For those members with only two anterior intercalary plates, this convention could not be used. LEBOUR (1922) proposed that the latter be recognised as a subgenus: *Archaeperidinium* (JÖRGENSEN), those with three anterior intercalary plates remaining in the subgenus *Peridinium.* This subdivision is followed here.

Other subgenera have also been proposed. The majority of freshwater members lack an apical pore, and LEFÈVRE (1932) proposed the subgenus *Cleistoperidinium* (LEMMERMANN) LEFÈVRE for the latter, *Poroperidinium* (LEMMERMANN) LEFÈVRE including all those with an apical pore (now restricted to fresh-water species). As *Cleistoperidinium* includes the type species of the genus it has to be referred to as the subgenus *Peridinium* (Botanical Code, Article 22).

At present, using a broad definition for the genus, it can be recognised from its nearest relatives (*Diplopsalis* and other similar genera) by its possession of four apical plates, two or more anterior intercalary plates (up to four), and two antapical plates, the latter being fairly evenly developed.

Thus the plate formula for *Peridinium* can be written:

$4', 2\text{–}3(4)^a, 7'', 5''', 2''''$

excluding the cingular and sulcal plates for the moment.

The girdle (cingular) and ventral area (sulcal) plates have assumed considerable significance in the taxonomy of *Peridinium,* although for differing purposes. The cingular plates (designated by a capital C) have become important in distinguishing subgenera (or according to some authors, genera) and the shape, size and configuration of the sulcal plates have provided valuable accessory information in the recognition of species. Text fig. 3 illustrates the cingular and sulcal plate terminology of members of the subgenus *Protoperidinium* (BERGH) OSTENFELD.

KOFOID (1909a) was the first to depict the sutures of the sulcal plates of a member of the genus (*P. steinii*), although he did not dissociate them for a complete examination and consequently saw only the gross features of the four principal platelets. He called them the anterior, median, sinistral and posterior ventral plates (see table 5 for his notation and that used by later authors).

BARROWS (1918), in his study on plate variability in the genus, experienced great difficulty in seeing the sulcal plates, incorrectly predicting that they would prove too variable to be of value.

FAURÉ-FREMIET & PUIGAUDEAU (1922) figured ventral sutures in a few species of *Peridinium* but, as GRAHAM (1942, p. 12) put it: "These must have been drawn from the authors' imagination, as they bear no relation whatever to the actual tabulation of these species."

It was ABÉ (1936 a, b) who placed considerable emphasis on the sulcal plates, having found that they were remarkably conservative, his observations agreeing with KOFOID's except for slight modification. In addition he discovered an interesting platelet which, because of its location at the left proximal end of the girdle but protruding into the sulcal region, could be considered either a cingular or a sulcal plate. It is much smaller than the regular cingular plates. He termed it the transitional plate. He used the terms anterior, posterior, left and right to designate the sulcal plates. His very clear figures showed that, with the exception of the longitudinal lists bordering the ventral area (usually more strongly developed on the left side), the main fin near the flagellar pore (the right accessory sulcal list) arises from the inner (pore side) posterior edge of the right sulcal plate. From his figures it is also evident that the large posterior flagellar pore is formed chiefly as an excavation of the left sulcal plate.

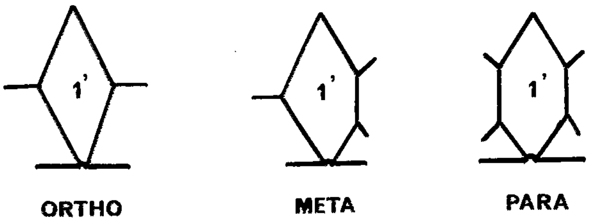
Table 5. Notational equivalents used for the sulcal plates of *Peridinium.*

	KOFOID 1909a	ABÉ 1936b	NIE 1939	GRAHAM 1944	BALECH after 1964
Transitional	–	t	LA	lg	T
Anterior	a. pl.	a	RA	as	Sa
Right	m. pl.	d	RF	rs	Sd
R. accessory	–	–	–	ras*	
Left	s. pl.	s	LF	Ls	Ss**
Median (internal)	–	–	conn.	ris	Sm
P. accessory	–	–	?	pas	Spa
Posterior	p. pl.	p	post.	ps	Sp

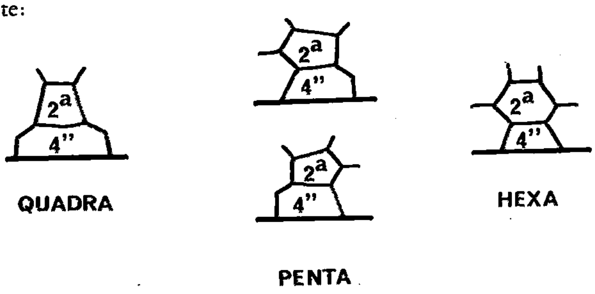
* Only observed in *P. pallidum,* occurring at the distal end of the girdle.

** In his earlier papers, noted as S. i. (e.g. BALECH 1949a).

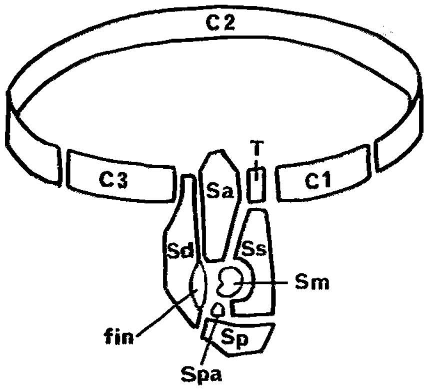
The first apical plate:



The second (mid-dorsal) intercalary plate:



The girdle and sulcal plate designations:



Text fig. 3. Conventional nomenclature for important plates in the description of *Peridinium*.

NIE (1939) also focussed his attention on the sulcal plates of several species, obtaining similar results to ABÉ although he used a different terminology. In addition he discovered a small plate in the flagellar pore region which he called the connecting plate (conn.). He treated the transitional plate as a sulcal plate.

GRAHAM (1942) recognised the four main sulcal plates (anterior, posterior, left and right) as conservative elements which varied in size and shape only. However he recognised three other plates of varying occurrence: a right accessory sulcal plate (in 1 species only), a small posterior accessory plate forming the posterior end of the flagellar pore, and a right internal sulcal plate lying internally to the flagellar pore. PAULSEN (1949) considered that the laboriousness involved in resolving these plates detracted from the usefulness in the analysis of field material, and he also doubted if some of the distinctions drawn by ABÉ were as great as he claimed.

Despite such reservations BALECH has, in an extensive series of papers over the last twenty years, undertaken to dissect the ventral plates of many species, with great success and has contributed to the understanding of the structure of the ventral region in a fundamental way. His notation for the sulcal plates now seems to be gaining acceptance.

There is little doubt that when new species are described in this and related genera, all efforts should be made to elucidate the ventral plates. However, in view of the rarity of species distinguished at present solely by sulcal plate differences, and faced with the floristic analysis of hundreds of samples, sulcal plate dissection does not seem to be feasible except in isolated cases.

DIWALD's (1939) study of variability in primary plate patterns in 16 species has been unjustifiably ignored.

The first genus to be separated from *Peridinium* purely on the grounds of the cingular plates was *Scrippsiella* (BALECH 1959a). *S. sweenyae,* the type species, was found to have five cingular plates plus a "transitional plate" and 4 sulcal plates. LOEBLICH III (1968) added a second genus, *Cachonina,* which has a similar number of cingular plates (six, fully developed) but differs from *Scrippsiella* in having more plates in its apical and precingular series. BALECH (1967a) created *Ensiculifera,* which possesses four cingular plates plus a transitional plate (the latter possessing a long, anteriorly-directed, internal spine).

BALECH (1963b) and LOEBLICH III (1968) raised an interesting and taxonomically disturbing point. The marine species of *Peridinium* were all found to possess three cingular plates plus a transitional plate. However it appeared that the freshwater species, including the type: *P. cinctum* (MÜLLER) EHRENBERG, may have more cingular plates. Consequently, as they had made the number of cingular plates a criterion for generic distinction, it appeared that the many species of marine peridinia might all have to be renamed, being attributed to the next available generic name. LOEBLICH III (1968) first suggested this to be *Archaeperidinium* JÖRGENSEN, but then later (1970) realised that *Protoperidinium* BERGH was the earliest genus which specifically included members with three cingular plates, its type being *P. pellucidum.*

BOURRELLY (1968a) investigated the cingular plates of twelve freshwater species of *Peridinium.* He found that the type species and three other members of the subgenus *Peridinium,* all of which lack an apical pore plate, possess five cingular plates, the sutures corresponding with the postcingular series. In addition two members of the subgenus *Poroperidinium* (fresh-water species possessing an apical pore) also have five cingular plates. The remaining five members of *Poroperidinium* examined and one member of *Cleistoperidinium* all have six cingular plates. He concluded that as the freshwater peridinia varied in cingular plate number, and that this variance did not correspond with the presence or absence of an apical pore, it was not appropriate to use cingular plate number as a generic criterion. BOLTOVSKOY (1973 a, b) has made similar plate observations, and also concluded that apical pore development may be variable in fresh water species.

Apart from any consideration as to the quantitative taxonomic significance of the number of cingular plates (as opposed to any other thecal criteria) the procedural situation seems to be clear. If the sole means of recognising *Scrippsiella* and *Ensiculifera* as distinct from *Peridinium* at the generic level is the number of cingular plates then all the marine species of *Peridinium* (more than 200) have to be renamed, as well as many freshwater species, a step clearly contrary to the avowed conservationary aim of the International Codes of Nomenclature. BOURRELLY (1968a) considered such changes as of little value.

One solution out of this dilemma would be to accept cingular plate number as a subgeneric character where appropriate, the marine peridinia retaining their combinations at the cost of reducing *Scrippsiella* and *Ensiculifera* to subgeneric status. The existence of similar cingular plate numbers (five or six) in the freshwater members of the subgenus *Peridinium* also argues against their separate generic status. *Cachonina* seems to warrant generic separation in view of its large number of apical plates (five), the first apical plate not reaching the sulcus, and the numerous (eight) precingular plates. Its hypothetical tabulation resembles that of *Peridinium.* If it were reduced to a subgenus of *Peridinium* it would also be necessary to sink several other long established genera separated from *Peridinium* on apical or antapical plate differences.

However, another solution can be offered which retains *Scrippsiella* and *Ensiculifera* at the generic level: an additional distinction can be made between them and *Peridinium*: the production of calcified cysts. *Peridinium trochoideum* (STEIN) LEMMERMANN is the only member of *Peridinium* known to produce calcitic cysts like those of the above genera, and has been considered closely related to them by WALL et al. (1970). In fact, if cyst characters are considered of major importance *P. trochoideum* should probably be transferred to *Scrippsiella.* This would accord with the views of TAYLOR (1972a) and SWIFT & WALL (1972), as well as micropaleontological practice.

It is hoped that this action may stave off the creation of a great many new combinations, all of which, even if not accepted, will have to be cited in any formal taxonomic treatment which may follow. However this hope is a meagre one. LOEBLICH III (1970) has already transferred two of the species considered to *Protoperidinium* BERGH.*

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* The hope of fore-stalling the creation of large numbers of new combinations, resulting from the recognition of the genus *Protoperidinium,* by the above proposals, has been negated by the appearance, after the submission of this manuscript to the publisher, of two additional papers on *Protoperidinium* by BALECH (1973, 1974). In the second of these he has created 231 new combinations for marine peridinia transferred to *Protoperidinium* (including all the species referred to *Peridinium* here, but not those referrable to *Scippsiella*).

Key to the subgenera of *Peridinium*, and some related genera, recognised here

1. Apical pore always lacking, usually with 5 cingular plates	*Peridinium* [= *Cleistoperidinium* LEFÈVRE]
Apical pore present	2.
2. Three cingular plates + transitional plate	3.
More than three cingular plates	5.
3. Two anterior intercalary plates	*Archaeperidinium*
Three anterior intercalary plates	4.
4. Six precingular plates	*Minusculum*
Seven precingular plates	*Protoperidinium*
5. Four cingular plates (+ transitional plate)	*Ensiculifera* (Genus)
Five cingular plates (+ transitional plate)	*Scrippsiella* (Genus)
Six cingular plates	*Poroperidinium*

Four of these, *Archaeperidinium, Minusculum, Protoperidinium* and the genus *Scrippsiella,* were present in the "Anton Bruun" material.

The subgenera *Archaeperidinium* and *Protoperidinium* are usually dealt with as one unit, sharing the same number of cingular plates. The key below follows this convention.

Key to the sections of the subgenera *Archaeperidinium* JÖRGENSEN and *Protoperidinium* (BERGH) OSTENFELD

1. Two anterior intercalary plates	2	(Subgenus *Archaeperidinium*)
Three anterior intercalary plates	4	(Subgenus *Protoperidinium*)
2. Anterior intercalary plates equal in size	3	
Ant. intercalary plates very unequal in size	Sect. *Excentrica* PAULSEN	
3. Girdle left-handed (descending)	Sect. *Avellana* PAULSEN	
Girdle not displaced	Sect. *Archaeperidinium*	
4. Lacking antapical spines or horns	Sect. *Tabulata* JÖRGENSEN	
Lacking hollow antapical horns but with antapical spines	5.	
With hollow antapical horns	6.	
5. First apical plate: Meta	Sect. *Humili-Piriformia* PAULSEN	
First apical plate: Para	Sect. *Protoperidinium*	
6. First apical plate: Meta	Sect. *Divergentia* JÖRGENSEN	
First apical plate: Ortho	7.	
7. Antapical horns blunt, short, 2^a usually hexa	Sect. *Conica* JÖRGENSEN	
Antapical horns more drawn out, 2^a usually quadra	Sect. *Oceanica* JÖRGENSEN	

Subgenus *Archaeperidinium* (JÖRGENSEN) LEBOUR

Members of this subgenus differ from those of the subgenus *Protoperidinium* by the possession of only two anterior intercalary plates. In other respects, such as the possession of an apical pore and number of cingular plates, they appear to be similar to the latter. They all have an "ortho" first apical plate.

