless aboral end, the diameter of which is 0.62 oral diameter.

The wall is hyaline and uniformly 0.02 oral diameter in thickness.

Length, 155 to 193 $\mu$ .

*Eutintinnus turgescens* swells in the mid-region, unlike *E. lusus-undae*, which it otherwise resembles. It is stouter than *E. tenuis* and has a bulge.

Recorded from nineteen stations, six in the Atlantic and thirteen in the Pacific, as follows: one (14) in the Gulf Stream, four (22, 23, 24, 27) in the Atlantic equatorial region, one (34) in the Caribbean Sea, three (44, 46, 77) in the Galápagos region, one (54) in the South Pacific middle latitudes, one (86) in the region of South Pacific island fields, one (109) in the North Pacific trade region, three (132, 134, 135) in the California region, two (142, 145) in the North Pacific middle latitudes, and two (153, 155) in the Pacific equatorial region.

There are 9 pump and 11 net samples, of which 6 were taken at the surface, 11 at 50 meters, and 3 at 100 meters. Maximum frequency, 6 per cent at station 153; other records above minimum (2 to 4 per cent) from stations 14, 34, 46, 77, 86; average in net samples, 1.6 and 3.7 per cent in the Atlantic and Pacific, respectively; in pump samples there were 1 to 7 loricae, average 2.2.

Temperature: Atlantic, net samples  $17^\circ 50$ – $26^\circ 04$  ( $22^\circ 30$ ); Pacific, pump samples  $16^\circ 90$ – $27^\circ 51$  ( $21^\circ 82$ ), net samples  $19^\circ 16$ – $27^\circ 71$  ( $23^\circ 31$ ). Salinity: Atlantic, net samples 35.23–36.53 (36.01); Pacific, pump samples 33.89–36.20 (35.52), net samples 34.32–36.04 (35.07). Density: Atlantic, net samples 23.98–25.30 (24.62); Pacific, pump samples 23.48–25.15 (24.18), net samples 22.46–24.53 (23.86). pH: At-

lantic, net samples 8.10-8.30 (8.19); Pacific, pump samples 8.03-8.37 (8.26), net samples 8.16-8.34 (8.25).

#### DATURELLA Kofoid and Campbell

*Daturella* Kofoid and Campbell, 1929, p. 342.

The soft, flaccid wall of *Daturella* places the genus as more specialized than *Eutintinnus*, although the two are similar in general form. All are tropical.

One species is described here.

#### *Daturella stramonium* Kofoid and Campbell

(Figure 82)

*Daturella stramonium* Kofoid and Campbell, 1929, p. 346, fig. 664.

The soft-walled, almost transparent, elongated lorica, with oral brim, high fins, and aboral cylinder, has a length of 4.3 oral diameters. The oral brim surrounds the oral opening and is recurved; its diameter reaches 1.12 oral diameters. Below the oral opening is a short, swollen, convex-conical (66°) collar with a length of 0.3 oral diameter, and with a diameter of 0.7 oral diameter at the lower end. The elongated, conical (8°) shaft has a barely perceptible elongated bulge in the upper 0.35 total length, and narrows down more or less uniformly so that at the aboral end its diameter is only 0.23 oral diameter. There is a short, squarish aboral cylinder at the lower end, which encloses the open part. There are 3 long, equidistant, rather wide fins across one side of the lorica. These fins run from the upper end of the aboral cylinder and onto the suboral collar. They are vertical except near the upper end, where they are sharply deflected to the left.

The whole lorica is flaccid, with large, faint secondary hexagonal prisms.

The animal is binucleate.

Length, 362 $\mu$ .

*Daturella stramonium* has few, high fins, unlike *D. gausi* and *D. luanae*, in which last there are many ridges. It has fewer fins than *D. datura* and is much larger; its aboral cylinder also marks it off from that species. The presence of an oral brim suggests *D. ora* and *D. recta*, but these smaller species lack suboral flaring collars and aboral cylinders. On the whole, there is slight likelihood of confusing *stramonium*. It may, however, be overlooked because of its transparency in a crowded microfield.

Recorded from eleven stations, four in the Atlantic and seven in the Pacific, as follows: two (23, 27) in the Atlantic equatorial region, two (32, 34) in the Caribbean Sea, one (35) in the Pacific equatorial region, one (41) in the Galápagos region, two (95, 160) in the region of South Pacific island fields, one (147) in the California region, and two (150, 151) in the North Pacific trade region.

There are 3 pump and 14 net samples, of which 3 were taken at 50 meters and 14 at 100 meters. Maximum frequency, 4 per cent at station 160; two other records (stations 32, 147) were 2 per cent; average in Atlantic and Pacific net samples, 1.5 and 1.8 per cent, respectively.

Temperature: Atlantic, net samples 20°09-26°04 (22°83); Pacific, pump samples 14°55-28°74 (20°85), net samples 14°33-28°74 (21°25). Salinity: Atlantic, net samples 36.02-38.38 (37.86); Pacific, pump samples 34.63-35.35 (35.00), net samples 34.42-35.68 (35.14). Density: Atlantic, net samples 23.98-25.76 (24.96); Pacific, pump samples 22.43-26.11 (24.40), net samples 22.43-26.06 (24.42). pH: Atlantic, net samples 8.15-8.30 (8.18); Pacific, pump and net samples 7.92-8.32 (8.15).

#### SALPINGELLA Jörgensen emended

*Salpingella*, Kofoid and Campbell (part), 1929, p. 349.

As revised here, *Salpingella* includes only those species in which there are neither facets, nor fins extending the whole length of the lorica; instead, the tube is always circular in cross section, and the fins are limited definitely to the aboral region of the bowl.

*Salpingella* is most frequent in the tropics, but a number of northern species are also to be found. One or two are distinctly eurythermal, for example *S. acuminata*. Few of the species enter the Antarctic.

Thirteen species are described here.

#### *Salpingella acuminata* (Claparède and Lachmann) Jörgensen emended Kofoid and Campbell

(Figure 118)

*Salpingella acuminata*, Kofoid and Campbell, 1929, p. 350, fig. 682; Hofker (part), 1931, pp. 387-388 (see also *S. attenuata*).

The lorica is thin, with widely flaring funnel and acuminate aboral end, and with a length of 5.65 oral diameters. The thin oral margin, without brim, arises from the funnel. The suboral funnel is a basal segment of an inverted, truncated, plane cone (60°) with a length of nearly 0.42 oral diameter, and with a diameter of 0.5 oral diameter at the lower end. The shaft is a long tube with a length of about 3.2 oral diameters, and aborally there is a convex cone (15°) with a length of within 1.67 oral diameters; its open aboral end has a diameter of about 0.08 oral diameter. There are 6 equidistant, bladelike, decurrent fins on the aboral cone, arising from just above the distal end. They are slightly twisted to the left, especially anteriorly.

The uniform, thin wall hardly exceeds 0.02 oral diameter in thickness, and it is always glassy. In some loricae in this collection coccoliths are attached to the outside of the middle of the shaft (see also Kofoid and Campbell, fig. 682).

The animal has 2 macronuclei. The membranelles are short.

Length, 200 to 260 $\mu$ .

As usual in species of wide distribution, there is much variation, especially in length and proportions.

*Salpingella acuminata* is easily distinguished from most tropical species by the shorter, stouter lorica and more gradually flaring suboral funnel. It has a more flaring funnel and is longer than *S. subconica*. It differs from *S. ricta* in its smooth instead of rugose surface. From *S. jugosa*

it differs in lacking suboral ridges. It is close to *Salpingelloides altiplicata* in shape and size, but always lacks the right-turning long folds; this latter species, in this character, approaches *Epicranella*, and may be ancestral to that genus. *Salpingella acuminata* lacks the aboral cylinder of *S. secata*. It is a bit unusual in the tropics, although distinctly common in cool waters, especially in high latitudes.

Hofker's material (1931) only possibly belongs here. His large loricae (up to 350 $\mu$ ) seem, as he admits, to belong to *S. attenuata*, and even to *S. gracilis*.

Recorded from eight stations, two in the Atlantic and six in the Pacific, as follows: one (6-7) in the North Sea, one (10) in the Atlantic drift, two (45, 73) in the Galápagos region, one (86) in the region of South Pacific island fields, one (120) in the East Asiatic marginal sea, one (141) in the North Pacific middle latitudes, and one (151) in the North Pacific trade region.

There are 6 pump and 3 net samples, of which 1 was taken at the surface, 7 at 50 meters, and 1 at 100 meters. Frequency, minimum.

Temperature: Atlantic, net sample 9°86; Pacific, pump samples 2°17-22°37 (16°72), net sample 26°24. Salinity: Atlantic, net sample 34.94; Pacific, pump samples 33.06-36.20 (34.90), net sample 34.72. Density: Atlantic, net sample 27.96; Pacific, pump samples 23.48-26.41 (24.81), net sample 22.77. pH: Atlantic, net sample 8.04; Pacific, pump samples 7.90-8.33 (8.14), net sample 8.24.

### *Salpingella attenuata* Jörgensen

(Figures 117, 120)

*Salpingella attenuata*, Kofoid and Campbell, 1929, p. 351, fig. 687; Hada, 1932b, pp. 571-572, fig. 26.

*Salpingella acuminata*, Hofker (part), 1931, pp. 387-388 (see also *S. acuminata*).

The elongated, narrow lorica, with long, vertical, low fins, has a length of 7.35 to 10.0 oral diameters. The oral margin has a narrow, thickened brim. The suboral funnel is a markedly concave basal segment of a cone (45° to 54°) with a length of 0.5 oral diameter, and with a diameter of 0.44 to 0.51 oral diameter at the lower end. The long shaft tapers (3° to 5°) for most of its length and reaches a diameter at its lower end of less than 0.3 oral diameter. Immediately below, it becomes definitely convex conical (6° to 12°) for 1.0 to 2.0 oral diameters, and its open, truncated end, without aboral cylinder, reaches not over 0.18 oral diameter in diameter. There are 6 long, low fins, the length of which reaches 0.29 to 0.33 total length. The fins are slightly right-turning (3°) in their upper part where they begin to fade away; they are higher aborally.

The hyaline wall is thin, and the elongated animal has 2 round macronuclei.

Length, 255 to 433 $\mu$ .

Variations in length, probably correlated with temperature, are important, and to a less extent variations in proportions are prominent. Hada (1932b) has a lorica with wider funnel (60°) than the *Carnegie* specimens, and a cylindrical rather than tapering shaft. Hofker's (1931) longer loricae

(up to 350 $\mu$ ) possibly belong to *Salpingella attenuata* or to *S. gracilis* rather than to *S. acuminata*.

*Salpingella attenuata* differs from *S. gracilis* in length, and in having fewer fins. In form it resembles *S. ricta*, but lacks the surface rugae. The aboral end is conical rather than swollen as in *S. gloeckentögeri*, and lacks the aboral cylinder of *S. secata*. It is one of the more common elongated tropical species.

Recorded from fourteen stations, five in the Atlantic and nine in the Pacific, as follows: one (14) in the Gulf Stream, two (18, 21) in the Sargasso Sea, one (25) in the Atlantic equatorial region, one (33) in the Caribbean Sea, one (45) in the Galápagos region, two (84, 94) in the region of South Pacific island fields, one (110) in the North Pacific trade region, four (111, 113, 115, 128) in the North Pacific middle latitudes, and one (147) in the California region.

There are 6 pump and 9 net samples, of which 5 were taken at 50 meters and 10 at 100 meters. The preference of *Salpingella attenuata* for deeper levels is, thus, strongly suggested. Maximum frequency, 4 per cent at station 113; other records above minimum (2 to 3 per cent) from stations 18, 84, 110, 147; average in net samples, 1.6 and 2.6 per cent, in the Atlantic and Pacific, respectively; in Pacific pump samples, 1.2 loricae.

Temperature: Atlantic, pump sample 14°95, net samples 14°60-24°44 (20°93); Pacific, 11°88-28°66 (18°76) and 18°74-21°74 (20°36), respectively. Salinity: Atlantic, pump sample 35.10, net samples 35.70-36.82 (36.41); Pacific, 33.07-35.47 (34.49) and 34.66-35.35 (35.06), respectively. Density: Atlantic, pump sample 26.08, net samples 24.47-26.62 (25.55); Pacific, 22.56-25.51 (24.58) and 24.06-25.37 (24.72), respectively. pH: Atlantic, pump sample 8.18, net samples 7.93-8.25 (8.16); Pacific, 8.10-8.21 (8.14) and 8.12-8.29 (8.20), respectively.