Three sections have been recognised within this subgenus: *Avellana* PAULSEN, in which the girdle is left-handed and the anterior intercalaries are symmetrical; *Archaeperidinium* (= *Monovela* ABÉ) in which the girdle has no displacement; and *Excentrica* PAULSEN in which the anterior intercalary plates are very unequal in size (see PAULSEN 1949 for further details). As so few species are involved in the present work the sections have not been employed.

Peridinium abei PAULSEN Plate 33, Figs. 363, 366

SCHILLER 1935:138, f. 136 a–h; ABÉ 1936a:667, f. 52–61; KISSELEV 1950:157, f. 250; WOOD 1954:229, f. 91; SILVA 1956a:60, t. 10, f. 4–6; MARGALEF 1957a:45, f. 3a; YAMAJI 1966:86, t. 41, f. 10; HALIM 1967:734, t. 5, f. 68, 69; WOOD 1968:97, f. 283; STEIDINGER et WILLIAMS 1970:55, t. 27, f. 90 a–c; HASSAN et SAIFULLAH 1972b:160, f. 1 a, b.

Syn.: *P. biconicum* ABÉ . . . BÖHM 1931a:194, f. 14; MATZENAUER 1933:454, f. 26 a–d; NIE 1939, f. 4. Non *P. biconicum* DANGEARD.

This species exhibits quite a large variation in its shape. Although always biconical, it can be elongated due to the extension of the apical and antapical (right side only) horns. BÖHM (1931a) termed this the forma *elegans* (of *P. biconicum*: it was transferred to *P. abei* by ABÉ 1936a) and it is equivalent to the f. *elongata* of MATZENAUER (1933). At the other extreme it can be broad and short with no apical or antapical prolongations, this being termed the *f. rotundata* by ABÉ (1936a). The var. (forma) *abei* is between these two extremes. Although the antapex is usually noticeably asymmetrical, the right side being larger than the left (fig. 363); one can also find cells in which the antapex is perfectly conical (fig. 366). The latter are usually megacytic (with intercalary bands well developed). The above variants are considered as varieties in accordance with the principles outlined in the introduction:

P. abei PAULSEN var. *elegans* (BÖHM) stat. nov. [Basionym: *P. biconicum* forma *elegans* BÖHM 1931a:194 = *P. abei* f. *elegans* ABÉ].

P. abei PAULSEN var. *rotundata* (ABÉ) stat. nov. [Basionym: *P. abei* forma *rotundata* ABÉ 1936a:667].

P. abei is in most respects very similar to *P. ventricum* ABÉ, the chief distinction being that in the former the epi- and hypotheca are subequal in length, whereas in the latter the epitheca is smaller than the hypotheca. As can be seen from fig. 521a, this is not always easy to judge. *P. abei* is larger (length 70–105 µm) than *P. ventricum* (length 51–54 µm).

Stations: 46, 104, 363, 369.

The species occurred in the Bay of Bengal and at the southern end of the Mozambique Channel. It is evidently thermophilic, and is evidently tolerant of high salinities in view of its occurrence in the Persian Gulf (BÖHM 1936 – record omitted by WOOD 1963a). It is interoceanic, and has been found in the Indian Ocean also by MATZENAUER (1933), WOOD (1954), SILVA (1956a), and HASSAN & SAIFULLAH (1972b).

Peridinium minutum KOFOID Plate 33, Fig. 372

WAILES 1928:4, t. 3, f. 42, 43; SCHILLER 1935:141, f. 140 a–d; ABÉ 1936a:671; NIE 1939, f. 12 A–E; KISSELEV 1950:158, f. 239; SILVA 1955:135, t. 4, f. 7, 8; MARGALEF, DURÁN et SAIZ 1955:95, f. 5 i, j; BALECH 1964a:180, t. 1, f. 1–10; HALIM 1967:741, t. 9, f. 125, 126; WOOD 1968:104, f. 311; WALL et DALE 1968a, t. 4, f. 6, 7.

Syn.: *P. monospinum* PAULSEN ... WAILES 1928:3, t. 3, f. 34–36; – 1939:32, f. 93; ABÉ 1936a:670; SILVA 1949:344, t. 5, f. 12, 13.

This is a distinctive rotund species with a small, smoothly attached apical horn and lacking girdle excavation. The two anterior intercalary plates are asymmetrically or symmetrically developed. BALECH (1964a) has provided a detailed plate analysis.

PAULSEN (1930, 1949) agreed with the conspecificity of his species with that of KOFOID. Originally he had asserted that it differed in being larger (length 48–60 µm instead of 23–43 µm). BALECH (1964 a, b) revised the size data of *P. minutum* (to length 46–56 µm, partly to distinguish it from *P. aspidotum* BALECH (length 35–39 µm) which also exhibits greater dorso-ventral flattening, asymmetrical development of 1″ and 7″ and postcingulars and subequal anterior intercalaries. *P. constrictum* ABÉ is large (length 55–64 µm) and supposedly has a shorter sulcus.

WALL & DALE (1968a) have studied the species during encystment, finding that it produces a cyst with numerous blunt processes.

Station: 53.

Found in small numbers at only one station situated in the northern Bay of Bengal. The species is known from both cold temperate and tropical waters in the three major oceans but not from the Mediterranean Sea, suggesting an exclusion from high salinity areas. It has been recorded from the southern Arabian Sea by SUBRAHMANYAN (1958) and SUBRAHMANYAN & SARMA (1967) and from the southwest Indian Ocean by SILVA (1956a, 1960) and TAYLOR (1967).

Peridinium ventricum ABÉ Plate 45, Fig. 521 a–c

SCHILLER 1935:143, f. 144 a–e; NIE 1939, f. 9 A–E; KISSELEV 1950:210, f. 345; WOOD 1954:229 vix f. 93 a, b.

As indicated under *P. abei* this species is very similar to it, the chief distinction being the smaller size of *P. ventricum* (length 51–54 µm) and the short epitheca in comparison with the hypotheca. Both exhibit the curious, slit-like apical plate (fig. 521 b) found also in some other members of the subgenus. Also, in both, the right posterior part of the hypotheca usually protrudes beyond the left part. *P. thorianum* PAULSEN, as interpreted by some authors (e.g. NIE 1939), also looks very similar to *P. ventricum*, showing a similar curved first apical plate (also in *P. abei*). However other authors (e.g. WAILES 1939) have interpreted *P. thorianum* quite differently, showing a more conventionally-shaped "ortho" plate.

Station: 420.

Only one specimen was found in the vicinity of Mombassa. The species appears to be thermophilic, like *P. abei*, but is rarer than it. It is known only from Far Eastern waters and from the Indian Ocean (one record: WOOD 1962 in WOOD 1963a).

Subgenus *Protoperidinium* (BERGH) OSTENFELD

This subgenus contains the bulk of the marine species of *Peridinium;* that is, those with an apical pore, three girdle plates plus a transitional plate, and three anterior intercalary plates. It has been subdivided into numerous sections (see the key appearing before the subgenus *Archaeperidinium*) and they are useful in handling the species here. The criteria used for recognising the sections are the nature of the first apical plate, the second (mid) anterior intercalary plate and, to a lesser extent, the girdle displacement and possession or absence of hollow antapical projections.

Section *Conica* JÖRGENSEN

Members of this section have an "ortho" (four-sided) first apical plate. The second anterior intercalary plate is usually "hexa", but "quadra" and "penta" configurations occasionally occur. Girdle displacement is either negligible or left-handed. The epitheca of most specimens is conical, having fairly straight sides. Antapical projections consist of slight, hollow projections, angular, often tipped with short spines but never having long, slender antapical spines.

As in the section *Divergentia* problems in recognition can arise as a result of the strong development of intercalary bands ("megacytic" cells).

Peridinium achromaticum LEVANDER Plate 33, Figs. 371 a, b

SCHILLER 1935:229, f. 225 a–h (vix g); WAILES 1939:34, f. 103; NIE 1939, f. 16; KISSELEV 1950:195, f. 330; SILVA 1952b:601, t. 6, f. 5, 6; WOOD 1954:250 vix f. 144; HALIM 1960a, t. 3, f. 12 a, b; BALECH 1963b:112, f. 1–10.
Vix BIECHELER 1952:67, f. 39/1–5.

This is an interesting species because of its usual association with brackish water (see distributional comments below). It is recognisable by its almost rhomboidal shape with convexly rounded antapices, negligible girdle displacement, and the presence of small spines on the antapices. It is not dorso-ventrally flattened. It most closely resembles *P. conicoides* PAULSEN with which it may have been confused at times, the latter having a more smoothly rounded epitheca and antapices, which have an angular shape.

There are several interpretational problems associated with this species. Firstly, in the brackish water Baltic specimens, such as those illustrated by WOLOSZYNSKA (reproduced in SCHILLER 1935), the edge of the sulcus is lined with low but strong sulcal lists and it is the profiles of these which give the appearance of antapical spines. However in the figures of SILVA (1952b), HALIM (1960a) and particularly in the detailed analysis by BALECH (1963b), the spines appear to arise independently at the termination of rather angular antapices, like those of *P. conicoides.* Also in their specimens the sides of the epithecae are smoothly convex rather than angular. *P. conicoides* is apparently larger (length 48–60 µm in comparison with values of 24–48 µm usually given for *P. achromaticum*). However the megacytic cell illustrated here, which seems to fit *P. achromaticum* in other respects, was very large (length 64 µm, transdiameter 59 µm).

Another unusual feature of the specimen illustrated is the longitudinal rather than cross-striation of the intercalary bands. This is rare in marine species (but see fig. 306 b) but it is not uncommon in fresh-water species.

Station: 45.

The occurrence of this species at a station close to the delta of the Ganges River in the northern Bay of Bengal accords with its common occurrence in brackish or even fresh-water. The surface salinity at this station was 19.82 ‰, and at 10 metres 31.74 ‰. MATZENAUER (1933) apparently found specimens (not illustrated) near Ceylon, this being the only previous record of the species from the Indian Ocean. In other oceans it is usually found in cold-temperate to tropical coastal waters with low salinity, such as the Baltic Sea, Argentinian lagoons, and in the Pacific Ocean, low salinity waters off British Columbia and Port Hacking harbour (New South Wales). A notable exception to this pattern is HALIM's (1960a) discovery of the species at Villefranche-sur-Mer in the Mediterranean Sea where the salinity only drops below 37 ‰ in very localised parts after strong rainfall.

Peridinium biconicum P. DANGEARD [non ABÉ] Plate 33, Fig. 365

MATZENAUER 1933:458, f. 33; SCHILLER 1935:230, f. 227 a–e; NIE 1939, f. 4; STEIDINGER et WILLIAMS 1970:55, t. 28, f. 91 a, b.
Non SILVA 1956a:64, t. 11, f. 1–3 [= *P. symmetricum* HALIM].
Syn.: ? *Peridinium* sp., WANG et NIE 1932:294, f. 5.

A moderately sized (length 75–100 μm) rounded species with slight dorso-ventral flattening. The shapes of the epi- and hypotheca are rather similar but the latter is slightly more rounded. It is not particularly like any of the other members of the section, most of which have a mid-ventrally indented hypotheca. However *P. symmetricum* HALIM (1967) is very similar, differing in that the sides of the epi- and hypotheca are straight or concave and the apices, especially the antapex, are acute.

Stations: 71, 88, 95.

Found only at three stations in the central and western Bay of Bengal. The species is rare. It is known from temperate and tropical regions of the Atlantic Ocean, the Mediterranean Sea, and has been found previously in the Indian Ocean by MATZENAUER (1933; – SILVA's 1956a record is discounted). There do not seem to be any Pacific Ocean records of the species as yet.

Peridinium conicum (GRAN) OSTENFELD et SCHMIDT Plate 33, Figs. 361, 362

SCHILLER 1935:233, f. 229 a–j, 230 a–c, 231 a–d; 232; DIWALD 1939:178, f. 3 a, b; WAILES 1939:34, f. 100; SILVA et PINTO 1948:168, t. 6, f. 10, 11; BALECH 1949a:405, t. 6, f. 131–142; KISSELEV 1950:195, f. 326, 327; RAMPI 1950b:235, t. 1, f. 3; MARGALEF et DURÁN 1953:29, f. 6 m–p; WOOD 1954:250, f. 146 a, b; MARGALEF, DURÁN & SAIZ 1955, f. 5 h; MARGALEF 1957a:45, f. 2d; TRÉGOUBOFF et ROSE 1957:111, t. 23, f. 18; HALIM 1960a, t. 3, f. 11; BRUNEL 1962:189, t. 56, f. 1–4, t. 57, f. 1–3; KLEMENT 1964:351, t. 1, f. 6; YAMAJI 1966:87, t. 42, f. 5; TORIUMI 1966a:3, t. 3, f. 6; DEFLANDRE 1966, t. 1, f. 1–6; HADA 1967:18, f. 28 F; HALIM 1967:736, t. 6, f. 74; WOOD 1968:99, f. 292; STEIDINGER et WILLIAMS 1970:55, t. 29, f. 94 a, b; HERMOSILLA 1973b:32, t. 14, f. 1–20.
Vix WANG 1936:132, f. 9.
Non GRAN et BRAARUD 1935:380, f. 57 (= *P. laticeps* GRÖNTVED, cf. GAARDER 1954).