### *Salpingella curta* Kofoid and Campbell

*Salpingella curta* Kofoid and Campbell, 1929, p. 352, fig. 675.

The very short, test-tube-like lorica, with low collar and fins, has a length of 5.3 oral diameters. The oral rim has a narrow, horizontal brim less than 0.1 oral diameter in width. The flaring funnel is a basal segment of an inverted truncated cone (34°) with a length of 0.75 oral diameter, and a diameter of 0.7 oral diameter at its lower end. The tubular shaft extends uniformly for 3.3 oral diameters, and below it becomes convex conical (24°) with a length of less than 1.6 oral diameters. On the aboral cone are 6 decurrent, equidistant bladlike fins with length equal to that of the cone. The open aboral end has a very low aboral cylinder just below the lower end of the fins.

The thin wall is nearly transparent. There is a conical closing apparatus (90°) at the lower end of the funnel.

Length, 79 to 93 $\mu$ .

*Salpingella curta*, a small, easily overlooked species, differs from *S. minutissima* in the shape of the oral funnel, which is decidedly flaring in *minutissima*. It is unlike *S. decurtata* in size, longer funnel, shorter aboral cone, and fins. It is not at all like *S. lineata* in shape; it has a longer cone than

*S. rotundata*, different fins, and differing proportions. Its size alone distinguishes it from the remaining tropical species.

Recorded from eight stations, five in the Atlantic and three in the Pacific, as follows: two (17, 18) in the Sargasso Sea, three (22, 23, 26) in the Atlantic equatorial region, two (45, 46) in the Galápagos region, and one (136) in the California region.

There are 3 pump and 5 net samples, of which 1 was taken at the surface, 4 at 50 meters, and 3 at 100 meters. Maximum frequency, 2 per cent at station 23; other records minimum; the average in Atlantic net samples is 1.5 per cent.

Temperature: Atlantic, pump samples  $24^{\circ}10-24^{\circ}44$  ( $24^{\circ}27$ ), net samples  $20^{\circ}32-21^{\circ}85$  ( $21^{\circ}05$ ); Pacific,  $18^{\circ}87$  and  $21^{\circ}69-23^{\circ}30$  ( $22^{\circ}48$ ), respectively. Salinity: Atlantic, pump samples 36.14-36.18 (36.16), net samples 36.04-36.81 (36.48); Pacific, 35.02 and 35.21-35.32 (35.26), respectively. Density: Atlantic, pump samples 24.42-24.49 (24.45), net samples 25.30-26.07 (25.62); Pacific, 25.09 and 24.11-24.48 (24.24), respectively. pH: Atlantic, pump samples 8.21, net samples 8.14-8.27 (8.21); Pacific, 8.29 and 8.12-8.16 (8.14), respectively.

#### *Salpingella decurtata* Jörgensen

*Salpingella decurtata*, Kofoid and Campbell, 1929, p. 352, fig. 685.

The short, bradlike lorica, with low, rimlike flare and left-turning fins, has a length of 8.5 oral diameters. The thin oral rim is surrounded by a thick-edged low funnel. The suboral funnel is a basal segment of a concave cone ( $70^{\circ}$ ) with a length of less than 0.25 oral diameter, and with a diameter of 0.82 oral diameter at its lower end. The shaft is tubular in the anterior 0.55 and conical ( $12^{\circ}$ ) in the remaining 0.45. The lower part of this region is thin, and there is a narrowed open cylinder within its aboral tenth. There are 4 to 8 left-turning, low, plica-like fins which run up 0.25 to 0.33 total length.

The wall is thin and hyaline.

Length, 128 to 150 $\mu$ ; diameter, oral 16 to 23 $\mu$ , shaft 12 to 16 $\mu$ .

*Salpingella decurtata* resembles *S. subconica* closely, but is proportionately longer, and has a shorter and wider suboral collar, a stouter shaft, and shorter, narrower fins. It is longer and less stout than *S. curta*, and has a wider collar and more numerous, narrower fins. From *S. minutissima* it may be distinguished by its less gradual suboral flare, and longer fins. *Salpingella lineata* lacks suboral flare and has fewer, bladlike fins than *decurtata*. The remaining species are much longer. On account of its size and transparency, and because of attachment to organic debris, this and other small species are commonly overlooked in plankton material quickly examined.

Recorded from one station (16) in the Gulf Stream, in a pump sample taken at 50 meters. The frequency is at a minimum.

Temperature,  $23^{\circ}64$ ; salinity, 36.41; density, 24.84; pH, 8.23.

#### *Salpingella faurei* Kofoid and Campbell

*Salpingella faurei* Kofoid and Campbell, 1929, p. 352, fig. 686.

The elongate, narrow, bradlike lorica, with 8 fins, has a length of 13.4 oral diameters. The oral margin is thin, and the suboral funnel is a basal segment of an inverted truncated cone ( $32^{\circ}$ ) with a length of nearly 0.7 oral diameter and a basal diameter of 0.67 oral diameter. The long shaft is swollen near its middle to a diameter equal to that of the oral diameter, and then contracts ( $7^{\circ}$ ) to the open aboral end. There are 8 exceedingly narrow vertical fins, with lengths of 0.36 total length.

The hyaline wall is thin.

Length, 130 to 205 $\mu$ .

*Salpingella faurei* is variable in proportions (length 7.6 to 13.4 oral diameters), in actual length, and in number of fins (7 to 9). These variations are all possibly correlated with temperature.

*Salpingella faurei* resembles *S. exilis* closely, but its oral rim is entire and without facets. The median expansion, narrow neck, and general form recall *S. laackmanni*, but that species is more elongate (15.4 oral diameters) and longer (230 to 250 $\mu$ ), and has fewer (4) and shorter fins, and an aboral cylinder; in habit *laackmanni* is antarctic, in contrast with the strict tropical limits of *faurei*.

Recorded from one station (80) in the Galápagos region, in a pump sample taken at 50 meters. Frequency, minimum.

Temperature,  $26^{\circ}06$ ; salinity, 35.95; density, 23.75; pH, 8.19.

#### *Salpingella glockentögeri* (Brandt) Jörgensen

*Salpingella glockentögeri*, Kofoid and Campbell, 1929, p. 353, fig. 688.

The greatly elongated, trumpet-shaped lorica, with median bulge, inverted aboral shoulder, and narrow cylinder, has a length of 11.4 oral diameters. The oral margin has a narrow, thickened, somewhat projecting brim. The suboral funnel flares gracefully as an inverted basal segment of a cone ( $30^{\circ}$ ) with a length of nearly 0.86 oral diameter and with a diameter of 0.51 oral diameter at the lower end. The generally tubular shaft is swollen near its middle to a diameter of 0.57 oral diameter and is narrowed within the upper 1.5 oral diameters, where it may be only 0.46. The shaft contracts aborally only a little, reaching 0.4 oral diameter within the aboral 2.0 oral diameters. As the shaft progresses aborally it rounds off with a distinct shoulder, and there is an inverted convex-conical ( $35^{\circ}$ ) region just above the aboral end (embracing the posterior 0.75 oral diameter). The aboral end has a very low, cufflike cylinder, the diameter of which is only 0.11 oral diameter. There are 8 left-turning ( $6^{\circ}$ ), narrow, ridgelike fins, the lengths of which are within 3.7 oral diameters.

The wall is thin (about 0.01 oral diameter), with just a trace of suboral thickening in some loricae; it is always hyaline.

Length, 252 to 433 $\mu$ .

Most loricae are over 300 $\mu$  in length and relatively narrow.

*Salpingella glockentögeri* is like *S. rotundata* in having an

ab orally saccular region and shoulder. It differs, however, in being pronouncedly longer (up to 433 $\mu$ , as against rarely as much as 160 $\mu$ ). Its fins are longer and less ridgelike, and the funnel is more gracefully concave. *Salpingella secata* has shorter fins and a narrower and distinctly tapering shaft. *Salpingella gracilis* and *S. attenuata*, though both elongated, are not likely to be confused with this species.

Recorded from one station (76) in the Galápagos region, in a pump sample taken at 50 meters. Frequency, minimum. Temperature, 20.43; salinity, 35.59; density, 25.11; pH, 8.14.

#### *Salpingella gracilis* Kofoid and Campbell

(Figures 119, 121)

*Salpingella gracilis* Kofoid and Campbell, 1929, p. 353, fig. 681.

The decidedly elongated, very slender lorica, with widely flaring funnel, narrow shaft, and 7 to 9 long fins, has a length of 8.90 to 13.57 oral diameters. The oral margin is thickened and has a recurved, extended brim. The wide, short funnel is an inverted basal segment of a truncated cone (59° to 110°) with a length of only 0.3 to 0.5 oral diameter, and its diameter at the lower end is approximately the same as the length, or a little less. The very long, attenuated shaft is thin and in sharp contrast with the wide funnel; it tapers (2° to 3°) to the narrow, open aboral end, the diameter of which is only about 0.1 oral diameter. The vertical fins arise at 0.2 oral diameter above the aboral end and are decidedly low, distinctly decurrent blades with lengths within 4.8 oral diameters; they number 7 to 9.

The exceedingly thin wall is glass-clear.

Length, 320 to 434 $\mu$ .

Variations in length with an amplitude of 114 $\mu$ , and in proportions from 8.90 to 13.57 oral diameters, are probably expressive of temperature relations and available lorica substance at the time of formation. Some few of Hofker's (1931) loricae assigned to *S. acuminata* from the warm Mediterranean may belong here, although they are not figured, and are treated in this report as part of *S. attenuata*, the commoner species.

*Salpingella gracilis* differs from *S. glockentögeri* in its more widely flaring funnel, narrower shaft, more numerous, longer fins, and narrow rather than swollen aboral end. From *S. secata* it differs in the lack of an aboral cylinder, and in longer, more numerous fins. It is more slender than *S. victa*, and hyaline rather than dense in wall. *Salpingella attenuata* has fewer fins and averages shorter in length. On the whole, *gracilis* is an outstanding tropical species rather easily differentiated from others of the longer ones.

Recorded from nine stations, one in the Atlantic and eight in the Pacific, as follows: one (26) in the Atlantic equatorial region, four (44, 45, 46, 75) in the Galápagos region, one (110) in the North Pacific trade region, two (136, 149) in the California region, and one (152) in the Pacific equatorial region.

There are 6 pump and 3 net samples, of which 4 were taken at 50 meters and 5 at 100 meters. Frequency, minimum.

Temperature: Atlantic, pump sample 18.40; Pacific, pump

samples 14.32-22.37 (18.80), net samples 18.40-23.26 (20.78). Salinity: Atlantic, pump sample 36.08; Pacific, pump samples 34.50-35.23 (34.86), net samples 34.92-35.47 (35.24). Density: Atlantic, pump sample 26.01; Pacific, pump samples 24.30-25.75 (24.95), net samples 24.13-25.55 (24.76). pH: Atlantic, pump sample 8.11; Pacific, pump samples 7.87-8.39 (8.11), net samples 8.10-8.38 (8.21).

#### *Salpingella incurva* Kofoid and Campbell

(Figure 116)

*Salpingella incurva* Kofoid and Campbell, 1939, pp. 386-387.

The rather thick, bradlike lorica has an in-rolled suboral funnel, a thick shaft, and a length of 8.8 oral diameters. The oral margin is narrowed by the thickened, incurved edge of the funnel. This collar is an inverted basal segment of a full cone (27°) with a length of 0.8 oral diameter; the diameter at its lower end is similar to the length, and the diameter at the upper end is 1.2 oral diameters. The shaft continues below the funnel as a straight tube for about 6 oral diameters. It becomes convex conical (15°) in the aboral 2.2 oral diameters, and the open aboral end lacks an aboral cylinder. On the cone are 8 vertical, bladelike fins, which reach their greatest width near their centers and become decurrent at each end.

The wall is uniformly scarcely 0.01 oral diameter in thickness, and is almost transparent, with no laminae or prisms.

Length, 155 $\mu$ .

*Salpingella incurva* lacks the thickened rim around the funnel, the aboral cylinder, and the great length of most tropical species. It is something like *S. subconica*, and might be confounded with it, but the suboral funnels are different. It is longer than *S. curta*, and not so long as *S. acuminatoides*. This last species also has the incurved funnel, but is thinner and antarctic.

Recorded from three stations (45, 46, 78) in the Galápagos region.

There are 1 pump sample, taken at 100 meters, and 2 net samples, taken at 50 meters. Frequency, minimum.

Temperature: pump sample 22.04, net samples 22.37-23.26 (22.81). Salinity: pump sample 36.17, net samples 35.23-35.33 (35.28). Density: pump sample 25.11, net samples 24.13-24.30 (24.21). pH: pump sample 8.14, net samples 8.13-8.16 (8.14).

#### *Salpingella jugosa* Kofoid and Campbell

*Salpingella jugosa* Kofoid and Campbell, 1929, p. 353, fig. 674.

The long, rather stout lorica, with distinct suboral ridges, has a length of 7.12 oral diameters. The oral margin is surrounded by a thickened brim. The suboral funnel is a slightly convex cone (53°) with a length of somewhat over 1.0 oral diameter, and has a diameter of 0.55 oral diameter at its lower end. Just below the brim, on the funnel, are 7 decidedly left-turning (35°), subequidistant, narrow, raised ridges, decurrent at each end, with lengths somewhat less than that of the suboral funnel. The tapering (3°) shaft has a length of 4.9 oral diameters and then rapidly becomes

more sharply convex conical ( $18^\circ$ ) for a distance within 1.22 oral diameters. The open aboral end lacks an aboral cylinder and there are 7 low, decurrent, more or less ridgelike, slightly left-turning fins, the length of which hardly exceeds 0.4 total length.

The thin wall is glass-clear.

Length, 312 to 396 $\mu$ .

In proportions (length 7.0 to 14.2 oral diameters) and in actual length, *Salpingella jugosa* shows considerable variation. The suboral ridges accord with the fins in number (6 to 7) and direction, and were possibly constructed by the same or similar agents at the time of fission.

*Salpingella jugosa* differs from all other species in the presence of suboral ridges. In some ways it resembles *S. acuminata*, but the shape of the suboral funnel is different, being concave conical in *acuminata* and convex conical in *jugosa*.

Recorded from two stations in the Pacific, as follows: one (80) in the Galápagos region, and one (146) in the California region.

There are 1 pump and 1 net sample, both taken at 50 meters. Frequency, minimum.

Temperature: pump sample  $22.37$ , net sample  $26.06$ . Salinity: pump sample  $34.91$ , net sample  $35.95$ . Density: pump sample  $24.07$ , net sample  $23.75$ . pH: pump sample  $8.30$ , net sample  $8.19$ .

#### *Salpingella ricta* Kofoid and Campbell

*Salpingella ricta* Kofoid and Campbell, 1929, p. 354, fig. 672.

The lorica is gracefully trumpet-shaped, with flaring funnel, with 7 fins, and with marked, short rugosities over the surface; its length is 7.5 oral diameters. The oral rim is somewhat thickened as a narrow brim. The suboral funnel flares widely as a decidedly concave basal segment of a cone ( $75^\circ$ ), with a length of only 0.3 oral diameter and with approximately a similar diameter at its lower end. The tapering ( $2^\circ$ ) shaft has a length of 5.9 oral diameters, and its diameter at the lower end is only a little less than at the neck. The convex aboral cone ( $15^\circ$ ) has a length of about 1.33 oral diameters, and at its open lower end is a short cylinder above which arise the 7 low fins, the length of which reaches 2.42 oral diameters. These fins are right-turning ( $5^\circ$ ) in their upper half and practically vertical lower down.

The thin wall (about 0.01 oral diameter) is decidedly dense, and its surface has short, roughened linear striae, giving the lorica a unique character.

Length, 338 to 400 $\mu$ .

The proportions (length 6.2 to 8.0 oral diameters) and the length of lorica of this species suggest the possibility of inclusion of related forms under the same name.

*Salpingella ricta* is at once set apart from other species by the roughened surface. In general shape it recalls *S. acuminata*, but it averages longer and thinner. The suboral flare ( $75^\circ$  to  $90^\circ$ ), the more numerous fins, and the tapering shaft are differences.

Recorded from two stations in the Pacific, as follows: one

(146) in the California region and one (153) in the Pacific equatorial region.

There are 2 net samples, both taken at 100 meters. Frequency, minimum.

Temperature,  $20.07$ – $22.73$  ( $21.40$ ); salinity,  $34.32$ – $34.73$  ( $34.52$ ); density,  $23.83$ – $24.24$  ( $24.03$ ); pH,  $8.26$ – $8.28$  ( $8.27$ ).

#### *Salpingella rotundata* Kofoid and Campbell

*Salpingella rotundata* Kofoid and Campbell, 1929, p. 354, fig. 677.

The short, rather plump, test-tube-shaped lorica, with sacular aboral region with ridgelike fins, has a length of 7.3 oral diameters. The oral margin is thin and the suboral funnel is a narrow basal segment of an inverted truncated cone ( $28^\circ$ ), with a length of barely 1.0 oral diameter and a posterior diameter of 0.84 oral diameter. The shaft remains tubular for somewhat less than 4.0 oral diameters, and then gradually expands ( $8^\circ$ ) within 2.5 oral diameters to a diameter of nearly 1.0 oral diameter. Below this level it quickly contracts, with an inverted, flatly rounded shoulder, to the tiny, short, open aboral cylinder. There are 6 subequidistant ridgelike fins above the shoulder, with lengths of 1.66 oral diameters.

The hyaline wall is thin.

Length, 92 to 160 $\mu$ .

There is not a great deal of variation in proportions (length 7.3 to 8.8 oral diameters), but there is considerable in length.

*Salpingella rotundata* is one of the smaller species, but is unlike the others in its posterior characters. The swollen aboral end recalls that of *S. glockentögeri*, but that species is more than twice as long and has a gracefully flaring, trumpet-like funnel.

Recorded from two stations (43, 45) in the Galápagos region.

There are 2 pump samples, 1 each taken at the surface and at 50 meters. Frequency, minimum.

Temperature,  $16.53$ – $22.43$  ( $19.48$ ); salinity,  $34.95$ – $35.26$  ( $35.10$ ); density,  $24.31$ – $25.66$  ( $24.98$ ); pH,  $7.93$ – $8.12$  ( $8.02$ ).

#### *Salpingella secata* (Brandt) Kofoid and Campbell

*Salpingella secata*, Kofoid and Campbell, 1929, p. 355, fig. 683; Bernstein, 1931, p. 14.

The elongated lorica, with flaring funnel with 8 fins and aboral cylinder, has a length of 6.8 oral diameters. The oral rim lacks a brim, and the thin, gracefully concave-conical ( $67^\circ$ ) funnel contracts evenly to the throat below. The throat is at 0.49 oral diameter below the rim and has a diameter of 0.4 oral diameter. The long shaft is tubular for 0.66 total length, and then becomes conical ( $9^\circ$ ) for 1.68 oral diameters. At its lower end it rounds off with a bare, minute shoulder to the open aboral cylinder. The cylinder is laterally concave, its length is only 0.21 oral diameter, and its diameter is only 0.13. There are 8 low, thickened ridges, which are rounded aborally and gradually die out above; their length reaches 2.2 oral diameters.

The wall is exceedingly thin and is always hyaline.

The elongated animal has short membranelles, and there are 2 round (0.3 oral diameter) macronuclei located in the aboral part.

Length, 345 $\mu$ .

Kofoid and Campbell (1929) figure a lorica 13.8 oral diameters in length, with a low, flaring funnel and short fins, from the warm Mexican Current. *Salpingella secata* is usually a cold-water form, and as the *Carnegie* specimens and Brandt's are stouter, they must have come from cooler waters. The differences between the *Carnegie* loricae and Kofoid and Campbell's are so great that the latter may be something other than *secata*.

*Salpingella secata* differs from *S. acuminata* in having a distinct aboral cylinder, above which the ridgelike fins arise; from the simple end of *acuminata*, fins arise directly.

Recorded from one station (6) in the Atlantic drift, in a net sample taken at 100 meters. Frequency, minimum.

Temperature, 11.28; salinity, 35.52; density, 27.15; pH, 8.08.

#### *Salpingella subconica* Kofoid and Campbell

*Salpingella subconica* Kofoid and Campbell, 1929, p. 355, fig. 676; Marshall, 1934, p. 660, fig. 43.

The stout, bradlike lorica, with steep suboral funnel and short fins, has a length of 7.0 oral diameters. The oral rim is thin, and the collar is a rather low funnel (38°), with a length of only 0.5 oral diameter, and a diameter of 0.75 oral diameter at its lower end. The shaft is a cylinder for 4.5 oral diameters, and is convex conical (17°) for the remaining part. The fins, 8 in number, have a length of 0.4 total length, and are decurrent blades. The open aboral end is tiny.

The wall is thin and clear.

Length, 97 to 220 $\mu$ .

There is considerable variation in actual length and also in proportions.

*Salpingella subconica* differs from *S. curta* in size and proportions, in longer fins, and in shorter funnel. It lacks the expanded aboral end of *S. rotundata*, has much less of a suboral flare than *S. minutissima*, and is of different type from *S. decurtata*. It lacks the facets of *S. crenulata*.

Recorded from fourteen stations, four in the Atlantic and ten in the Pacific, as follows: one (20) in the Sargasso Sea, two (22, 23) in the Atlantic equatorial region, one (33) in the Caribbean Sea, six (43, 45, 46, 68, 73, 78) in the Galápagos region, three (63, 65, 67) in the South Pacific middle latitudes, and one (144) in the North Pacific middle latitudes.

There are 10 pump and 9 net samples, of which 3 were taken at the surface, 9 at 50 meters, and 7 at 100 meters. Maximum frequency, 6 per cent at station 45 at 50 meters; other records above minimum (2 to 3 per cent) from stations 65, 68, 78; average in Pacific pump and net samples, 1.8 loricae and 2.0 per cent, respectively.

Temperature: Atlantic, pump sample 28.25, net samples 17.50–23.17 (21.09); Pacific, 15.84–24.38 (20.54) and 15.03–23.26 (18.72), respectively. Salinity: Atlantic, pump

sample 36.19, net samples 36.04–36.60 (36.37); Pacific, 34.58–36.17 (35.29) and 34.30–35.33 (34.88), respectively. Density: Atlantic, pump sample 23.23, net samples 24.34–25.30 (24.89); Pacific, 24.11–25.60 (24.80) and 24.13–25.52 (24.97), respectively. pH: Atlantic, pump sample 8.24, net samples 8.14–8.26 (8.19); Pacific, 7.93–8.33 (8.23) and 8.09–8.16 (8.12), respectively.

#### SALPINGELLOIDES, new genus

*Salpingella* Kofoid and Campbell (part), 1929, pp. 349, 351, 354.

The lorica is elongated and trumpet-shaped, with circular cross section, lacking facets or ridges, always open aborally, and with vertical ridges or fins extending to, or nearly to, the oral end from the posterior part.

*Salpingelloides* differs from *Salpingella* in having the fins extending the whole length of the lorica. It differs from *Daturella* in having a firm rather than flaccid wall. It is aborally contracted unlike *Eutintinnus*, and has no oral teeth as in *Salpingacantha*. There is no suboral necklace as in *Epicranella*, nor are there facets as in *Rhabdosella* and in *Epirhabdosella*, those in the last-mentioned genus extending only part-way down the tube, whereas in the former they are extended the whole length.

The type species is *Salpingelloides costata* (Laackmann) from the Antarctic. Two other species are included in the genus, namely, *S. altiplicata* and *S. regulata*. None of these is found in the material of this expedition, although *S. regulata* is tropical Atlantic and *S. altiplicata* is northern; thus, the genus as a whole is widely spread in many waters.

#### EPIRHABDOSELLA, new genus

*Salpingella* (*Rhabdosella*) Kofoid and Campbell (part), 1929, p. 347.

The lorica is elongated and trumpet-shaped; it is faceted in the upper section but not in the lower part, otherwise as in *Salpingella*.