Syn.: . . . *P. matzenaueri* GAARDER 1954:46, f. 60 a–c non BÖHM 1936 = *P. aliferum* GAARDER in PARKE et DIXON 1968:803; vix BALECH 1971a:87 (t. 14, f. 218–227 sub *P. vulgare*?).
P. leonis auct. non PAVILLARD; BALECH 1949a, f. 91; MARGALEF et DURÁN 1953, f. 7 b.

This species is distinctive but is somewhat polymorphic, particularly with regard to the size and shape of the hypotheca, leading to the recognition of various varieties and forms. Its length has been reported to vary from 52–105 μm. It is easily distinguishable from *P. pentagonum* and *P. latissimum* by its lack of dorso-ventral flattening, and from others such as *P. leonis* by the triangular shape of its first and seventh precingular plates.

The "Anton Bruun" specimens corresponded with two varieties: the var. *concavum* MATZENAUER, and the var. *asamushi* (ABÉ) stat nov. [Basionym *P. conicum* forma *asamushi* ABÉ 1927, f. 25].

The first of these was distinguished by MATZENAUER (1933) on the basis of the concave sides of its epi- and hypotheca, rather than convex as in the var. *conicum*. GAARDER (1954) considered such cells sufficiently different to warrant the recognition of a separate species, naming it *P. matzenaueri*, not knowing the name was pre-occupied by a species of BÖHM's (cf. PARKE & DIXON 1968). She corrected this in a checklist in 1968 by renaming it *P. aliferum*. An additional feature she added for the distinction of the taxon as a species was a slight right-handedness in the girdles of her specimens. However, none of the "Anton Bruun" specimens exhibited any appreciable displacement while agreeing in all other respects with MATZENAUER's description. Furthermore, the var. *asamushi* also has concave sides to its hypotheca and, although it was originally found to have slightly convex epithecal sides, here it was seen to occasionally be slightly concave (fig. 362).

It seems best to keep both taxa with *P. conicum* for the present until their position is further studied. Both varieties, have larger antapical projections than the var. *conicum*, but in the var. *asamushi* they are particularly large, appearing as blunty pointed lobes. ABÉ found four anterior intercalary plates in his type material, but here all had only three and the "four" condition seems to be a teratological subdivision of the central plate.

The forma *guardafuiana* MATZENAUER appears to be a megacytic form of one of these two varieties. DEFLANDRE (1966) has provided photographs of an apparent specimen of this species present in a flint deposit approximately 80 million years old! DIWALD's (1939) specimens illustrate plate aberrations.

Stations: var. *conicum*: 23, 25, 38.
var. *asamushi*: 51, 105.

Both varieties were found only in the Andaman Sea and the Bay of Bengal. As HALIM (1967) has indicated, the species as a whole appears to be cosmopolitan, very eurythermal and halotolerant, although the above varieties occur predominantly in tropical waters. There are numerous records of the species in the Indian Ocean, those listed by WOOD (1963a) requiring augmentation by those of SILVA (1956a, 1960), SOURNIA (1968b, 1970), and NEL (1968).

Peridinium divaricatum MEUNIER Plate 33, Fig. 370
SCHILLER 1935:235, f. 233 a–e; SILVA 1952b:603, t. 6, f. 7, 8; WOOD 1954:251, f. 147; – 1968:101, f. 297.

This brackish water species is similar to *P. leonis* and *P. conicoides* in shape and in the shape of the first and seventh precingulars (quadrangular rather than triangular). It differs from both in the possession of hollow, divergent antapices, not as well-developed here as in European coastal waters. The original size data indicated that the length was subequal to the transdiameter, in the vicinity of 50 µm. Cells here reached 62 µm (illustrated).

Stations: 44, 45, 49.

The occurrence of this species only along the northern coast of Burma, particularly near the delta region at the head of the Bay of Bengal, accords with its designation as a low-salinity species. It has not been previously recorded from the Indian Ocean, but is known from brackish coastal water off Belgium, England, eastern Australia, and from the Strait of Florida (high salinity?).

Peridinium latissimum KOFOID Plate 33, Fig. 360
MATZENAUER 1933:456, f. 30 a, c, e (vix b non d); MARGALEF 1957a:45, f. 2 c; WALL et DALE 1968a:274, t. 2, f. 6, 7, t. 3, f. 14; WALL 1971a, t. 2, f. 14.
Syn.: *P. pentagonum* GRAN var. *latissimum* (KOFOID) SCHILLER 1935:242, f. 243 a–j (vix b, non d); WOOD 1954:253, f. 150 b, c; KLEMENT 1964:352, t. 1, f. 8; STEIDINGER et WILLIAMS 1970:57, t. 34, f. 113; WALL et DALE 1967, t. 1, f. Q; vix BALLANTINE 1961:222, f. 26, 27.
P. pentagonum GRAN forma/var. *depressum* ABÉ... HALIM 1967:745, t. 6, f. 82, 83, t. 7, f. 86 (as forma); YAMAJI 1966:88, vix t. 42, f. 8 (as forma).
P. pentagonum auct. non GRAN; NIE 1939, f. 2 A–E; vix SILVA et PINTO 1948:170, t. 6, f. 19; BALECH 1949a:401, t. 5, f. 92–110; MARGALEF et DURÁN 1953:29, f. 6 1, q–x (partim); WOOD 1968:107, f. 321.
? *P. pentagonides* BALECH 1949a:403, t. 5, f. 111–113, t. 6, f. 114–130; SILVA 1956b:356, t. 3, f. 7, 8.
? *P. exiquipes* MANGIN ... SCHILLER 1935:265, f. 263; HALIM 1967:739, t. 6, f. 76, 77. [et HALIM 1965:376, f. 1/1–3 sub *P. pentagonum* var. *depressum*].
? *P. parapentagonum* WANG 1936:136, f. 11, 12.

For a taxon which at first sight appears to be readily recognisable, there has been a great deal of confusion and complication. Although many authors have followed SCHILLER's decision to relegate this taxon to varietal status under *P. pentagonum* GRAN, which it does resemble very closely, WALL & DALE (1968a), for example, have maintained its distinction as a species largely on two grounds: firstly, that the first apical plate is "para" instead of "ortho", and secondly, because its cyst is smooth-walled with very reduced antapical projections instead of being covered by small spinules and possessing large antapical projections. Their first assertion is questionable, even though much has been made of the position of the sutures to either side of the first apical plate by several other authors above (for example *P. pentagonides* BALECH is given as having a "meta" first apical plate). In KOFOID's original figures the condition can barely be described as "para". Instead the sutures all come together very close to one another. That was also the case in the "Anton Bruun" material but cells were found in which the sutures on either side were either barely anterior to, posterior to, or coincident with the first apical plate sutures arising from the girdle. The result, theoretically, is that "ortho", "meta" and "para" conditions were seen, the differences arising from the shifting of sutures by only a few microns. It would seem to be much better to maintain that in *P. latissimum* the lateral sutures are very close to or anterior to the junction, whereas in *P. pentagonum* both sutures are situated antapically from the junction.

The difference in cysts is not minor, and to this distinction could be added the earlier means of distinguishing the taxa, namely: the cells are much flattened dorso-ventrally, that dimension usually being half or less than half of the transdiameter. The transdiameter is usually greater than in *P. pentagonum* (usually more than 105 µm and reaching 124 µm) although there is overlap; and the antapical depression is relatively flat, broad and angular.

P. pentagonides BALECH was distinguished not only by its "meta" first apical plate but also by its relatively small size (transdiameter 87–95 µm) and the less-curved appearance of its girdle when seen in ventral view.

P. exiquipes MANGIN (= *P. parapentagonum* WANG) is distinguished from *P. latissimum* chiefly by its girdle displacement (left-handed) of approximately one girdle width. HALIM (1967) has discussed their separation at length. *P. exiquipes* shares the great flattening of *P. latissimum* but is more angular in apical view, having a V-shape rather than a narrowly reniform shape. Thus a distinction between the two is possible although at which level remains in doubt.

KLEMENT (1964) and HALIM (1967) have both commented on the asymmetry of the left and right sides of the cells when seen from above, but whereas the former indicates that the left side is larger than the right, HALIM claims the reverse. This difference could be real, significant or insignificant, or could be due to optical reversal.

All the specimens in the "Anton Bruun" material were similar to that illustrated here in being flattened, very wide, lacking girdle displacement (although with a sinuous curve when seen in ventral view), and with the suture junctions very close to one another. It is possible, however, under routine analytical conditions, that a few cells of one taxon may have been confused with another.

Stations: 43, 45, 103.

A few cells were seen, only in Bay of Bengal samples close to the coast. Judging from the records of the "var. *latissima*" listed in WOOD (1963a) they have been moderately frequent in the Indian Ocean. To these should be added the records of TAYLOR (1967) and WALL & DALE (1968b), the latter discovering cysts in western Arabian Sea sediments. The species appears to be an inter-oceanic, tropical form.

Peridinium latistriatum BALECH? Plate 33, Figs. 373 a–c

– 1958:86, t. 4, f. 66–80.
Syn.: *P. subinerme* auct. non PAULSEN; PETERS 1928:52, f. 15 c, g.

One large cell (length 102 µm, transdiameter 84 µm) with extremely wide intercalary bands was observed. It most closely resembled BALECH's taxon although it seems inadvisable to recognise a "species" known only in its megacytic state. It is suspected that this organism may be the megacytic condition of one of *P. subinerme*'s relatives, possibly *P. rosaceum* BALECH (not *P. roseum* PAULSEN!), the latter having a similar shape with a flattened antapex and high, conical epitheca.

An unusual feature of the present cell was either a shifting of the first apical plate to the right side of the cell, or the subdivision of the existing first apical plate into two unequal components. The former seems more likely.

Station: 99.

It was found in the south-western Bay of Bengal. Neither of the above species has been recorded previously from the Indian Ocean. The species was originally described from the Antarctic Ocean, making the tropical Indian Ocean locality an unusual discovery.

Peridinium leonis PAVILLARD Plate 33, Fig. 369

SCHILLER 1935:236, f. 236 a–m (non k), 237 a–d; DIWALD 1939:177, f. 23 a–e; SILVA et PINTO 1948:165, t. 6, f. 3; KISSELEV 1950:196, f. 333, 334; RAMPI 1950b:235, f. 14; MARGALEF et DURÁN 1953:31, f. 6 j, k, 7 c (non b); WOOD 1954:251, f. 148 a (vix b, c); TRÉGOUBOFF et ROSE 1957:111, t. 23, f. 19; HALIM 1960a, t. 3, f. 10; WOOD 1968:104, f. 310.
Vix KISSELEV 1950:198, f. 335 (var. *concavilaterale*). Non MATZENAUER 1933:456, f. 29 b, c (vix a): WANG 1936:134, f. 10 (= *P. striatum* BÖHM); BALECH 1949a, t. 4, f. 91 (= *P. conicum*); KLEMENT 1964:351, t. 1, f. 7, 9; STEIDINGER et WILLIAMS 1970:56, t. 32, f. 105, (= *P. striatum* BÖHM); HERMOSILLA 1973b:34, t. 16, f. 1–21.

Like *P. subinerme* this species can be readily distinguished from *P. conicum* and its relatives by the quadrangular instead of triangular shape of the first and seventh precingular plates (a constant feature of *P. conicum* whereas it is variable in *P. persicum*). It can be distinguished from *P. subinerme* by the straighter sides of its epitheca and the narrower angle which they subtend at the apex. Small antapical spines are usually present. Most of the "Anton Bruun" specimens corresponded with the taxon referred to as the f. *gainii*, which has the most widely set apart antapices, the posterior margin being only shallowly indented (similar to *P. subinerme*).

P. divaricatum MEUNIER is very similar to *P. leonis*, being distinguished primarily by the greater development of the cell antapices into small, acute, strongly-divergent horns.

In the reference citation here specimens with a striated epithecal surface resembling *P. striatum* BÖHM, sometimes with a more convex epitheca, and with closely set antapices, have been excluded as they are not here considered to be the same species. BÖHM's name cannot be used for such specimens, however, as it is preoccupied by one created by OSTENFELD & SCHMIDT (1901), and if recognised as distinct, will require a new name.

Stations: 39, 41, 45, 142.

The first three stations listed above are fairly near large river deltas (the Irrawaddy and the Ganges) within the Andaman Sea and the Bay of Bengal, the last station being south of India. This would seem to suggest a preference for lower salinity or a land-derived nutrient, but Mediterranean records (where it has been found to be plentiful) negate this idea, Mediterranean salinity being high (circa 38 $^{o}/_{oo}$) except in the vicinity of the major river outflows. The species is known from cold-temperate to tropical waters, and has been found in all the major oceans. There are several previous Indian Ocean records (excluding some, at least, of MATZENAUER's) and those of SILVA (1956a, 1960) and TAYLOR (1967) can be added to the list given by WOOD (1963a).