*Epirhabdosella* differs from *Rhabdosella* in the limitation of the region of the facets: in the latter, they extend the whole length of the lorica and the cross section is octagonal. It differs from *Salpingelloides* in that there is a limited region with fins. There is no suboral necklace as in *Epicranella*.

The type and only species is *Epirhabdosella cuneolata* (Kofoid and Campbell) from the eastern tropical Pacific. This species was found seven times in the material of this expedition.

#### *Epirhabdosella cuneolata* (Kofoid and Campbell)

*Salpingella* (*Rhabdosella*) *cuneolata* Kofoid and Campbell, 1929, p. 347, fig. 667.

The slender, trumpet-shaped lorica, with 18 facets, has a length of 6.2 oral diameters. The oral margin is bounded by 18 equal planes formed by the upper margins of the adjacent suboral facets. These facets extend from within

1.43 oral diameters, and their edges are not especially thickened as stays, as in *Dadayiella*. The collar-like flaring region is a basal segment of an inverted truncated cone ( $35^\circ$ ) with a length of 0.71 oral diameter and a diameter, at the lower end, of 0.7 oral diameter. The tapering ( $3^\circ$ ) shaft extends below the collar for 0.6 total length, and then becomes more convex conical ( $16^\circ$ ) for the remaining part. There are 6 decurrent, bladelike fins of equal length on the aboral cone. Around the open aboral end is a weakly developed aboral cylinder.

The wall is thin and hyaline.

Length, 163 to 266 $\mu$ .

Caribbean and Panamic loricae differ a little in length, the former averaging longer. The length of the faceted region also differs in various loricae.

*Epirhabdosella cuneolata* differs from the highly aberrant and distantly related *Rhabdosella octogenata* in having more facets (18 to 20) instead of but a few (8), and also in having the facets limited to the suboral region; in *octogenata* they extend the whole length of the lorica. Other differences include the lack of fins in *octogenata* and the aboral twist in its shaft. None of the species of *Salpingella* has suboral facets.

Recorded from seven stations, one in the Atlantic and six in the Pacific, as follows: one (33) in the Caribbean Sea, one (35-36) in the Pacific equatorial region, one (45) in the Galápagos region, two (93, 95) in the region of South Pacific island fields, and two (135, 136) in the California region.

There are 5 pump and 2 net samples, of which 1 was taken at the surface, 2 at 50 meters, and 4 at 100 meters. Frequency, 4 per cent at station 35-36; other records minimum.

Temperature: Atlantic, pump sample  $28^\circ 25$ ; Pacific, pump samples  $18^\circ 87$ - $27^\circ 65$  ( $20^\circ 91$ ), net sample  $28^\circ 74$ . Salinity: Atlantic, pump sample 36.19; Pacific, pump samples 34.88-35.83 (35.49), net sample 35.35. Density: Atlantic, pump sample 23.23; Pacific, pump samples 23.16-25.09 (24.37), net sample 22.43. pH: Atlantic, pump sample 8.24; Pacific, pump samples 8.13-8.39 (8.28), net sample 8.22.

#### SALPINGACANTHA Kofoid and Campbell

*Salpingacantha* Kofoid and Campbell, 1929, p. 355.

*Salpingacantha* probably arose from *Salpingella*, from which it differs mainly in the oral teeth, always lacking in *Salpingella*.

*Salpingacantha* is commoner in the tropics than elsewhere, although a few species do extend northward and southward into cool waters. None is found in the Antarctic.

Three species are described here.

#### *Salpingacantha crenulata* Kofoid and Campbell

*Salpingacantha crenulata* Kofoid and Campbell, 1929, p. 357, fig. 694.

The bradlike lorica, with a length of 6.4 to 10.3 oral diameters, has a crenulated brim and no aboral cylinder. The oral margin has 7 to 12 low, subequidistant, subequal

triangular points. The collar is a short, full cone ( $40^\circ$ ) with a length of 0.6 oral diameter, and a diameter of 0.75 oral diameter at its lower end. The shaft is an elongated cylinder in the upper 0.65, and a narrow cone ( $18^\circ$ ) in the lower section. There are 7 low, ridgelike fins, extending 0.4 total length above the distal end. The open aboral end lacks a cylinder.

The wall is hyaline, and not over 0.01 oral diameter in thickness.

Length, 145 to 197 $\mu$ .

*Salpingacantha crenulata* has a crinkled margin, but this differs from the margin in *S. perca*, which has definite points and suboral facets. It is much like *S. subconica*, but has crenulations instead of a smooth margin.

Recorded from one station (45) in the Galápagos region, in 2 net samples taken at 50 and 100 meters. Frequency, minimum.

Temperature,  $21^\circ 69$ - $22^\circ 37$  ( $22^\circ 03$ ); salinity, 35.21-35.23 (35.22); density, 24.23-24.48 (24.35); pH, 8.12-8.13 (8.125).

#### *Salpingacantha perca* Kofoid and Campbell

*Salpingacantha perca* Kofoid and Campbell, 1929, p. 357, fig. 690.

The small, short lorica, with a length of 7.0 oral diameters, has an oral margin formed by 10 longitudinal folds. The oral rim has a 10-sided cross section with a crinkled, thin edge. There is a low, conical ( $32^\circ$ ) collar only 0.5 oral diameter in length, and with a diameter of 0.7 oral diameter at the lower end. The long shaft is a cone ( $3^\circ$ ) for 0.75 total length, and then, below, becomes a wider ( $20^\circ$ ) cone for the remaining part of the length. There are 5 more or less erect, narrow fins, which extend 0.3 total length above the aboral end. There is a tiny aboral cylinder around the open end.

The wall is glassy and uniformly not over 0.01 oral diameter in thickness. At the junction of collar and shaft is a low, conical closing apparatus.

Length, 92 $\mu$ .

*Salpingacantha perca* has creases or folds around the oral rim, unlike any of the other species, all of which have pretty definite teeth, except, perhaps, *S. simplex* from the Antarctic, which has an irregular but circular margin. *Salpingacantha crenulata*, the nearest tropical species, has 7 fins, no folds, and 7 to 12 teeth.

Recorded from one station (45) in the Galápagos region, in 2 pump samples, 1 taken at the surface and 1 at 50 meters. Average frequency, 1.5 per cent.

Temperature,  $22^\circ 37$ - $22^\circ 43$  ( $22^\circ 40$ ); salinity, 35.23-35.26 (35.24); density, 24.30-24.31 (24.305); pH, 8.12-8.13 (8.125).

#### *Salpingacantha undata* (Jørgensen) Kofoid and Campbell

*Salpingacantha undata*, Kofoid and Campbell, 1929, p. 358, fig. 695.

The elongated, nail-shaped lorica, with clawlike oral margin, has a length of 8.0 oral diameters. The oral rim is folded inward between the 4 to 6 erect, triangular, equi-



distant, equal, wide claws. These arise from a concave-conical ( $52^\circ$ ) collar with a length of about 1 oral diameter. The long shaft has a diameter at the lower end of the collar of somewhat less than 0.5 oral diameter, and decreases regularly and evenly, without local modifications in contour, as a cone ( $2^\circ$ ) to the aboral end. There are 8 long, narrow, ridgelike fins extending from the aboral end for 0.45 total length. There is an inconspicuous aboral cylinder around the open aboral end.

The wall is hyaline and about 0.01 oral diameter in thickness.

There are 2 oval macronuclei.

Length, 400 $\mu$ .

The number of fins and claws is variable.

*Salpingacantha undata* lacks the suboral alae of *S. ampla*, and averages shorter and stouter. Its claws are also fewer and larger, and the fins are fewer. It is longer than other species and has a better-developed collar and fewer teeth.

Recorded from two stations, one each in the Atlantic and the Pacific, as follows: one (33) in the Caribbean Sea, and one (80) in the Galápagos region.

Both are pump samples taken at 50 meters. Frequency, minimum.

Temperature: Atlantic,  $28^\circ.25$ ; Pacific,  $26^\circ.06$ . Salinity: Atlantic, 36.19; Pacific, 35.95. Density: Atlantic, 23.23; Pacific, 23.75. pH: Atlantic, 8.24; Pacific, 8.19.

## SUMMARY OF RESULTS

1. The material discussed in this report of the *Carnegie* expedition includes 13 families, 44 genera, and 311 species (of which 307 were found in this material) of Tintinnina. Of these, 2 are new genera and 14 are new species. Three new subfamilies are introduced. There is 1 new variety, and 1 new name. The Tintinnididae are absent from the material of this expedition.

2. The lorica is a satisfactory basis for systematic arrangement of genera and species. This organ is the product of secretion and behavior and is the external expression of the internal peculiarity of the animal.

3. The species of Tintinnina are subject to definite limitation in distribution. The principal faunal regions are: (a) the boreal region, (b) the austral region, (c) the tropical region, (d) the coastal region, and (e) the temperate region.

4. The Tintinnina are quantitatively significant in the sea. Within the levels exposed diurnally to light, these animals are commonly among the most frequent.

5. Superposed stratification of faunas occurs.

6. The physical and chemical data accumulated suggest that each species occurs within definite limits.

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PLATE

PLATE I

All figures drawn with camera lucida from specimens in sea water and formalin.

FIG. 1. Lorica of *Proplectella aulti*, n. sp., from station 22 at 100 meters.  $\times 600$ .

FIG. 2. Lorica of *Proplectella merriami*, n. sp., from station 4 at 50 meters.  $\times 600$ .

FIG. 3. Lorica of *Tintinnopsis penrhynensis*, n. sp., from the lagoon of Penrhyn Island in the western tropical Pacific.  $\times 375$ .

FIG. 4. Lorica of *Xystonella flemingi*, n. sp., from station 14 at 100 meters.  $\times 375$ .

FIG. 5. Lorica of *Parafavella affinis*, n. sp., from station 121 at 50 meters.  $\times 375$ .

FIG. 6. Lorica of *Codonella grahami*, n. sp., from station 117 at 100 meters.  $\times 375$ .

FIG. 7. Lorica of *Undella hawaiiensis*, n. sp., from station 145 at 100 meters.  $\times 375$ .

FIG. 8. Lorica of *Favella minutissima*, n. sp., from station 75 at 100 meters.  $\times 712$ .

FIG. 9. Lorica of *Codonellopsis aleutiensis*, n. sp., from station 120 at 100 meters.  $\times 600$ .

FIG. 10. Lorica of *Eutintinnus magnificus*, n. sp., from station 19 at 50 meters.  $\times 600$ .

FIG. 11. Lorica of *Epiplocylis carnegiei*, n. sp., from station 3 at 50 meters.  $\times 600$ .

FIG. 12. Lorica of *Favella septentrionalis*, n. sp., from station 116 at the surface.  $\times 375$ .

FIG. 13. Lorica of *Undella carnegiei*, n. sp., from station 151 at 50 meters.  $\times 375$ .



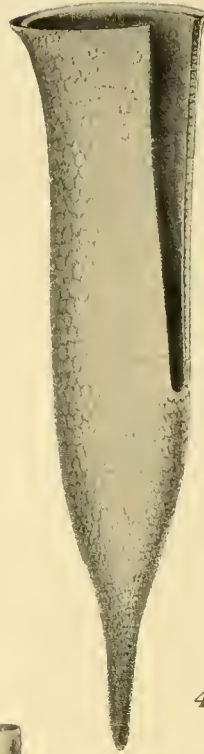
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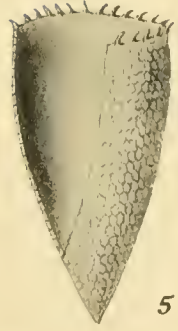
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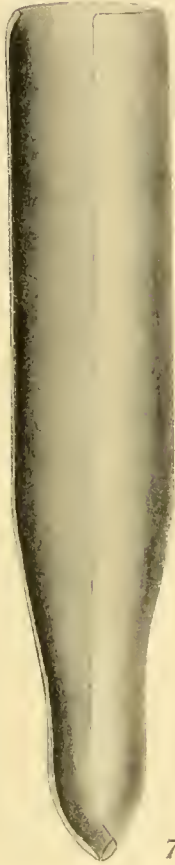
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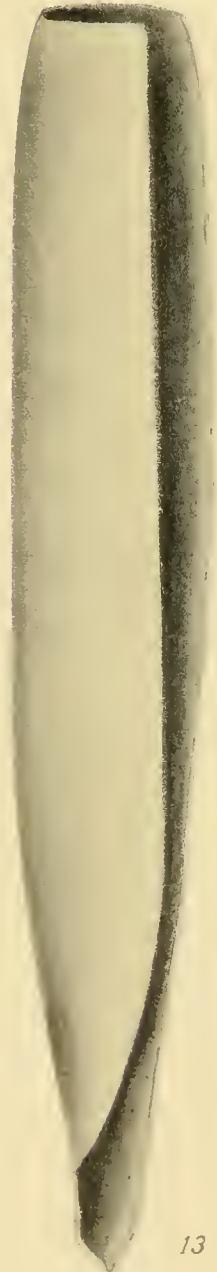
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## FIGURES

FIGURES 1-18

- FIG. 1. Lorica of *Codonellopsis pura* from station 23 at 50 meters.  $\times 375$ .
- FIG. 2. Lorica of *Codonellopsis parva* from station 20 at 100 meters.  $\times 375$ .
- FIG. 3. The same from station 25 at 100 meters.  $\times 375$ .
- FIG. 4. Lorica of *Codonellopsis speciosa* from station 23 at 100 meters.  $\times 375$ .
- FIG. 5. Lorica of *Codonellopsis longa* from station 16 at 50 meters.  $\times 375$ .
- FIG. 6. Lorica of *Codonellopsis brevicaudata* from station 18 at 100 meters.  $\times 375$ .
- FIG. 7. Lorica of *Codonellopsis ecaudata* from station 46 at 50 meters.  $\times 375$ .
- FIG. 8. Lorica of *Codonellopsis pusilla* from station 6 at 50 meters.  $\times 600$ .
- FIG. 9. Lorica of *Codonellopsis turgida* from station 25 at 100 meters.  $\times 375$ .
- FIG. 10. Lorica of *Codonella rapa* from station 64 at 1000 meters.  $\times 375$ .
- FIG. 11. Lorica of *Codonella amphorella* from station 20 at 100 meters.  $\times 375$ .
- FIG. 12. Lorica of *Codonaria lata* from station 28 at 100 meters.  $\times 375$ .
- FIG. 13. Lorica of *Codonaria mucronata* from station 17 at 50 meters.  $\times 375$ .
- FIG. 14. Lorica of *Codonella galca* from station 18 at 50 meters.  $\times 375$ .
- FIG. 15. Lorica of *Codonella olla* from station 19 at 100 meters.  $\times 375$ .
- FIG. 16. The same from station 20 at 100 meters.  $\times 375$ .
- FIG. 17. Lorica of *Codonella galca* from station 25 at 100 meters.  $\times 375$ .
- FIG. 18. Lorica of *Codonella elongata* from station 24 at 100 meters.  $\times 600$ .





FIGURES 1-18

FIGURES 19-34

FIG. 19. Lorica of *Craterella armilla* from station 23 at 50 meters.  $\times$  600.

FIG. 20. Lorica of *Craterella urceolata* from station 41 at the surface.  $\times$  600.

FIG. 21. Lorica of *Acanthostomella norvegica* from station 7 at the surface.  $\times$  375.

FIG. 22. The same from the same station at 50 meters.  $\times$  600.

FIG. 23. The same from the same station at 100 meters.  $\times$  600.

FIG. 24. Lorica of *Petalotricha major* from station 2 at 50 meters.  $\times$  375.

FIG. 25. The same from the same station at 100 meters.  $\times$  600.

FIG. 26. Lorica of *Petalotricha ampulla* from station 14 at 100 meters.  $\times$  375.

FIG. 27. Lorica of *Petalotricha foli* from station 151 at 50 meters.  $\times$  375.

FIG. 28. Lorica of *Coxliella pseudannulata* from station 10 at 50 meters.  $\times$  375.

FIG. 29. Lorica of *Coxliella laciniosa* from station 20 at 100 meters.  $\times$  375.

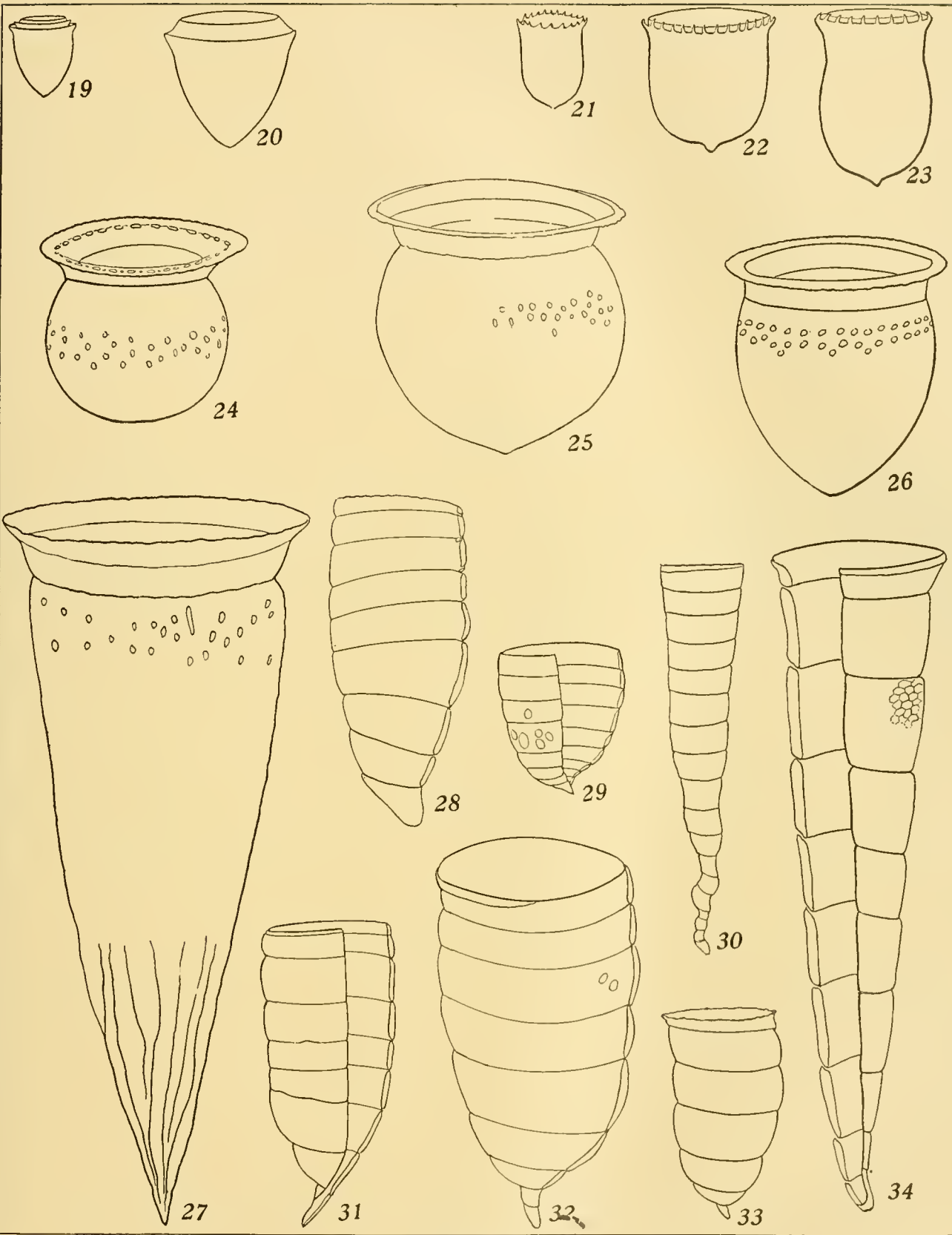
FIG. 30. Lorica of *Coxliella fasciata* from station 24 at 100 meters.  $\times$  375.

FIG. 31. Lorica of *Coxliella laciniosa* from station 29 at 100 meters.  $\times$  375.

FIG. 32. The same from station 15 at the surface.  $\times$  600.

FIG. 33. The same from station 23 at 50 meters.  $\times$  375.

FIG. 34. Lorica of *Coxliella fasciata* from station 23 at 50 meters.  $\times$  375.



FIGURES 19-34

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FIG. 35. Lorica of *Cyttarocyli*s *acutiformis* from station 23 at 50 meters.  $\times$  375.

FIG. 36. The same from station 25 at 100 meters.  $\times$  375.

FIG. 37. The same from station 20 at 100 meters.  $\times$  375.

FIG. 38. Lorica of *Cyttarocyli*s *mucronata* from station 19 at 100 meters.  $\times$  375.

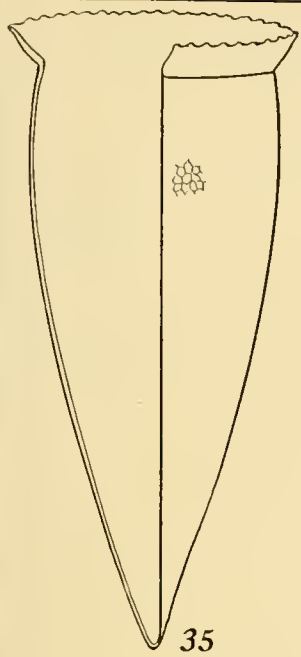
FIG. 39. Lorica of *Cyttarocyli*s *brandti* from station 19 at 100 meters.  $\times$  375.

FIG. 40. Lorica of *Cyttarocyli*s *conica* from station 19 at 100 meters.  $\times$  375.

FIG. 41. Lorica of *Cyttarocyli*s *longa* from station 2 at 100 meters.  $\times$  375.

FIG. 42. Lorica of *Cyttarocyli*s *eucecryphalus* from station 16 at 50 meters.  $\times$  375.

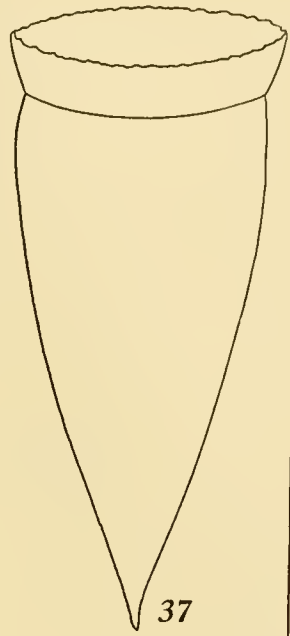
FIG. 43. Lorica of *Cyttarocyli*s *longa* from station 2 at 100 meters.  $\times$  375.



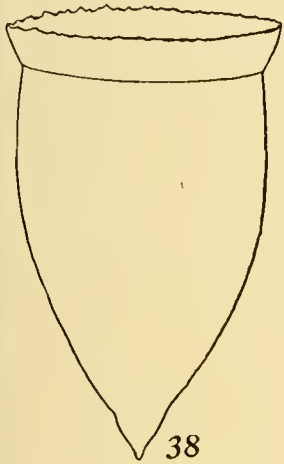
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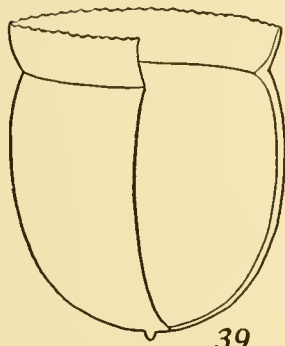
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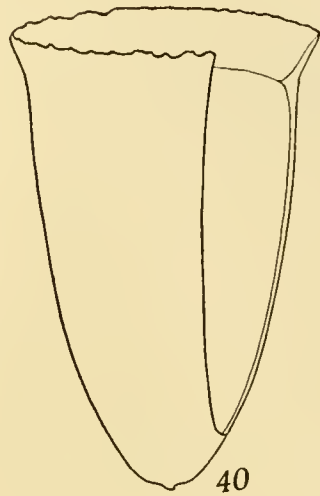
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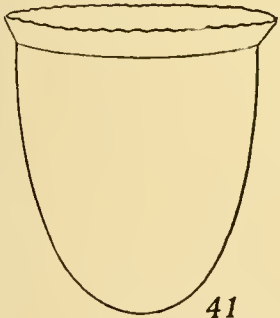
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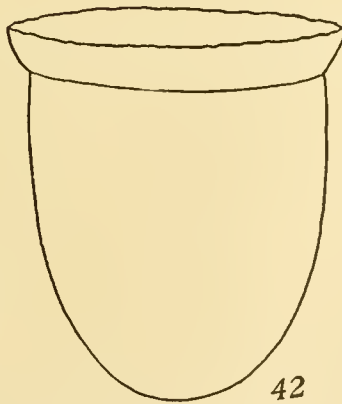
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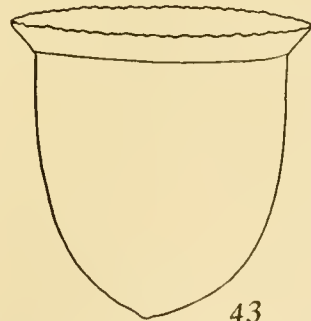
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FIGURES 35-43