Peridinium persicum SCHILLER Plate 33, Figs. 368 a, b
– 1935:272.
Syn.: *P. schilleri* BÖHM 1931a:193, f. 9, non *P. schilleri* PAULSEN.
P. punctulatum forma *asymmetrica* MATZENAUER 1933:458, f. 32.
P. matzenaueri BÖHM 1936:44, f. 19 b; HALIM 1967:741, t. 7, f. 89.
P. margalefii SILVA 1956a:64, t. 11, f. 4–7.
? *P. subinerme* forma *asymmetrica* MATZENAUER 1933:458, f. 31.

This is a distinctive member of the section Conica. Although like many, it has an "ortho-hexa" tabulation, it can be recognised by the asymmetrical development of the antapices, the left being distinctly larger than the right. Theoretically it might be possible to distinguish *P. persicum* from *P. matzenaueri* on the basis of two quadrangular precingulars (1″ and 7″ in the former, and triangular precingulars in the latter), but the existence of specimens such as the present one or that of SILVA (1956a) in which one is quadrangular and the other is triangular makes the distinction of dubious value. HALIM 1967, has previously suggested their synonymy, although not also with *P. margalefii* SILVA. There seem to be no sound distinctions between the latter, and SILVA (1956a) may not have been aware of the earlier taxa as she makes no reference to any similarity of her taxon with them. The girdle may be slightly left-handed or not displaced.

Because of tilting, the specimen illustrated here appears to have a greater antapical indentation than is usual for the species. However, in reality the posterior indentation is only moderate and it is the deeply excavated sulcus which produces the deeply indented appearance.

The size range for the species is: length 72–82 μm, transdiameter 75–91 μm. Dorso-ventral flattening is slight.

Although the species was based only on MATZENAUER's form of *P. punctulatum* by BÖHM, it seems likely that MATZENAUER's asymmetrical form of *P. subinerme* is also the same taxon, the only difference being that the antapical indentation is minimal.

P. obtusum KARSTEN, as originally figured by him (1906, pl. 13, f. 12) has resemblances to *P. matzenaueri* and the left antapical horn does appear to be slightly larger than the right. However as he figured it only in three-quarter apico-ventral view it is difficult to make a good comparison. Most later authors have interpreted his taxon as having equally developed antapical horns. The surface striations of *P. obtusum* (resembling *P. striatum* BÖHM) are apparently not present in *P. matzenaueri.*

Station: 144.

A single cell was found to the south of Ceylon. The species appears to be an inter-oceanic warm-water form as it has been recorded form the Caribbean Sea, the Indian Ocean, including the Persian Gulf (by BÖHM 1931a, MATZENAUER 1933 and SILVA 1956a, 1960) and the tropical western Pacific Ocean.

Peridinium subinerme PAULSEN Plate 33, Figs. 364, 367 a, b
SCHILLER 1935:243, f. 244 a–o (non 245 a–c); BÖHM 1936:44, f. 16 a 1–4; DIWALD 1939:175, f. 22 a–d; SILVA 1949:345, t. 5, f. 15–17; MARGALEF et DURÁN 1953:29, f. 6 e (vix d); WOOD 1954:254, f. 151; SILVA 1955:142, t. 5, f. 4, 5; YAMAJI 1966:87, t. 42, f. 3; HALIM 1967:748, t. 6, f. 84, t. 7, f. 85; WOOD 1968:109, f. 330.
Vix KISSELEV 1950:200, f. 338, 342; RAMPI 1950b:235, f. 10; GAARDER 1954:49, f. 64 a–c (f. *excavatum* GAARDER); MUÑOZ, HERRERA et MARGALEF 1956, f. 1 i–k; BALECH 1971a:91, t. 15, f. 249–252.
Non STEIDINGER et WILLIAMS 1970:58, t. 34, f. 115 (= *P. obtusum* KARSTEN?).

The body of this species varies considerably in length, from broader than long, to longer than broad. It is distinguished from other members of the section by its greater convexity, particularly in the broad angle subtended to each other by the sides of the epitheca as they approach the apex. The antapices are broadly rounded or slightly pointed. Many of the specimens illustrated are megacytic, leading one to suspect that the taxon may consist partially of megacytic members of another species of the section. However, in the "Anton Bruun" material a very small cell (fig. 364) was found which exhibited the same features without megacytism. The second dorsal intercalary plate is "hexa" in non-megacytic specimens, but may or may not become "quadra" with the development of intercalary bands (in fig. 367 the "hexa" formation was retained).

GAARDER (1954) has recognised a "forma" *excavatum*, distinguished by a strong indentation of the posterior part of the sulcus (not affecting the post-margin, however). One specimen had a very peculiar epithecal tabulation, the anterior intercalary plates being discontinuous because of the third apical plate contacting the precingular series directly on the dorsal side. However other specimens were "ortho-hexa".

P. punctulatum PAULSEN has a similar shape, but the plates may be finely rugose due to numerous small spines. It usually has a "penta" rather than a "hexa" second anterior intercalary plate, but not always. Another supposed distinction is that the epitheca is not as high as in *P. subinerme* but the specimens here plainly contradict this distinction (cf. PAULSEN 1949 for further discussion). Indeed it is suspected that the specimen in fig. 367 may correspond to *P. punctulatum*, having puncta, but it did not possess spinulae. The distinction of these two species remains troublesome, expecially in tropical waters.

HALIM (1967) considered that *P. subinerme* is smaller than *P. punctulatum*. While the specimen in fig. 364 is indeed small, the other megacytic specimen had a length exceeding 90 μm, nearly twice the normal length for the species.

Stations: 38, 105.

Specimens were found only at a station in the eastern Andaman Sea and at one close to Madras in the Bay of Bengal. SILVA's (1956a and 1960) records should be added to the few listed for the Indian Ocean by WOOD (1963a).

Section *Divergentia* JÖRGENSEN
[= Divergens auct. nonnul.; Metaperidinium; incl. Paradivergentia]

Members are characterised by a meta/quadra (rarely hexa) plate combination and by the presence of an antapex more or less divided into antapical horns. Girdle displacement is variable, being none, left-handed or right-handed. Left-handed species, or those with no displacement, show affinities with the section Oceanica (*P. venustum*, ortho/quadra, is very similar to *P. elegans*) whereas those with right-handed displacement tend more towards the section Protoperidinium (e.g. *P. solidicorne*).

This section is very commonly represented in tropical waters, especially by members of the "Divergens Complex". The latter is particularly troublesome to deal with as it embraces considerable multidirectional variation. More than ten taxa have been recognised at the species level. Where some have been combined with others (e.g. *P. curtipes* with *P. crassipes*) there has been inconsistency in treating others which differ by equally small or even lesser differences.

Text figure 4 below provides a view of the variation within the "Divergens Complex" as indicated by simplified outline figures (to scale).

All the taxa shown in the diagram, with the exception of *P. curtipes* forma *asymmetrica* MATZENAUER, *P. tregouboffii* HALIM and *P. anguipes* BALECH, were present in the "Anton Bruun" material. The outlines are derived from scanning electron micrographs in which the specimens could be oriented in a similar manner. In water mounts, they tend to lie tilted with the ventral apical surface showing the most (see figs. on the plates). Comparison of the outline drawings should obviate lengthy descriptive comments.

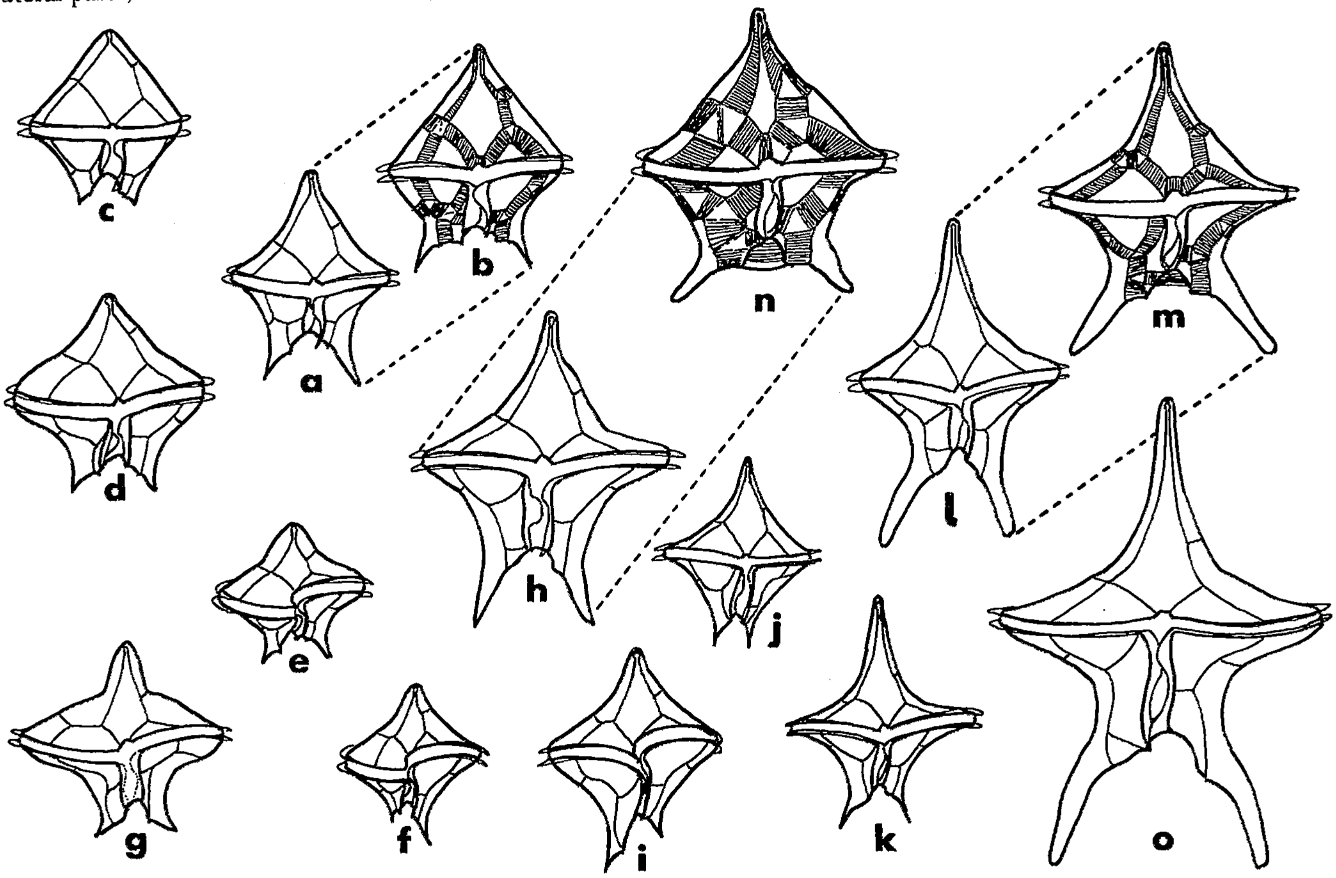
P. remotum KARSTEN and *P. fatulipes* KOFOID are considered to be parallel maturational states of *P. divergens* and *P. elegans* respectively and not as species. *P. tumidum* may be the corresponding state of *P. grande* but has been kept separate pending further examination. The lateral displacement of the antapical horns (by which they were recognised) is the result of the development of intercalary bands, a feature which has apparently escaped previous authors other than HALIM (1967 – for *P. fatulipes*). An interesting feature of intercalary band development in *Peridinium* is that, like the development of the megacytic zone in the Dinophysiales, it is greatest in the posterior region of the cell and least at the anterior end. This is most marked in *P. elegans* in the *"fatulipes"* stage where the great width of the band passing between the antapical horns (i.e. between the antapical plates), gives the appearance of a "bridge" between the bases of the horns.

A glance at the text figure below is sufficient to show that, with the possible exception of some as yet undiscovered sulcal plate distinctions, many of the taxa differ by less than in other species of *Peridinium* and, in another section, they might be considered infraspecific variants. Key questions in this problem are whether or not intermediates exist, what their frequency is, and whether or not such variation is genetically based. At present there is very little of such information. Also, information is lacking on the details of the ventral area for most species.

P. curtipes has been commonly combined with *P. crassipes* because of supposed intermediates, although, due to differing orientations of the figures, it is difficult to assess many of the existing figures. In the "Anton Bruun" material the girdle-displacement of the former could always be used to distinguish the two (see other comments under the species) provided the cells were oriented in full ventral view.

It is not possible at present to decide which members of the complex deserve specific, subspecific, varietal or other distinction. Although it undoubtedly is excessive "splitting" to distinguish most of the primary variants (with the exception of *"remotum"*, *"fatulipes"*, and possibly *P. tregouboffii*) at the species level, this practice is followed here as an interim measure except where new taxa would have to be created (see *P. elegans* f. *granulatum*).

One feature not shown in the figure which also exhibits trends is the shape of the cell equator seen from the apex. In the closest members to *P. divergens* it is round or broadly oval. In *P. grande* the ventral side becomes flattened so that the shape is almost hemispherical. This suppression of the ventro-median portion, with increased development of the ventro-lateral parts, results in an almost V-shaped profile both in *P. brachypus* and in *P. elegans*.



Text fig. 4. Members of the "Divergens Complex" of *Peridinium* section *Divergentia* (originals except for figures f, g and j).

a. *P. divergens* EHR. – b. Megacytic *P. divergens* EHR. [= *P. remotum* KARST.] – c. *P. acutipes* P. DANG. – d. *P. crassipes* KOF. – e. *P. curtipes* JORG. – f. *P. curtipes* f. *asymmetrica* (redrawn from MATZENAUER 1933) – g. *P. anguipes* BAL. (redrawn from BALECH 1967a) – h. *P. grande* KOF. – i. *P. asymmetricum* KARST. – j. *P. tregouboffii* HAL. (redrawn from HALIM 1955) – k. *P. brachypus* SCHILL. – l. *P. elegans* CLEVE – m. Megacytic *P. elegans* [= *P. fatulipes* KOF.] – n. *P. tumidum* OKAM. [? = megacytic *P. grande* KOF.] – o. *P. elegans* f. *granulatum* (KARST.) MATZ.

Here *P. elegans*, *P. brachypus*, and *P. remotum* (as a synonym of *P. divergens*) are included in this section, rather than in the section Oceanicum where they were placed confusingly by SCHILLER (1935). SCHILLER's action was based on the observation of an "ortho" tabulation in a specimen resembling *P. elegans*. Such a feature has not apparently been seen by any other authors, and all the numerous "Anton Bruun" specimens had "meta" tablature. He did not figure the tablature of *P. brachypus* but said it had an epitheca like *P. elegans* forma *granulatum*, thus mislocating it by association.

A further confusing element is that some of the figures of MANGIN (1928) seem to be optically reversed. Thus *P. obtusipes* MANGIN is almost certainly a short-horned variant of *P. elegans* or *P. grande*.

Peridinium acutipes P. DANGEARD   Text Fig. 4 C; Plate 31, Figs. 317, 318, 321, 325
MATZENAUER 1933:469, f. 54.
Syn.: *P. divergens* forma *acutipes* (DANGEARD) SCHILLER 1935:227, f. 223 a–d.
P. quadratum MATZENAUER 1933:469, f. 55.
P. brochii auct. non KOFOID et SWEZY; BALECH 1951b:320, t. 6, f. 88–114.

There is undoubtedly a strong resemblance between this taxon and *P. divergens* on the one hand, and *P. brochii* on the other. It is kept separate here for the reasons outlined in the introduction to this section although it will probably be combined with *P. divergens* again when more information is available. It differs from *P. divergens* in the flattened or almost convex sides of the epitheca and the more closely-set antapical prominences, each of which has only a small acute projection rather than the longer, conical points in *P. divergens*. The original length given was 110–120 µm, but in this material some cells as short as 88 µm were seen. Megacytic specimens (fig. 321) resemble those of *P. divergens*. *P. quadratum* MATZENAUER appears to represent the minimum divergence of the antapical projections of *P. acutipes*.

Stations: 17, 33–35, 37, 38, 40, 43, 50, 57, 59–64, 66–71, 87, 89–103, 105, 106, 108, 113, 141, 143, 150, 284, 287, 288, 294, 297, 313, 318, 323, 341, 358, 374, 399, 404, 405, 410, 413, 418.

This was the commonest representative of *Peridinium* in the material. In examining the record above it must be remembered that it must have undoubtedly been confused with *P. divergens* in some samples as the distinction is difficult to make consistently under routine conditions.

It occurred at only a few scattered stations on the eastern side of the Bay of Bengal/Andaman Sea, but was very evenly distributed at nearly all stations in the western half of the Bay of Bengal. On cruise II (S.W. Monsoon) it was only present at northern stations (only one being south of the equator). On cruise III it occurred at only one station near the equator. During the N.E. Monsoon (cruise V) it was more widespread but scattered, occurring as far south as 29 °S in the central region. With the return of the S.W. Monsoon it was present at one station near 8 °S (cruise VI). It also occurred at various stations in the Mozambique Channel region during the late S.W. Monsoon and the intermonsoon period following it.

Thus the general picture is one of a distribution chiefly limited to the northern and western regions during the S.W. Monsoon, but spreading into the south central regions during the N.E. Monsoon while remaining very common in the western Bay of Bengal at such times.

Because of confusion and combination with *P. divergens*, it is difficult to assess this taxon's distribution independently. MATZENAUER (1933) recorded *P. acutipes* from the northern Indian Ocean (and also the synonymous *P. quadratum*), and the species was originally described from the "Sylvana" cruise in the tropical Atlantic Ocean.

Peridinium angustum P. DANGEARD   Plate 31, Figs. 333, 334
– 1927b:362, f. 29 a, b; SCHILLER 1935:228, f. 224 d, e (sub *P. wiesneri* SCHILLER); NIE 1939, f. 15 (sub *P. wiesneri*).

SCHILLER (1935) included DANGEARD's species tentatively under his *P. wiesneri*. Although they are closely similar *P. angustum* is much broader relative to its length, *P. wiesneri* being round or narrowly oval like *P. pellucidum*. Also *P. angustum* has much less right-handed girdle displacement (approximately 0.5) than *P. wiesneri* (in the latter it exceeds one girdle width). Finally, the antapical horns of *P. angustum* are very short and subequal in length, whereas they are longer, closely set, divergent and unequal in length in *P. wiesneri*. BALECH (1971b) has given a detailed analysis of the latter species, concluding that SCHILLER's action in combining the two was unjustified.

Stations: 65, 114, 290.

A few cells were found at three stations in the northern Indian Ocean: two in the southern Arabian Sea and one in the western Bay of Bengal. This is the first record of the species in the Indian Ocean. It was originally described from the tropical Atlantic Ocean, and NIE has figured a mis-identified specimen from Japanese waters.

Peridinium asymmetricum KARSTEN   Text Fig. 4 i; Plate 31, Fig. 326
– 1907:418, t. 53, f. 2; MATZENAUER 1933:467, f. 51; BÖHM 1936:41, f. 17 a 1, 2; KISSELEV 1950:208, f. 351, 358 (sub *asymmetrica*, sic).
Non *P. asymmetricum* (MANGIN) OSTENFELD.

KARSTEN's original figure is rather poor, probably leading to the neglect of the species by SCHILLER (1935 – listed only) and it is due to MATZENAUER's figure of a dorsal view that the species is clearly recognisable. The cells show a very strong asymmetry of the antapical horns, with the right antapical horn much longer than the left horn. This is the reverse of that found in the var. *asymmetricum* of *P. curtipes.* The asymmetry is also expressed on the epitheca due to the strongly raised curve of the left side of the girdle, the proximal end being displaced similarly to *P. curtipes.* The original illustration does not show these features as strongly as those of MATZENAUER, BÖHM and the present author. Spines on the antapical horns were not strongly developed in many of the specimens observed although they have been reported by KARSTEN and MATZENAUER. The posterior ends of the horns bear linear striations (ridges) similar to those in *P. divergens.*

Stations: 16, 17, 32, 57, 67, 70, 103, 143, 318.

Observed in small numbers in the higher salinity regions of the Andaman Sea/Bay of Bengal area, to the south of India, and at one central station (17 °S). It has only been previously recorded from the northern Indian Ocean by KARSTEN (1907) and MATZENAUER (1933), these being omitted from WOOD (1963a).

Peridinium brachypus SCHILLER Text Fig. 4 k, Plate 30, Figs. 313 a, b
– 1935:248, f. 249.
Syn.: ? *P. tregouboffii* HALIM 1955:1, t. 1, f. 1–6, t. 2, f. 1–7; –1960:197, t. 2, f. 31.

This is a distinctive, relatively small species, described originally from the Indian Ocean and only seen since in the Mediterranean Sea. Unfortunately SCHILLER included the species under the section Oceanica, implying the presence of an "ortho" first apical plate although this assignment was due to a resemblance to *P. elegans* (which usually has "meta"). His figure showed no plates at all. It is similar to *P. acutipes* in possessing closely-set, non-divergent antapical horns (acutely pointed), but its epitheca and equatorial profile are more like *P. grande* and *P. elegans.* SCHILLER illustrated a specimen with a longer apical horn than most of the specimens observed here, and such individuals could be considered as representing the var. *brachypus.* On the other hand, individuals corresponding to *P. tregouboffii* have the shortest apical horn, not much greater than *P. depressum.* Some specimens of *P. tregouboffii* resemble intermediates between *P. depressum* and *P. brachypus.*

The epitheca of the species is similar to *P. elegans* and the strong dorso-ventral distortion resembles *P. granulatum.* However it differs strikingly in size (length 94–130 µm, diameter 86–110 µm). The second anterior intercalary plate is narrow, being much higher than wide.

Stations: 26, 27, 28, 34, 54, 60, 65, 66, 95, 97–101, 103, 130, 140, 141, 142, 144.

Common in samples from the western Bay of Bengal, but also to a lesser extent in the Andaman Sea. The remaining records were from a group of stations to the south of India. In view of this distribution the record from station 130, below 32 °S, is suspect. A re-examination of the sample did not reveal further specimens.

The species is known only from its type locality: the Indian Ocean near Sumatra (SCHILLER 1935), and, if conspecific with *P. tregouboffii,* from Villefranche-sur-Mer in the Mediterranean. HALIM (1960a) considered the latter to be a rare, umbriphilic ("sciaphile") species.

Peridinium brochii KOFOID et SWEZY Plate 31, Figs. 332, 335
SCHILLER 1935:221, f. 218 a–g (non h, i = *P. acutipes* DANGEARD); BÖHM 1936:41, f. 16 d; NIE 1939, f. 18 A–D; KISSELEV 1950:192, f. 322 *β–e* (non *a*, *б*); RAMPI 1950b:235, f. 9; MARGALEF et DURÁN 1953:27, f. 4 w, y; WOOD 1954:247, f. 136; TRÉGOUBOFF et ROSE 1957:111, t. 23, f. 15; HALIM 1967:734, t. 6, f. 72, 73; HERMOSILLA 1973a:30, t. 1, f. 1–6, t. 3, f. 6–13.
Vix WOOD 1968:98, f. 288; STEIDINGER et WILLIAMS 1970:55, t. 28, f. 92 (= ? *P. acutipes* DANGEARD).
Non BALECH 1951b:320, t. 6, f. 88–114 (= *P. acutipes* DANGEARD); HALIM 1960a, t. 3, f. 1 (= *P. divergens* EHRENBERG).
Syn.: *P. adriaticum* BROCH non SCHMARDA . . . HADA 1967:17, f. 28 c.
Non TORIUMI 1966a:3, t. 3, f. 7 (= ? *P. divergens* EHRENBERG).
P. divergens var. *adriaticum* (BROCH) SCHILLER 1929:407, f. 23, 24.

This problematic species is similar to *P. acutipes* DANGEARD, *P. inflatum* OKAMURA (which was made a form of it by SCHILLER 1935) and *P. angustum* DANGEARD. It differs from the first-named by having roundly concave-convex sides to the epitheca (instead of almost flat) and the posterior projections are more widely set. However it should be mentioned here that all the specimens which resembled *P. brochii* in this material were more or less megacytic. As has been pointed out in the introduction to this section, the shape distortion which results from growth of the intercalary bands has not been taken into account by former authors and, for example, with the exception of the more narrowly conical apex, *P. brochii* could very easily be the megacytic form of *P. angustum* or *P. wiesneri* SCHILLER, the latter having closely-set antapical projections. *P. inflatum* can be recognised as distinct here by the presence of small antapical spines, but this feature derives more from MATZENAUER's (1933) interpretation of the latter and not the original figures. All three are obviously very similar. *P. retiferum* MATZENAUER has rather coarse reticulation, similar to the specimen in fig. 334 here, and could be considered synonymous with this taxon, or *P. inflatum* as indicated by SCHILLER (1935).

Japanese authors, no doubt using the early works of ABÉ, have tended to continue using the pre-occupied epithet of BROCH's (*P. adriaticum*).

Stations: 22, 24, 25, 28, 29, 31, 34, 36, 68, 69, 94, 102, 103, 105, 110, 118, 150.

It occurred in small numbers in the central Andaman Sea, a few stations in the western Bay of Bengal, two northern stations on cruise II, and another equatorial station on cruise III (both latter cruises being undertaken during the S.W. Monsoon period).

It has been recorded most commonly from tropical and warm-temperate waters, the coldest areas being those in which GAARDER (1954) found it to the north of Ireland (presumably under the influence of the Gulf Stream). It has been recorded fairly commonly from the Indian Ocean (as listed in WOOD 1963a, plus NEL 1968 and SOURNIA 1968b, 1970).

Peridinium crassipes KOFOID Text Fig. 4 d, Plate 31, Figs. 327, 331

SCHILLER 1935:223, f. 220 a–i, l–p (non j, k); WANG 1936:141, f. 14; DIWALD 1939:173, f. 8 d, e, 21 a, vix b; WAILES 1939:38, f. 15; SILVA et PINTO 1948:167, t. 6, f. 7, 8; KISSELEV 1950:192, f. 328 *а, в, з*; RAMPI 1950b:235, f. 17; WOOD 1954:247, f. 137 a–d; MARGALEF 1957a:45, f. 2 e; TRÉGOUBOFF et ROSE 1957:111, t. 23, f. 16; HALIM 1960a, t. 2, f. 32; BRUNEL 1962:192, t. 58, f. 1–5; WOOD 1968:99, f. 293; STEIDINGER et WILLIAMS 1970:55, t. 29, f. 95 a, b; BALECH 1971a:146, t. 28, f. 530–534, t. 29, f. 535–537.

Vix MARGALEF 1948a:19, f. 2/5, 2/6; KISSELEV 1950, f. 323 *а–в*, 328 *д, е*; HALIM 1967:736, t. 6, f. 75.