FIGURES 44-48

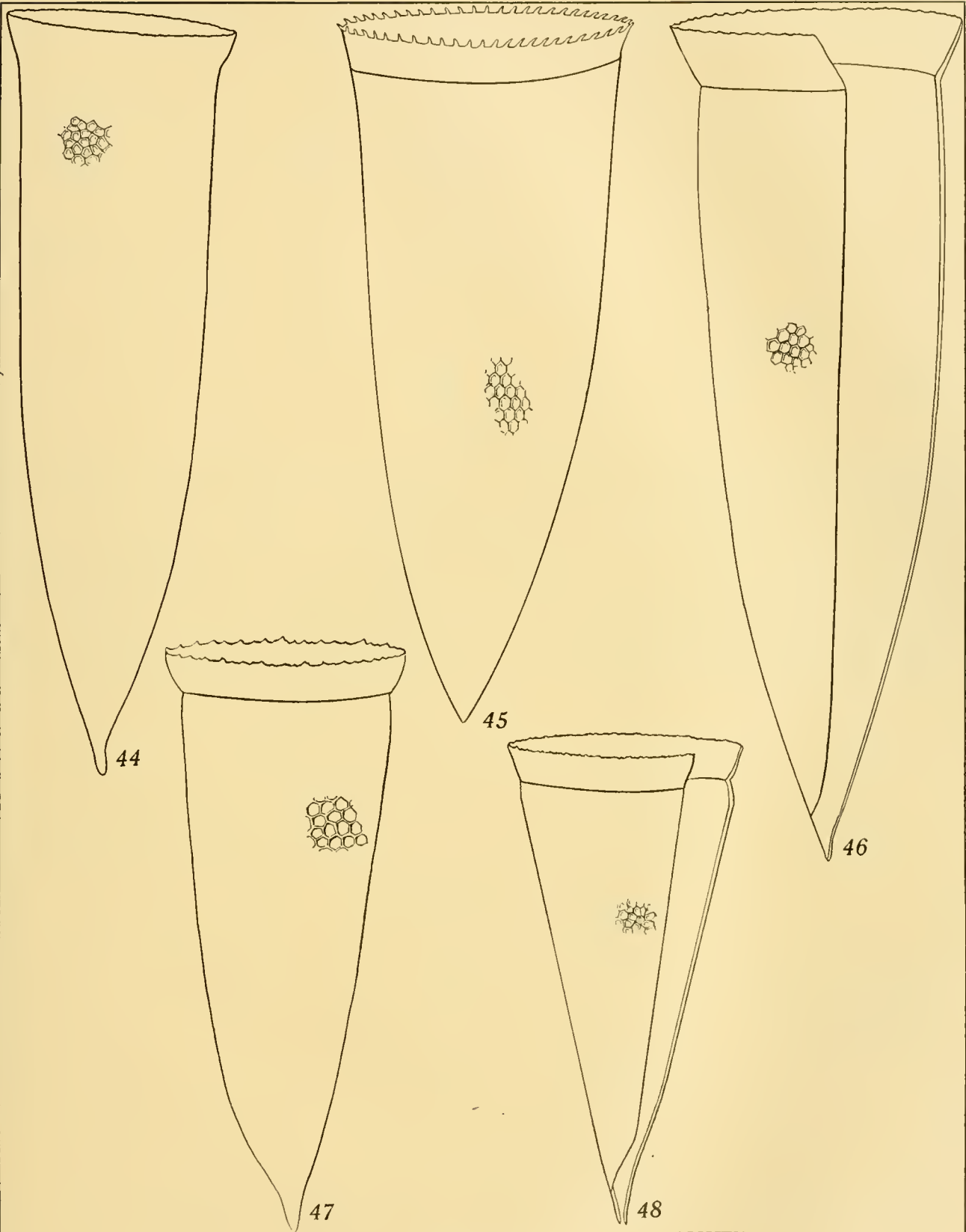
FIG. 44. Lorica of *Cyttarocyclus magna* from station 16 at 50 meters.  $\times$  375.

FIG. 45. Lorica of *Cyttarocyclus acutiformis* from station 2 at 100 meters.  $\times$  375.

FIG. 46. Lorica of *Cyttarocyclus magna* from station 45 at 100 meters.  $\times$  375.

FIG. 47. The same from station 17 at 50 meters.  $\times$  375.

FIG. 48. Lorica of *Cyttarocyclus acutiformis* from station 22 at 50 meters.  $\times$  375.



FIGURES 44-48

FIGURES 49-61

FIG. 49. Lorica of *Parafavella parumdentata* from station 7 at the surface.  $\times 375$ .

FIG. 50. Lorica of *Parafavella denticulata* from station 13 at 50 meters.  $\times 375$ .

FIG. 51. Lorica of *Parafavella cylindrica* from station 118 at the surface.  $\times 375$ .

FIG. 52. Lorica of *Parafavella gigantea* from station 13 at the surface.  $\times 375$ .

FIG. 53. The same from station 122 at the surface.  $\times 375$ .

FIG. 54. Lorica of *Parafavella parumdentata* from station 7 at 50 meters.  $\times 375$ .

FIG. 55. The same from the same station at 100 meters.  $\times 375$ .

FIG. 56. Lorica of *Favella azorica* from off Easter Island at the surface.  $\times 375$ .

FIG. 57. Lorica of *Ptychocypris obtusa* from station 7 at 100 meters.  $\times 600$ .

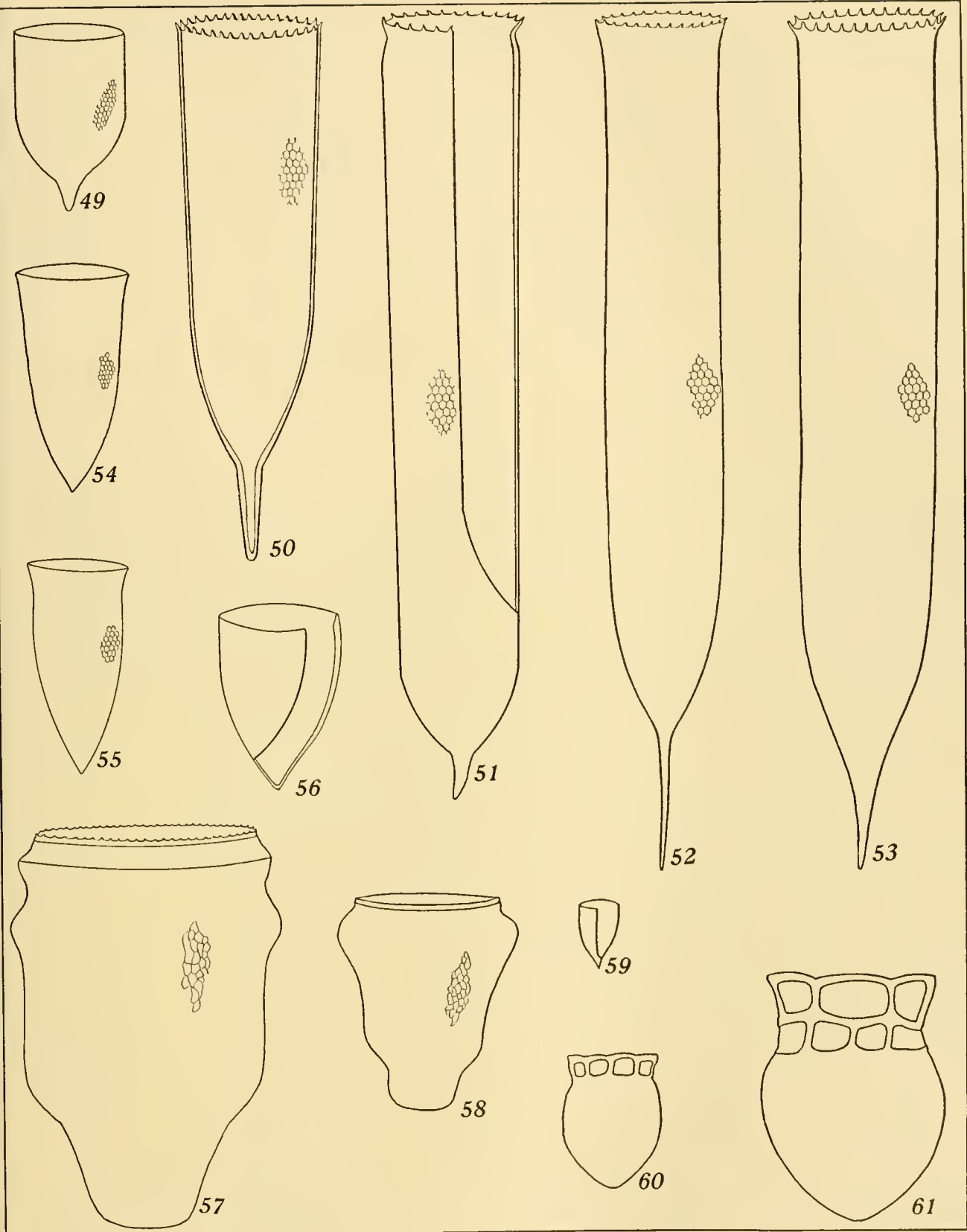
FIG. 58. The same from station 13 at the surface.  $\times 375$ .

FIG. 59. Lorica of *Favella minutissima*, n. sp., from station 75 at 100 meters.  $\times 712$ .

FIG. 60. Lorica of *Dictyocysta mitra* from station 3 at 100 meters.  $\times 375$ .

FIG. 61. The same at the same station and depth.  $\times 600$ .





FIGURES 49-61

FIGURES 62-70

FIG. 62. Lorica of *Xystonella curticauda* from station 4 at 50 meters.  $\times$  375.

FIG. 63. Lorica of *Xystonellopsis paradoxa* from station 19 at 100 meters.  $\times$  375.

FIG. 64. Lorica of *Xystonellopsis crassispinosa* from station 41 at 100 meters.  $\times$  375.

FIG. 65. Lorica of *Xystonellopsis cymatica* from station 19 at 100 meters.  $\times$  375.

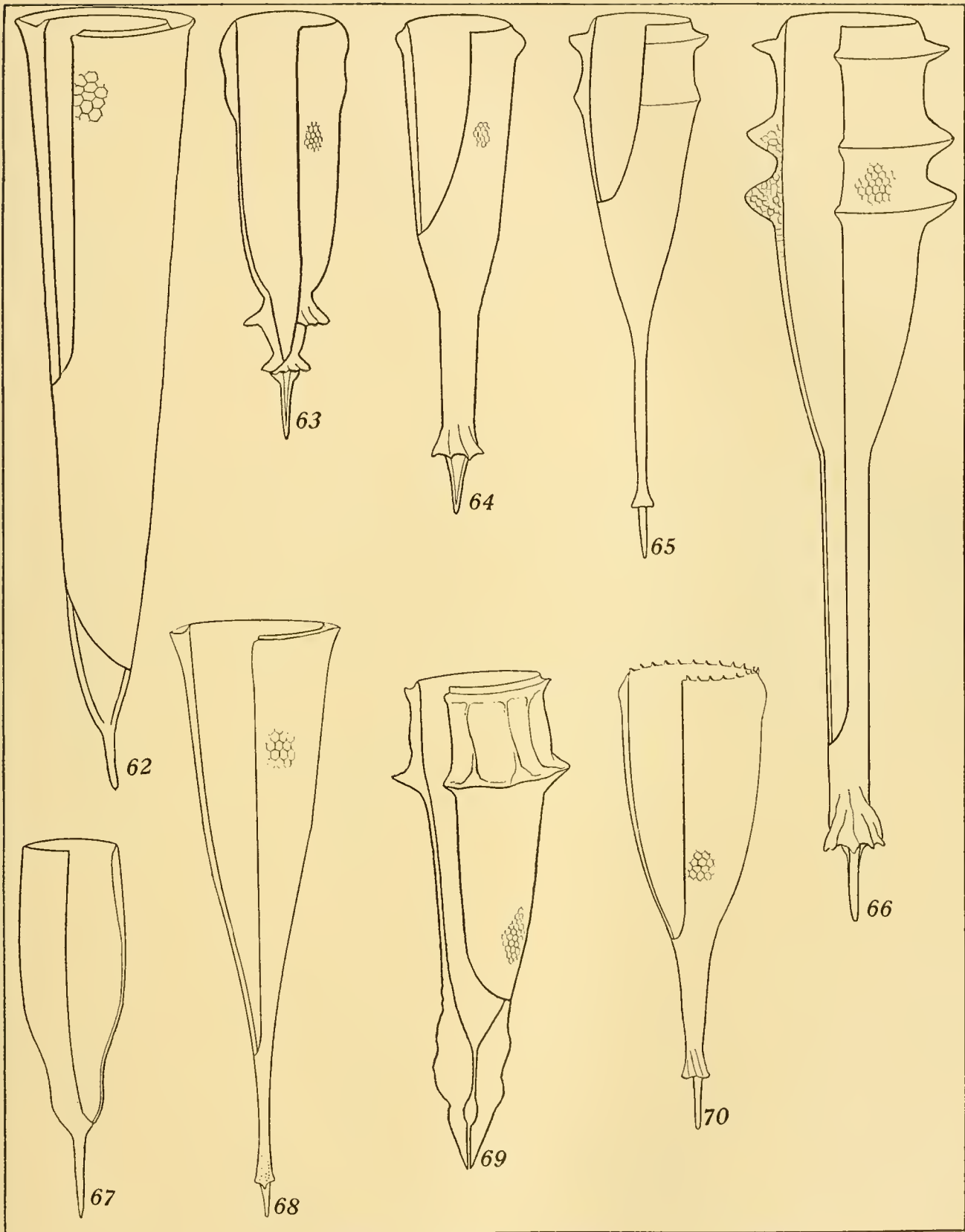
FIG. 66. Lorica of *Xystonellopsis pulchra* from station 23 at 50 meters.  $\times$  600.

FIG. 67. Lorica of *Parundella inflata* from station 19 at 100 meters.  $\times$  375.

FIG. 68. Lorica of *Xystonella treforti* from station 26 at 50 meters.  $\times$  375.

FIG. 69. Lorica of *Xystonellopsis ornata* from station 35 at 50 meters.  $\times$  375.

FIG. 70. Lorica of *Xystonellopsis hastata* from station 23 at 100 meters.  $\times$  375.



FIGURES 62-70

FIGURES 71-81

FIG. 71. Lorica of *Epiplocylis undella* from station 15 at the surface.  $\times 600$ .

FIG. 72. Lorica of *Epiplocylis atlantica* from station 19 at 100 meters.  $\times 600$ .

FIG. 73. Lorica of *Epiplocylis blanda* from station 19 at 100 meters.  $\times 600$ .

FIG. 74. Lorica of *Epiplocylis labiosa* from station 19 at 50 meters.  $\times 600$ .

FIG. 75. Lorica of *Epiplocylis mucronata* from station 28 at 50 meters.  $\times 375$ .

FIG. 76. The same from station 47 at the surface.  $\times 375$ .

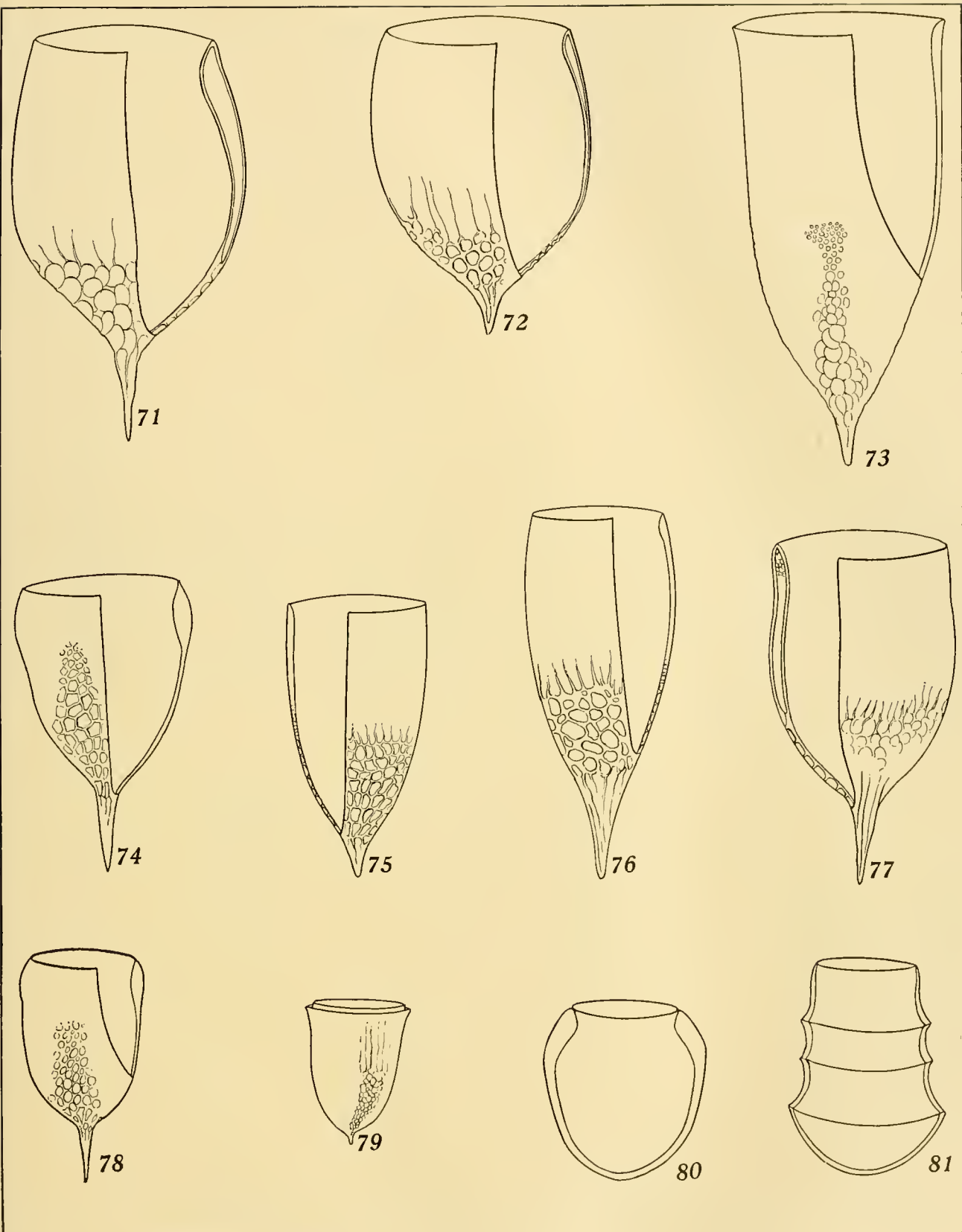
FIG. 77. Lorica of *Epiplocylis undella* from station 19 at 50 meters.  $\times 375$ .

FIG. 78. Lorica of *Epiplocylis lata* from station 45 at 50 meters.  $\times 375$ .

FIG. 79. Lorica of *Epiorella healdi* from station 40 at 50 meters.  $\times 375$ .

FIG. 80. Lorica of *Proplectella fastigata* from station 4 at 50 meters.  $\times 375$ .

FIG. 81. Lorica of *Amplectella collaria* from station 18 at 100 meters.  $\times 375$ .



FIGURES 71-81

FIGURES 82-92

FIG. 82. Lorica of *Daturella stramonium* from station 23 at 50 meters.  $\times$  375.

FIG. 83. Lorica of *Protorhabdonella simplex* from station 21 at the surface.  $\times$  375.

FIG. 84. The same from station 41 at the surface.  $\times$  375.

FIG. 85. Lorica of *Rhabdonella amor* from station 15 at the surface.  $\times$  375.

FIG. 86. Lorica of *Rhabdonellopsis triton* from station 21 at the surface.  $\times$  375.

FIG. 87. Lorica of *Rhabdonellopsis composita* from station 15 at the surface.  $\times$  375.

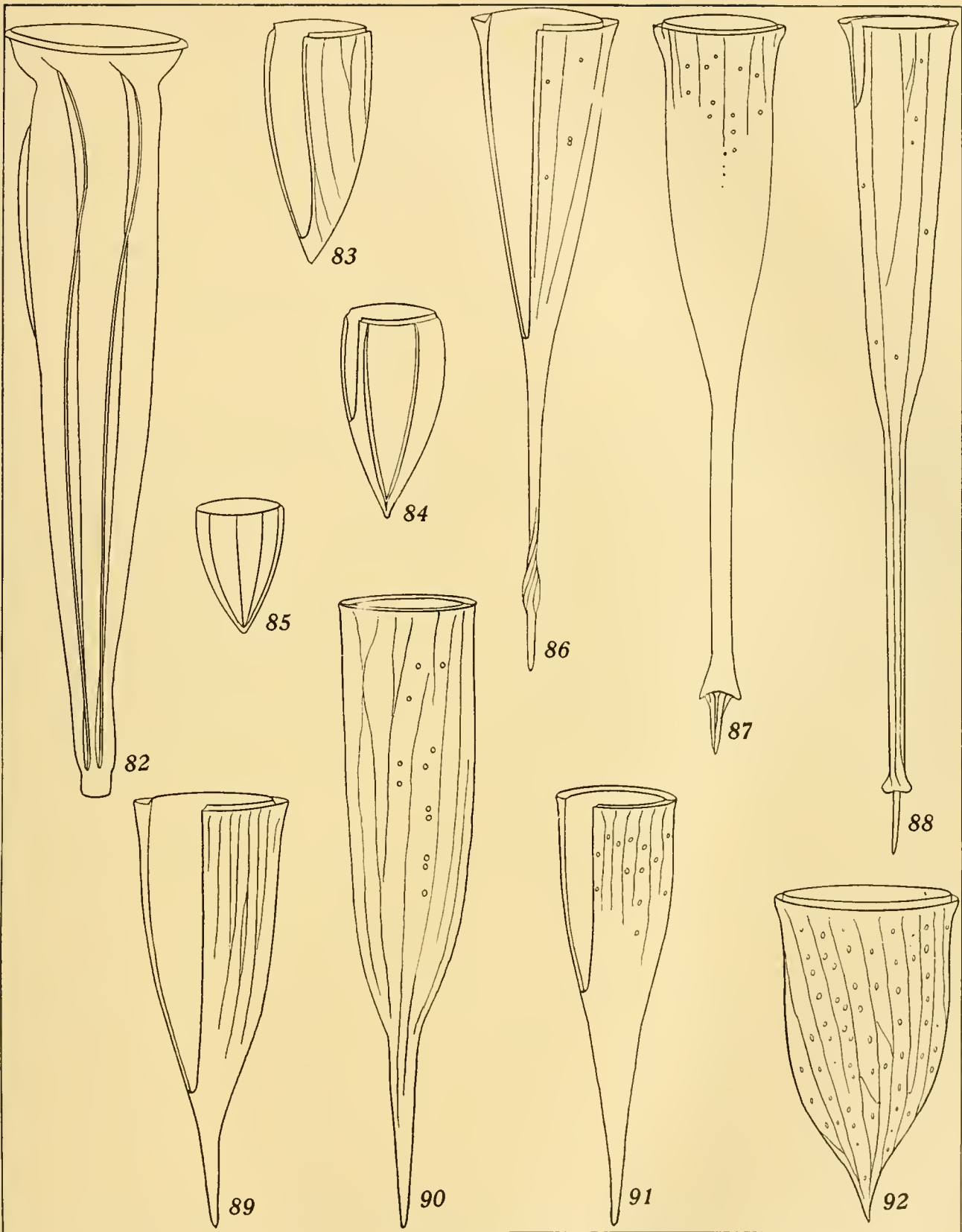
FIG. 88. Lorica of *Rhabdonellopsis longicaulis* from station 45 at the surface.  $\times$  375.