Non MATZENAUER 1933:467, f. 50 a–d (incl. forma *asymmetrica* MATZENAUER); BÖHM 1936:41, f. 16 c; GRAHAM 1942:27, f. 37 A–G; KISSELEV 1950, f. 328 *б, ж*; YAMAJI 1966:89, t. 43, f. 5.

Syn.: *P. curtipes* auct. non JÖRGENSEN . . . . MARGALEF et DURÁN 1953:29, f. 5 i–n (*P. crassipes curtipes*).

This is a large, distinctive species, distinguishable from *P. divergens* in being much wider relative to its length, with the hypotheca usually narrowing rapidly until approximately one-half to two-thirds of the distance from the girdle to the antapex. The apex usually tapers smoothly, but if *P. amplum* MATZENAUER (1933, p. 468, f. 53 a, b) is synonymous, it it may also abruptly become sharply conical at the apical-precingular junction. *P. anguipes* BALECH, is also similar [text fig. 4g], bearing an abruptly conical epitheca, but is very narrow in the hypocone as well, resulting in a greatly flattened appearance. If *P. amplum* MATZENAUER is included, the transdiameter of this species can reach 137 μm.

The distinction of *P. crassipes* from *P. curtipes* has caused difficulties from the beginning, and SCHILLER (1935) followed PETERS (1928) in uniting them. In this author's opinion much of the difficulty may arise from the fact that the most clear distinction, the girdle displacement, is not evident when the cells are lying in their normal position under the coverslip (as are most of the specimens on plate 31). In the "Anton Bruun" material it was possible to distinguish two quite distinct taxa, provided the cells were seen in full ventral view, as shown in the outlines in the text figure here.

In *P. crassipes* girdle displacement is lacking, the proximal ends meeting more or less symmetrically at the sulcus, the latter being relatively shallowly depressed. In *P. curtipes,* as recognised here, the left proximal region of the girdle rises up at an angle to the plane of the girdle and the right proximal region curves sharply into the deep, narrow sulcus at a generally lower level. PAULSEN (1949) and WOOD (1954) also kept the species distinct, although the comments of the latter on the criteria used do not fit the original concept of *P. curtipes.* DANGEARD (1927b) and MATZENAUER (1933) made a similar distinction, but reversed the criteria, their *curtipes* corresponding to *crassipes* and *vice versa.* BALECH (1971a) considered that the specimens of PETERS (1928) were not the same taxon as those of KOFOID.

In the introductory comments to this section it was pointed out that, while many of these taxa could, and probably should, be united at infraspecific levels, the difficulty in handling them all in a consistent manner makes this perhaps premature at present. Data arising from excessive "splitting" can always be recombined whereas the discovery of excessive "lumping" leads to an inevitable doubt of existing data for both of the "lumped" taxa.

Here *P. crassipes* and *P. curtipes* have been kept as distinct. In what is probably an exercise in futility, the recent literature pertaining to them has also been segregated although in some cases it is difficult to determine which taxon was involved.

As a matter of historical curiosity, the unnamed specimen figured by MICHAELIS (1830) on which EHRENBERG based *P. michaelis* strongly resembles *P. crassipes* in shape. However, it could conceivably belong to several different species and most recent authors have neglected the species.

Stations: 38, 45, 95, 110, 133, 135, 141.

Cells of this species were positively identified from only a few stations in the Bay of Bengal/Andaman Sea region (including rather low salinity stations) and on cruise II from scattered stations extending to 30 °S. It is strongly suspected that this distribution is minimal because of the inadvertent attribution of smaller specimens to *P. curtipes* when full ventral views were not obtainable.

Records of this widely distributed tropical to temperate species are frequent from the Indian Ocean (see WOOD 1963a plus SILVA 1956a, 1960; PRAKASH & SARMA 1964; SOURNIA 1968b, 1970; NEL 1968 and ANGOT 1970) but due to the lack of illustrations in many cases, the true representation of the species cannot be judged at present. As noted above, MATZENAUER's (1933) record is incorrect, but he did record this species as *P. curtipes.*

Peridinium curtipes JÖRGENSEN sensu stricto Text Fig. 4 e, Plate 31, Figs. 322, 323
– 1913, Bericht 8.
Vix WOOD 1954:248, f. 138.
Non MATZENAUER 1933:468, f. 52 a, b, vix c.

Syn.: *P. crassipes* auct. non KOFOID . . . . DANGEARD 1927b:365, f. 32 c; SCHILLER 1935, f. 220 j, k; BÖHM 1936:41, f. 16 c; GRAHAM 1942:27, f. 37 A–G; KISSELEV 1950, f. 528 σ; YAMAJI 1966:89, t. 43, f. 5. *P. crassipes* subsp. *curtipes* (JÖRGENSEN). . . MARGALEF 1957a:45, f. 2 e.

The difficulties in distinguishing this taxon from *P. crassipes* have been discussed extensively under the latter. Here *P. curtipes* is thought to be distinguishable principally by the torsion of the girdle exhibited near the sulcus, the left proximal part rising up at an angle, the right proximal part lower, projecting more ventrally before curving in to the narrow, deep sulcus. In the "Anton Bruun" material most of the cells were less than 80 µm in transdiameter (one, illustrated in fig. 323, being less than 50 µm), whereas those corresponding to *P. crassipes* were usually more than 90 µm and sometimes exceeded 110 µm in transdiameter.

Stations: 16, 19, 21, 24–26, 28, 31, 32, 36, 37, 40, 41, 45, 53, 57–59, 65, 67, 69, 87, 91, 92, 100, 101, 103, 105, 106, 108–110, 114–118, 129, 135, 140–142.

This distribution was similar to that of *P. crassipes* (the taxa co-occurring at 4 stations) although *P. curtipes* was more common. It was patchy in the Bay of Bengal and Andaman Sea, and like *P. crassipes*, was recorded from the remaining Indian Ocean only during cruise II (S.W. Monsoon), also reaching 30 °S. It was particularly well represented in the South Equatorial Current, and in the returning Monsoon Current off the west coast of India.

As with *P. crassipes* the world distribution is difficult to determine, other than that it is probably inter-oceanic. JÖRGENSEN (1913) thought that it was a northern species with a colder distribution than *P. crassipes*, but that is not borne out here. DANGEARD (1927b) also found it to be common in warmer waters, but his confused conception of the species in this case casts doubt on such supportive data.

It has been recorded from the Indian Ocean by KARSTEN (1907), MATZENAUER (1933, with *crassipes* and *curtipes* reversed), and SILVA (1956a, 1960), and by WOOD (1954) from the Antarctic sector.

Peridinium divergens EHRENBERG sensu PAULSEN Text Fig. 4 a, b; Plate 31, Figs. 319, 320, 324; Plate 46, Fig. 530
SCHILLER 1935:226, f. 222 d–g (non a – *P. acutipes*, b, c – *P. grande*); DIWALD 1939:171, f. 6 a–c, 7, 8 f–h, 11 c, 19 a–c, vix 20 a, b; WAILES 1939:38, f. 114; SILVA et PINTO 1948:165, t. 2, f. 9; KISSELEV 1950:194, f. 234 non 329, vix 7, 16; RAMPI 1950b:235, f. 11; MARGALEF et DURÁN 1953:27, f. 5 a–c; WOOD 1954:248, vix. f. 139; MARGALEF 1957a:45, f. 3 d; TRÉGOUBOFF et ROSE 1957:111, t. 23, f. 17; YAMAJI 1966:89, t. 43, f. 6; STEIDINGER, DAVIS et WILLIAMS 1967, t. 8, f. c, d; WOOD 1968:101 vix f. 298; STEIDINGER et WILLIAMS 1970:56, t. 30, f. 98 a, b; TAYLOR 1972b, t. 1, f. 4.
Syn.: . . . . *P. remotum* KARSTEN sensu MATZENAUER 1933:473, f. 61 a, b (non WOOD 1954:249, f. 140).

As indicated by both JÖRGENSEN (1913) and LEBOUR (1925) the taxon most frequently referred to as *P. divergens* may not correspond with the original description. However it is impossible to be sure in view of the resemblance of *P. divergens* to several other species in shape although very different in tablature (e.g. *P. depressum*).

The interpretation here follows that of PAULSEN (1907, 1908) who tried to base his on a figure by Joseph MÜLLER referred to by EHRENBERG. LEBOUR (1925), SCHILLER (1935) and KISSELEV (1950) erroneously included figures from STEIN (1883, pl. 10) which correspond with *P. grande*, bearing large, hollow acute antapical horns. SCHÜTT (1895) figured a multitude of different taxa (as we now recognise them) under the name. PAULSEN's figures seem to provide the best critical starting point for the species.

The taxon is apparently solely distinguished from other members of the "Divergens Complex" which have sharp, thick, divergent antapical spines and no girdle displacement (e.g. *P. crassipes, P. grande*) by its size and shape. This is best seen in the text figure and its surface structure is evident from the scanning electron micrograph (fig. 530). It can be noted that *P. crassipes*, which can be similar in size, is much broader in girdle transdiameter relative to its length. *P. grande* is much larger (see notes under that taxon), with relatively larger, more obviously hollow, antapical horns.

P. acutipes DANGEARD was considered to be a form of *P. divergens* by SCHILLER (1935) Here it and others of the "Divergens Complex" are, for the most part, kept distinct because it seems premature to determine the levels at which the members should be combined (see comments under each taxon and under the sectional introduction). It differs by having short, more closely set posterior horns and a finer reticulation than *P. divergens.*

It seems evident that "*P. remotum*", as interpreted by MATZENAUER (1933), is only the appearance of *P. divergens* when intercalary bands are fully developed, and consequently does not deserve formal recognition. SCHILLER (1935) held this opinion, but repeated a type of inconsistency which appears several times in his monograph: on the one hand he made *P. remotum* KARSTEN a synonym of *P. divergens* and yet, on the other, recognised it on page 262 as a distinct species.

P. asymmetricum KARSTEN, also kept separate here, differs from *P. divergens* in that the right antapical horn is markedly longer than the left horn and, furthermore, the girdle shows strong left-handed displacement (the latter being similar to *P. curtipes*).

Superficially *P. divergens* also resembles *P. depressum.* However they can be immediately separated by the "ortho" tablature of the latter, larger posterior horns, and left-handed girdle displacement.

Stations: 24, 29, 33–35, 40–43, 48, 51, 52, 54, 58, 59, 62, 63, 65, 88–92, 101, 103, 105, 113, 130, 144, 147, 162.

This was a fairly common species of *Peridinium* in the material, but it was largely confined to the Bay of Bengal and the Andaman Sea. It had a maximum abundance at station 43 near the Irrawaddy delta and it probably prefers neritic conditions. It has been found in all the major oceans. In addition to the Indian Ocean records cited by WOOD (1963a) it has also been recorded by SILVA (1956a, 1960), TAYLOR (1967), SOURNIA (1968b, 1970) and NEL (1968).

Peridinium elegans CLEVE Text Fig. 4 l, m, o, Plate 30, Figs. 308, 309, 311, 312, 314, 315; Plate 46, Fig. 528
SCHILLER 1935:254, f. 252 a–e, (vix f), 253 a–d (vix e, f); KISSELEV 1950:203, f. 345; MARGALEF 1961a, f. 3/5, 6; – 1961b:140, f. 2/6; 3/5, 6; KLEMENT 1964:350, t. 1, f. 3, 5; STEIDINGER et WILLIAMS 1970:56, t. 30, f. 99, 100 a, b; TAYLOR 1973b, f. 6 d.
Vix WOOD 1954:249, f. 141.
Syn.: *P. annulatum* KOFOID et MICHENER 1911:280.
P. fatulipes KOFOID . . . . SCHILLER 1935:256, f. 254 a, b, e, f (non c, d, g, h); WOOD 1963b:36, vix f. 131; YAMAJI 1966:90, t. 43, f. 9 (*P. faltipes,* sic); HALIM 1967:740, t. 9, f. 127; WOOD 1968:101, f. 300 ("ortho"!); non STEIDINGER et WILLIAMS 1970:56, t. 31, f. 102 a, b (= *P. tumidum* OKAMURA).
P. grande auct. non KOFOID . . . . YAMAJI 1966, t. 43, f. 7.

This large (length usually between 150 and 220 µm), slender species is quite distinctive, particularly due to its hollow, elongate, non-acute antapical processes, usually bearing small lateral spinulae resulting from increased development of the surface reticulation. Nevertheless it has been confused on occasions with *P. grande* KOFOID, a species with shorter apical and antapical horns and a relatively more robust appearance, possessing acute antapices drawn out like *P. divergens.* PAVILLARD (1931, p. 65) has discussed some of the difficulties but SCHILLER's (1935) treatment is confused, and several other authors, including WOOD (1954) give the form of the first apical plate as "ortho."

It has been pointed out in the introductory comments to this section that the divergent antapical horns which were the only means of distinguishing *P. fatulipes* from *P. elegans* are solely the result of intercalary band development, a view first put forward by HALIM (1967) and confirmed here by the examination of numerous scanning electron micrographs of individuals corresponding to that taxon. Consequently it may not be formally recognised, being only a life-cycle stage. It corresponds with the forma *divergens* of MATZENAUER (1933). *P. tumidum* OKAMURA is larger with a fuller body and shorter antapical horns. It is kept separate here, possibly being the megacytic stage of *P. grande.*

P. annulatum KOFOID et MICHENER was never officially illustrated. However from original drawings by Josephine MICHENER in the author's possession, plus hindsight in reading their description, it is evident that it is the same as *P. elegans,* the annulations being the reticulation which is variably developed on the antapical (and to a lesser extent, the apical) horns of *P. elegans.* BALECH (pers. comm.) has concurred with this conclusion.