FIG. 89. Lorica of *Rhabdonella brandti* from station 19 at 50 meters.  $\times$  600.

FIG. 90. Lorica of *Rhabdonella henseni* from station 17 at 50 meters.  $\times$  375.

FIG. 91. Lorica of *Rhabdonella valdestriata* from station 35 at 50 meters.  $\times$  375.

FIG. 92. Lorica of *Rhabdonella poculum* from station 40 at 50 meters.  $\times$  600.



FIGURES 82-92

FIGURES 93-110

FIG. 93. Lorica of *Proplectella ellipsoidea* from station 67 at 100 meters.  $\times 375$ .

FIG. 94. Lorica of *Proplectella tenuis* from station 24 at 100 meters.  $\times 375$ .

FIG. 95. Lorica of *Proplectella globosa* from station 19 at 50 meters.  $\times 600$ .

FIG. 96. Lorica of *Proplectella fastigata* from station 4 at 100 meters.  $\times 600$ .

FIG. 97. Lorica of *Undellopsis cubitum* from station 45 at 100 meters.  $\times 375$ .

FIG. 98. Lorica of *Proplectella biangulata* from station 64 at the surface.  $\times 375$ .

FIG. 99. Lorica of *Proplectella subcaudata* from station 3 at the surface.  $\times 600$ .

FIG. 100. Lorica of *Proplectella globosa* from station 20 at 100 meters.  $\times 375$ .

FIG. 101. Lorica of *Proplectella ovata* from station 19 at 50 meters.  $\times 600$ .

FIG. 102. Lorica of *Undella hyalina* from station 45 at 100 meters.  $\times 375$ .

FIG. 103. Lorica of *Undella parva* from station 17 at 50 meters.  $\times 375$ .

FIG. 104. Lorica of *Undellopsis marsupialis* from station 25 at 100 meters.  $\times 375$ .

FIG. 105. Lorica of *Undellopsis entzi* from station 55 at 100 meters.  $\times 375$ .

FIG. 106. Lorica of *Proplectella cuspidata* from station 67 at 100 meters.  $\times 375$ .

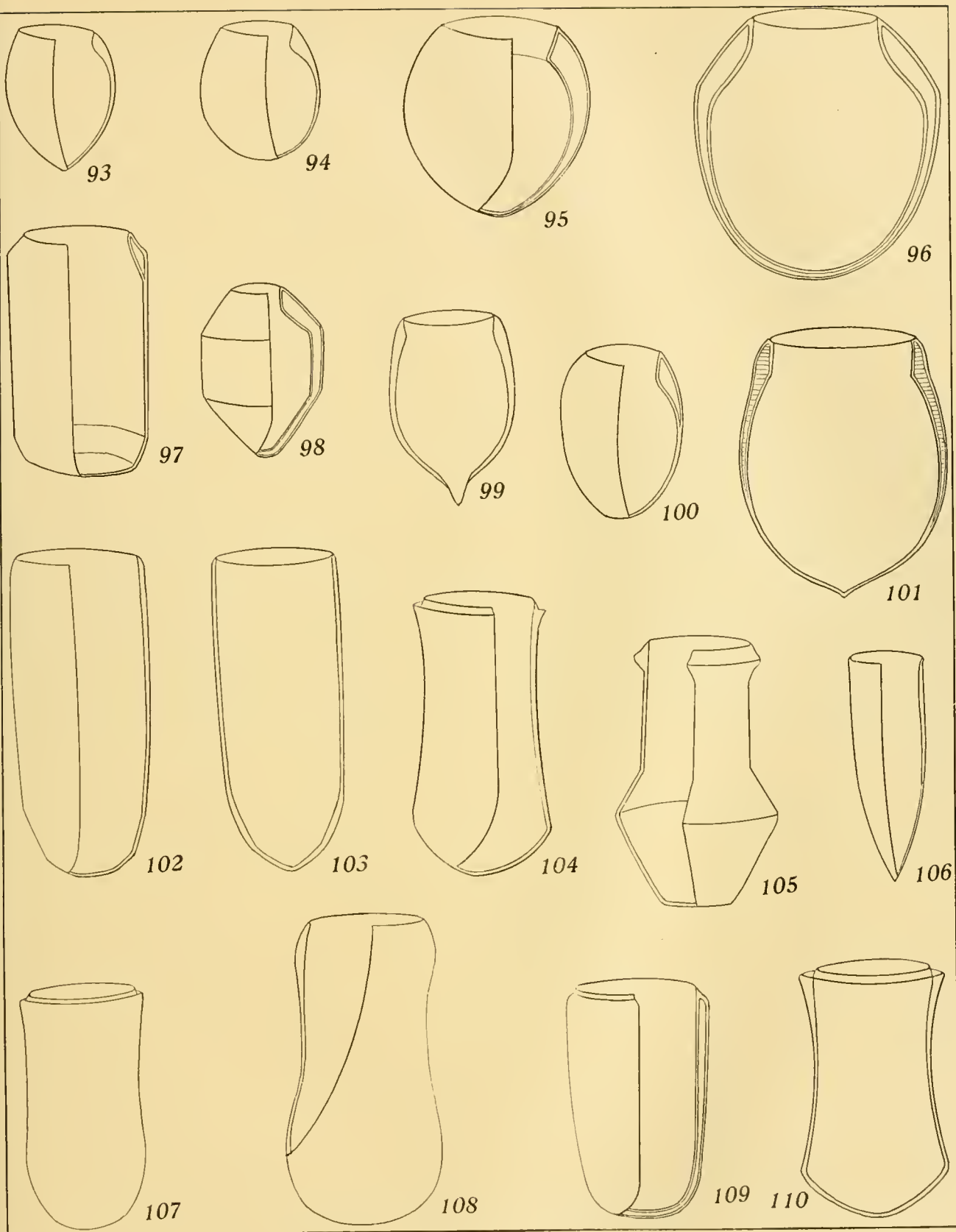
FIG. 107. Lorica of *Undellopsis pacifica* from station 42 at 100 meters.  $\times 375$ .

FIG. 108. Lorica of *Undella declivis* from station 23 at 50 meters.  $\times 375$ .

FIG. 109. Lorica of *Undellopsis pacifica* from station 67 at 100 meters.  $\times 375$ .

FIG. 110. Lorica of *Undellopsis lineata* from station 25 at 100 meters.  $\times 375$ .

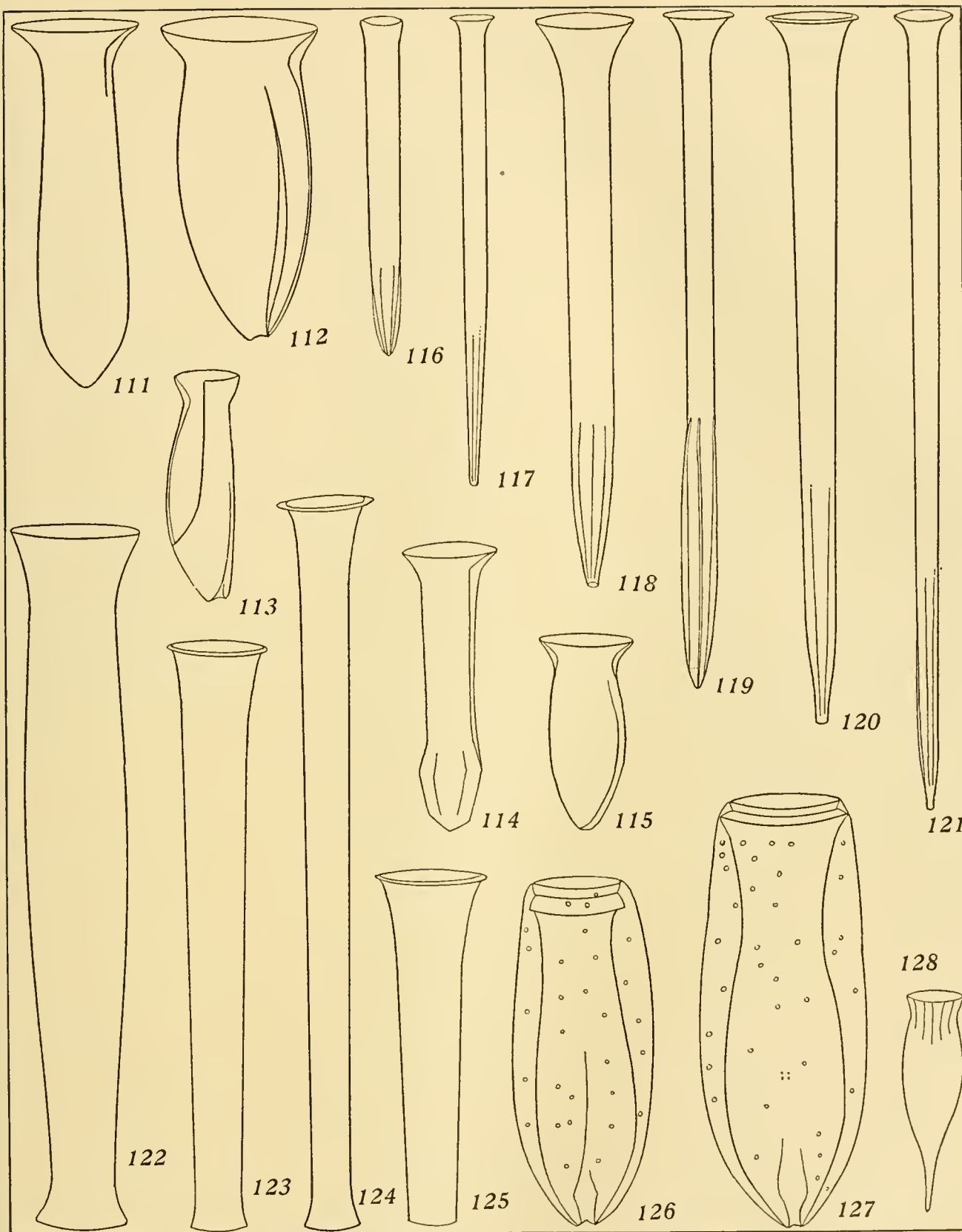




FIGURES 93-110

FIGURES 111-128

- FIG. 111. Lorica of *Amphorella quadrilineata* from station 3 at 50 meters.  $\times 600$ .
- FIG. 112. Lorica of *Amphorella minor* from station 3 at the surface.  $\times 600$ .
- FIG. 113. Lorica of *Amphorella quadrilineata* from station 40 at 50 meters.  $\times 375$ .
- FIG. 114. Lorica of *Steenstrupiella robusta* from station 3 at 100 meters.  $\times 375$ .
- FIG. 115. Lorica of *Amphorella minor* from station 21 at the surface.  $\times 375$ .
- FIG. 116. Lorica of *Salpingella incurva* from station 45 at 100 meters.  $\times 375$ .
- FIG. 117. Lorica of *Salpingella attenuata* from station 25 at 100 meters.  $\times 375$ .
- FIG. 118. Lorica of *Salpingella acuminata* from station 10 at 50 meters.  $\times 375$ .
- FIG. 119. Lorica of *Salpingella gracilis* from station 26 at 100 meters.  $\times 375$ .
- FIG. 120. Lorica of *Salpingella attenuata* from station 18 at 100 meters.  $\times 375$ .
- FIG. 121. Lorica of *Salpingella gracilis* from station 46 at 50 meters.  $\times 375$ .
- FIG. 122. Lorica of *Eutintinnus brandti* from station 23 at 100 meters.  $\times 375$ .
- FIG. 123. Lorica of *Eutintinnus frañóii* from station 21 at the surface.  $\times 375$ .
- FIG. 124. Lorica of *Eutintinnus magnificus*, n. sp., from station 20 at 100 meters.  $\times 375$ .
- FIG. 125. Lorica of *Eutintinnus lusus-undae* from station 2 at 100 meters.  $\times 375$ .
- FIG. 126. Lorica of *Brandtiella palliata* from station 22 at 50 meters.  $\times 375$ .
- FIG. 127. The same from station 20 at 100 meters.  $\times 375$ .
- FIG. 128. Lorica of *Dadayiella ganymedes* from station 14 at 100 meters.  $\times 375$ .



FIGURES 111-128



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(Synonyms are italicized; new names are in boldface.)

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