P. truncatum GRAHAM was distinguished primarily on the basis of the narrowness of the second precingular plate (in contrast to SCHILLER's wholly atypical specimen illustrated by him as f. 253 d). As all specimens in the Indian Ocean material examined here had a narrow second precingular plate (not necessarily narrowest distally, but varying slightly) there was the choice of assigning all the specimens to GRAHAM's well-described and elegantly illustrated taxon or to the early taxon of CLEVE's. The latter course seemed the most reasonable.

Recognition of the most appropriate position for *P.* (*divergens*) *granulatum* KARSTEN (1907) is particularly difficult. It is easy to recognise, being very large, the transdiameter approaching or exceeding 200 µm for cells 220 to 240 µm in length (instead of having a transdiameter less than 165 µm as is usual in *P. elegans*), with elongate antapical processes either moderately divergent and straight, or bent distally as in fig. 309 here. A spiny fin may be developed between the bases of the antapical horns, but only occasionally. MATZENAUER (1933) relegated it to a form of *P. elegans*, which it undoubtedly closely resembles. In view of the principle outlined in the introductory remarks to this section this should, perhaps, be raised to specific status. However, temporarily MATZENAUER's taxon has been retained. It should also be noted that it does not apparently correspond with this author's concept of a forma (see comments in the Introductory section on Infraspecific Taxa, p. 15), there being no indication of its form being due to environmental influence.

P. obtusipes MANGIN resembles a very short-horned variant of *P. elegans* (allowing for the evident optical reversal), but it is premature to make a decision concerning it. The specimen allocated to *"fatulipes"* by HALIM (1967) also appears to have had short antapical horns.

Stations: forma *elegans*: 13, 38, 65, 68–70, 94, 99–103, 108, 110, 130, 141, 142, 284, 286, 287, 297, 320, 325.
"forma" *granulatum*: 24, 38, 52, 60, 70, 71, 91, 92, 101, 106, 144, 344.

The species occurred chiefly in the western Bay of Bengal, the Gulf of Aden and at stations to the south of India. The forma *granulatum* occurred in general in more northern Bay of Bengal samples than the forma *elegans*. The most southerly station for the species was an isolated record at st. 130, south of 32 °S. WOOD (1954) considered it to be a tropical inter-oceanic species. Indian Ocean records additional to those of WOOD (1963a) are: KARSTEN (1907); SUKHANOVA (1962b); TRAVERS & TRAVERS (1965), TAYLOR (1967), SOURNIA (1968b) and NEL (1968). The records from the S.W. Indian Ocean suggest that it is carried south-westward by the Agulhas Current.

Peridinium grande KOFOID Text Fig. 4 h; Plate 30, Fig. 310 a, b

SCHILLER 1935:259, f. 255 a–e; WANG 1936:142, f. 15 (non 16); BÖHM 1936:41, f. 18 a 1–4; KISSELEV 1950:204, f. 355; RAMPI 1950b:236, f. 16; WOOD 1954:249, f. 142; SILVA 1955:145, t. 5, f. 8, 9; HALIM 1967:741, t. 6, f. 78–80; WOOD 1968:102, f. 303; STEIDINGER et WILLIAMS 1970:56, t. 31, f. 104.
Non YAMAJI 1966:90, t. 43, f. 7 (= *P. elegans* CLEVE).
Syn.: *P. divergens* auct. non EHRENBERG .... SCHILLER 1935, f. 222 b, c (ex STEIN 1883); KISSELEV 1950, f. 329.
P. tumidum OKAMURA?

This is a large, robust species, distinguishable from *P. elegans*, which rivals it in size, by the relatively rotund body, with shorter antapical processes shaped as acutely-pointed horns. It resembles *P. divergens* in the latter aspect but the horns are relatively longer in *P. grande* and the whole cell is much bigger, the transdiameter of the former not exceeding 100 µm, whereas *P. grande* is over 130 µm and usually near 150 µm in transdiameter. KOFOID gave 195 µm as the maximum transdiameter, but cells as large as this were not seen in the "Anton Bruun" material. All specimens had a "meta" first apical plate, as did those of PAVILLARD (1931), MATZENAUER (1933) and HALIM (1967). Only SCHILLER (1935) appears to have seen "ortho" tablature (as he also did for *P. elegans*, another "meta" species).

P. knipowitschii USSATCHEV is rather similar in shape, but it is only approximately half the size and has very acute and slender antapices (see KISSELEV 1950, p. 203, f. 341).

As pointed out elsewhere *P. tumidum* may represent a megacytic stage of this species but has been kept temporarily separate here.

Stations: 14–16, 21, 23, 25–28, 30–32, 34, 37–39, 47, 51, 53–56, 64, 66–71, 103, 109, 111, 113, 115, 118, 125, 140, 141, 144, 148, 282, 283, 287, 291, 294, 325, 327, 332, 334, 340, 399, 419, 420.

This was very commonly represented over the whole northern Indian Ocean in a manner similar to *P. acutipes*. However unlike the latter it was common in the southern Andaman Sea and the north-eastern parts of the Bay of Bengal, suggesting a greater salinity tolerance. It did not exhibit a southern spread in the N.E. Monsoon, perhaps being less thermotolerant.

It is apparently a strictly tropical, inter-oceanic species. In addition to the Indian Ocean records listed by WOOD (1963a) it has been recorded by SILVA (1956a), SUKHANOVA (1962b), TRAVERS & TRAVERS (1965), SOURNIA (1968b), NEL (1968) and ANGOT (1970).

Peridinium granii OSTENFELD ex PAULSEN Plate 32, Fig. 341

SCHILLER 1935:189, f. 188 g–z (non a–f = *P. petersii*); WAILES 1939:38, f. 112; KISSELEV 1950:182, f. 301, 307, 308; NORDLI 1951a: 52, f. 4; WOOD 1954:238, f. 116 a–c, 117 a–c; YAMAJI 1966:89, t. 43, f. 1 (ex PAULSEN); WOOD 1968:103, f. 304; BALECH 1971a:138, t. 27, f. 514–519.
Vix RAMPI 1950b:233, f. 8, 26; SILVA 1955:136, t. 4, f. 11, 12; TRÉGOUBOFF et ROSE 1957:110, t. 23, f. 10.
Non GRAN et BRAARUD 1935:383, f. 60 (? = *P. mastophorum* BALECH); GAARDER 1954:44, f. 54 a b, f. 55 a–c; f. 56 [= *P. garderae* BALECH et *P. spirale* (GAARDER) BALECH]; TORIUMI 1966a:3, t. 2, f. 4 a, b; HERMOSILLA 1973b:22, t. 6, f. 1–17.
Syn.: *P. breve* auct. non PAULSEN ... SCHILLER 1935, f. 194 e–i; MARGALEF 1957a:45, f. 3 c.

This species has here been assigned to this section because of its resemblance to *P. solidicorne* although it has probably the least developed antapical horns of any member of the group. The shape of the cell is distinctive (PAULSEN 1907, called it "almost cordate"), two outwardly-directed antapical spines representing prolongations of the antapical protuberances. The sulcal-fin profiles may also appear as spines marking the inner edges of the antapical horns. Some authors have shown the species as "para", but most seem to have found a "meta" condition (as here). PAULSEN's original figures are equivocal on this point. The second anterior intercalary is "penta" (five-sided). In BALECH's (1971a) figures the antapical spines project directly backwards, rather than outwards.

NORDLI (1951a) has illustrated a thick-walled, ovoid resting spore within a cell of this species.

P. mite PAVILLARD has been recognised as a distinct species (e.g. by LEBOUR 1925), supposedly having solid as opposed to hollow antapical spines more widely set apart than in *P. granii.* It is highly unlikely that any of the spines in this group are truly solid, virtually all being subulate extentions of the larger antapical horns. However, from the detailed figures of BALECH (1971a) it can be seen that the antapical spines do not arise from horns, as in *P. granii,* and so the species are here kept separate.

P. petersii BALECH is a large, cold-water species which is similar but which has only antapical spines, showing no evidence of a mid-antapical depression with consequent antapical projections of the body and is consequently more similar to *P. mite* than to *P. granii.*

P. garderae BALECH differs principally in having a strongly ascendant (right-handed) girdle displacement.

Stations: 53, 55.

The species was rare, occurring only at two stations in the north-eastern Bay of Bengal. It appears to be thermotolerant, known from cold-temperate to tropical waters in all the major oceans. Records are common from the Indian Ocean (see WOOD 1963 a plus SILVA 1956a, 1960; PRAKASH & SARMA 1964; ANGOT 1965, 1970; TAYLOR 1967 and NEL 1968) and it is possible that some of the records to *P. mite* (excluding that of MATZENAUER 1933 which, according to BALECH 1971a, is *P. mastophorum*) may apply to *P. granii* or vice-versa.

Peridinium inflatum OKAMURA Plate 31, Figs. 328, 330

MATZENAUER 1933:466, f. 48 a–d; MARGALEF 1961b:140, f. 2/5; MARGALEF et DURÁN 1953:29, f. 5 d–h.
Syn.: *P. brochii* forma *inflatum* (OKAMURA) SCHILLER 1935:222, f. 219 a–f; GAARDER 1954:39, f. 47.

This species has usually been considered to be a variant of *P. brochii* and is very similar to it. MATZENAUER (1933) had drawn attention to the small short spines arising from its antapical projections, these arising abruptly rather than as smoothly continuous projections of conical antapical horns. Also, the hypocone is relatively larger than in *P. brochii.*

In the original, very incomplete figures of this species no girdle displacement was indicated. In most of the "Anton Bruun" specimens referred to this taxon there was a slight right-handed displacement and in one specimen tentatively assigned to this taxon (fig. 330) the right-handed displacement was marked, being more than one girdle width. GAARDER's (1954) specimen also showed this anomaly.

As with *P. brochii,* the only specimens seen here were all megacytic and this undoubtedly influences the appearance of the cells. The status of the species is thus very unsatisfactory at present.

Stations: 25, 65, 87, 103.

A few cells were found scattered through the Andaman Sea and the Bay of Bengal. The species has been found in Japanese waters, in the warmer parts of the Atlantic Ocean, and in Pacific coastal waters of Australia, as well as being recorded from the Indian Ocean by MATZENAUER (1933) and DURAIRATNAM (1964).

Peridinium solidicorne MANGIN Plate 32, Figs. 338, 339

SCHILLER 1935:218, f. 215 a–1; BÖHM 1936:39, f. 15 b 1–5; DIWALD 1939:169, f. 8 a–c, 10 a–f; KISSELEV 1950:190, f. 317, 321; RAMPI 1950b:234, f. 25; WOOD 1954:247, f. 135; SILVA 1955:146, t. 5, f. 10, 11; MARGALEF 1957a:47, f. 3 b; MARGALEF, MUÑOZ et HERRERA 1957:6, f. 1 c; BALECH 1971b:25, t. 6, f. 105–111.
Vix WOOD 1968, f. 328 ("ortho").
Syn.: *P. spiniferum* SCHILLER 1935 (non CLAPARÈDE et LACHMANN):218, f. 214 A–E; KISSELEV 1950:190, f. 320; STEIDINGER et WILLIAMS 1970:50, t. 34, f. 114 a, b.
Peridinium sp., MEYER 1966 vix f. 48.

This is a medium-sized (length 70 to 120 μm) species, most readily distinguished by the strong short spines, often finned, protruding from the outer corners of the short antapical horns. Girdle displacement can be slightly right-handed. Although the original figure showed a "meta" first apical plate most other authors have found the plate to be "para" (it was this configuration which contributed to recognition of the section Para-divergentia, now discontinued). In the "Anton Bruun" material many examples of "meta" configurations were found (illustrated) as well as "para", the latter arising from a small shift in the suture on the right side between apical four and its corresponding precingular plate. There is also evidently variability in the shape of the second anterior intercalary plate, both "quadra" and "hexa" configuration having been reported (cf. DIWALD 1939).

MATZENAUER (1933) and SCHILLER (1929) referred to three varieties based on antapical horn plus spine shapes. These were: the var. *mikronyx* SCHILLER in which the spines are slender and more or less straight; the var. *makronyx* SCHILLER with short, conical antapical horns and thick, solid-looking, divergent spines (fig. 339 here), and the var. *bradynyx* MATZENAUER in which the depression between the antapical horns (associated with the sulcus) is deeply hollowed out, the ends of the antapical horns are "squared-off" and the spines are moderately divergent (fig. 338 here). It is not known if there is much point in recognising these taxa. SCHILLER (1935) did not discuss them in his monograph. As this author is in agreement with DIWALD (1939) and PAULSEN (1949) that *P. spiniferum* SCHILLER is a variant of *P. solidicorne*, it can be added that in this variant the antapical horns are sharply conical, the spines blending almost imperceptibly with the horns. The strongly developed puncta are often stronger on the hypotheca than on the epitheca. "Para-hexa" combinations are most common in the latter taxon. It is here proposed as the var. *spiniferum* stat. et comb. nov. [basionym *P. spiniferum* SCHILLER 1935:218, f. 214 A—E].

Specimens corresponding to the latter taxon have been examined with the scanning electron microscope and it has been observed that there are narrow furrows running down the inner side of each antapical horn from the sulcus, partly hollowing the antapical spines.

BALECH (1971b) has carried out a plate dissection of specimens corresponding to the var. *mikronyx.*

Stations: 13, 15, 18, 19, 25—27, 30, 32, 34, 37, 47—49, 51, 52, 59, 62, 65, 67—69, 87, 91, 95, 96, 98, 100, 101, 313, 318, 325—327, 337, 358, 361, 362, 371, 396, 398, 399, 413.

The varieties were not distinguished from each other at the time of the analysis. The species was one of the commonest members of the genus, but in certain seasons only. It was widespread in the Bay of Bengal/Andaman Sea following the N.E. Monsoon and was also present off the west coast of India at this time. However it was not found at any stations on cruises II, III or IV, only re-appearing during the N.E. Monsoon at scattered stations extending as far south as 29 °S on cruise V (only on the 75 °E meridian line). In the western regions it was common at the southern end of the Mozambique Channel during the S.W. Monsoon (S.E. Trades at that locality). This distribution is somewhat similar to *P. acutipes* but is more restricted than it.

In addition to the Indian Ocean records listed by WOOD (1963a; only two) it has been recorded by SILVA (1956a, 1960), TRAVERS & TRAVERS (1965), TAYLOR (1967), SOURNIA (1968b), NEL (1968) and THORRINGTON-SMITH (1969). The species is an inter-oceanic tropical to temperate species. If *P. areolatum* PETERS is conspecific, as considered by SCHILLER (1935), then it also occurs in Antarctic waters.

Peridinium tumidum OKAMURA Text Fig. 4 n; Plate 30, Fig. 316
MATZENAUER 1933:472, f. 60 a, b;
YAMAJI 1966:90, t. 43, f. 8.
Syn.: *P. tesselatum* KARSTEN 1907, t. 50, f. 11 a, b.
P. fatulipes auct. non KOFOID . . . SCHILLER 1935, f. 254 c, d, g, h; STEIDINGER et WILLIAMS 1970:56, t. 31, f. 100 a, b.

SCHILLER (1935) considered this species to be synonymous with *P. fatulipes.* However, as indicated elsewhere in this section, it is more probable that it is a megacytic stage of *P. gracile.* It can be rocognised by the greatly swollen cell body, the "bar" spanning the bases of the antapical horns (produced by the mid-dorsal intercalary band) being strongly evident and sometimes producing a convexity in this region (see MATZENAUER's 1933, figures and those of PAVILLARD 1931, pl. 2, f. 14 B, C). The bar appears to be differentiated from the intercalary band as a distinct structure, judging by various drawings, but it has not been possible to confirm this with the scanning electron microscope. The antapical horns are shorter than in the megacytic stage of *P. elegans.*

It is difficult to know whether *P. tesselatum* KARSTEN or *P. tumidum* OKAMURA has priority, as both appeared in the same year (1907). Previous authors have given priority to OKAMURA.

Stations: 67, 90, 102, 143, 284, 315.

Specimens corresponding to this taxon were found at a few scattered stations in the Northern Indian Ocean and at one southern Indian Ocean station (315) during the S.W. Monsoon. This distribution is compatible with the view that the taxon is a stage of *P. grande*, most of the stations being in proximity to those from which *P. grande* was recorded (co-occurring at one of them).

Specimens have been observed from the western Pacific Ocean, the Mediterranean Sea and the tropical Atlantic Ocean, and in the Indian Ocean by MATZENAUER (1933).

Section *Humili - Piriformia* (JÖRGENSEN) PAULSEN
[Incl. sect. *Humilia* JÖRGENSEN and *Piriformia* JÖRGENSEN]

This represents a synthesis of two earlier sections of JÖRGENSEN by PAULSEN (1949). All members have a "meta" first apical plate, the second anterior intercalary plate being either "quadra" (Humilia) or "penta". "Hexa" conformations of the second anterior intercalary plate have rarely been reported (see *P. dakariense* here, for example). Within one species variability of the anterior intercalary plates may occur (e.g. *P. ovatum* STEIN, as described in LEBOUR 1925, p. 110) and it was chiefly for this reason that PAULSEN combined the sections.

All members exhibit right-handed girdle displacement, sometimes greatly "over-hanging" due to torsion. The posterior margins of the sulcus may or may not be extended by spines. Large posterior spines may also be present, but only in some members.

As little information is available on phenotypic plasticity within members of this section (in particular on the relatives of *P. globulus* STEIN which evidently can exhibit great plasticity in cell shape and in the configuration of certain plates), the taxonomy of these taxa is unsatisfactory.

Here the same attitude has been adopted as in the case of the "Divergens Complex" within the section Divergentia, namely: to recognise small variants at the specific level for later ease in combining data on the taxa at any appropriate level.

Peridinium cerasus PAULSEN Plate 29, Figs. 302, 303

– 1907:12, f. 12 a–g . . . SILVA 1949:350, t. 6, f. 3, 4; WOOD 1954:237, f. 113 a, b; YAMAJI 1966:82, t. 39, f. 7 (ex PAULSEN); HALIM 1967:735, t. 9, f. 122.

Vix LEBOUR 1925:130, t. 27, f. 1 a–e; WAILES 1939:40, f. 119; RAMPI 1950b:232, f. 22; MARGALEF et DURÁN 1953:26, f. 4 f, g; MARGALEF DURÁN et SAIZ 1955:95, f. 5 g. Non DIWALD 1939:163, f. 14 a–c (= *P. subpyriforme*).

Syn.: ? *P. quarnerense* (SCHRÖDER) BROCH auct. nonnul.

This species was one of the earliest spherical species to be distinguished from *P. globulus.* In the original figures and description the most distinctive features were its more strongly developed apical horn and moderately well-developed antapical spines set wider apart than the main sulcal width. The cells were spherical and the girdle was only slightly right-handed, lacking the distortion commonly found in *P. globulus.* The tabulation was first shown as "ortho-quadra." Later PAULSEN (1930) asserted that a "meta" first apical plate was the usual condition. The species is small, the transdiameter usually being in the vicinity of 35 to 40 µm but reaching 61 µm in Antarctic material. The cells found here were between 42 and 56 µm. The illustrated specimen is atypical in having the second anterior intercalary plate "penta" rather than "quadra." BALECH (pers. comm.) has examined Atlantic material of *P. cerasus* and found it to have a "quadra" plate and a tapering apical horn instead of "affixed." Other specimens resembled those of PAULSEN (1930).

P. quarnerense (SCHRÖDER) BROCH is most probably the same species, possessing a usually spherical shape and well-developed antapical spines. The apical horn is not usually shown to be as well-developed as in the "typical" *P. cerasus.* In the majority of extant figures it appears as if the antapical spines are part of the sulcal lists (as in *P. subpyriforme* DANGEARD), not separate, as in *P. cerasus.* It is suspected that the majority of specimens attributed to *P. quarnerense* are either *P. subpyriforme*, a few being *P. cerasus* or small individuals of *P. globulus*, but it is not possible to be sure in most cases because of lack of details in the drawings. In the event of synonymy, *P. cerasus* PAULSEN has priority over *P. quarnerense* (SCHRÖDER) BROCH, at the species level. *P. subpyriforme* DANGEARD is here considered to be distinct in view of the antapical spines being integral parts of the left and right sulcal lists near the posterior flagellar pore rather than being set wide apart more posteriorly. DIWALD (1939) followed SCHILLER (1935), combining *P. quarnerense* with *P. globulus.*

P. bellulum BALECH (1971a) is also very similar to *P. cerasus*, differing mainly in being ovoid in shape. It can be smaller than the latter, some cells being only 30 µm in transdiameter, but there is overlap in the size ranges of the two species.

Stations: 17, 53, 289.

Only a few cells were seen, these being found at stations in the Andaman Sea, the Bay of Bengal and the southwestern Arabian Sea. The species appears to be very thermotolerant, being known from the Weddell Sea in the Antarctic (PETERS 1928) as well as from temperate and tropical waters. WOOD (1963a) lists two previous Indian Ocean records, to which those of SILVA (1956a, 1960) and NEL (1968) should be added.

Peridinium corniculum KOFOID et MICHENER Plate 32, Fig. 342
– 1911:281.

This species is one of many which KOFOID & MICHENER described but did not illustrate. In view of the difficulty experienced by most authors in attempting to visualise the appearance of these species it is not surprising that no further reference to the species has been made, other than SCHILLER's (1935, p. 273) comment that the diagnoses without illustrations are worthless.

The author has been assisted in making the identification by possession of the original pencil drawings of *Peridinium* made by Josephine MICHENER, presumably of the type material. The dates on the drawings (1907, 1908) predate the published descriptions (see also *P. pacificum* here). If possible these originals will be published separately at a later date.

A pair of the figures, marked tentatively as a variant of *P. globulus*, show the dorsal and ventral views of *P. corniculum* as it was later described. What is not evident in the description (as it predated JÖRGENSEN's system of plate nomenclature) is that the species is "meta-penta". It is quite similar to *P. tubum* especially with its rotund body and flaring apical horn. However it is much bigger. The transdiameter ranges from 48 μm (here) to 55 μm (type), the length without apical or antapical horns from 48 μm (here) to 51 μm (type). The apical horn is approximately 10 μm long. Girdle displacement is about one girdle width.

One difference between the present specimen and the type is the well developed right sulcal fin, projecting between the two antapical spines. This was presumably missed by MICHENER.

Stations: 59, 64, 99.
One specimen was found at each of several stations in the western Bay of Bengal. The species was originally described from the eastern tropical Pacific Ocean ("Albatross Expedition"), and does not appear to have been seen until now.

Peridinium dakariense P. DANGEARD Plate 29, Figs. 306 a, b
SCHILLER 1935:181, f. 184 a, b.
Non WOOD 1954:235, f. 109.
Syn.: *P. gibbosum* MATZENAUER 1933:461, f. 41 a, b; SCHILLER 1935:182, f. 181 c, d; BALECH 1971a:92, t. 16, f. 258–268.
P. parvispinum GAARDER 1954:48, f. 61 a, b; BALECH 1959b:22, t. 1, f. 25–35.

The shape of this species is distinctive, the epitheca smoothly hemispherical the hypotheca being indented posteriorly to form two rounded antapical lobes. It is slightly flattened dorso-ventrally. The apical pore is slightly raised and may be directed towards the ventral side, as here. On the inner surfaces of the posterior depression (or nearly at the apices of the posterior lobes) there are two short, acute spines. In the original specimen (only one was seen by DANGEARD) the girdle had virtually no displacement and the spines projected almost straight back. However in the specimens of MATZENAUER (1933), GAARDER (1954), and BALECH (1959b), and particularly here, right-handed girdle displacement is evident. BALECH's drawings do not exhibit the characteristic shape very clearly, perhaps due to lateral tilting.

An unusual feature of this species is its combination of a "meta-hexa" arrangement. This is most similar to the species figured on the same plate, *P. paradoxum* sp. n. (figs. 307 a, b) which also had a similar shape (while being megacytic) but which exhibited strong girdle torsion, and had a large, ventrally placed posterior flagellar pore. The longitudinal striations on some intercalary bands are also unusual in *P. dakariense*, being reminiscent of some fresh water and brackish water species (e.g. *P. achromaticum* here). BALECH (1971a) illustrated a specimen, designated as *P. gibbosum*, which had a "penta" second anterior intercalary plate and relatively little girdle displacement.

It could be argued that *P. dakariense* could be separated from the others (which are almost certainly synonymous) by its lack of girdle displacement and differently-directed, slightly larger antapical spines. This would be possible (in which case the present material would be attributed to *P. gibbosum*), but there seems to be a complete gradation of girdle displacement exhibited by the existing figures, with DANGEARD's specimens at one extreme and the present one and that of BALECH (1959b) at the other.

GAARDER's length data (53–87 μm excluding spines) embraces that reported by others.

Station: 148.
Only one specimen, as illustrated, was observed. The species is known from the tropical and temperate North Atlantic Ocean, and was recorded from the Indian Ocean by MATZENAUER (1933).

Peridinium globulus STEIN Plate 29, Figs. 301 a–d

SCHILLER 1935:182, f. 185 a–c, g, h, k–r, f. 187 a–i (non f. 185 d–f, i, j, f. 186 a–z); DIWALD 1939:159, f. 3e, 4 a–e, 11b, 13 a–c, vix f. 13 d–i; NIE 1939, f. 1; KISSELEV 1950:180, f. 299, f. 306 (non f. 298, f. 300); RAMPI 1950b:232, f. 20, 23 (non 21); WOOD 1954:236, f. 110 a, b; TRÉGOUBOFF et ROSE 1957:110, t. 23, f. 9.

Vix SILVA 1949:350, t. 6, f. 1, 2 ("ortho"); HERRERA, MUÑOZ et MARGALEF 1955, f. 1 C, D; WOOD 1968, f. 302 ("ortho").

Non SILVA 1952b:603, t. 6, f. 9 (= *P. subpyriforme* DANGEARD).

Syn.:. . . *P. ovatum* (POUCHET) SCHÜTT . . . SILVA et PINTO 1948:166, t. 6, f. 5, 6; WOOD 1954:236, f. 112 a–d; BRUNEL 1968:198, t. 61, f. 1–5, t. 62, f. 1–4; WOOD 1968:106, f. 316; BALECH 1971a:112, t. 21, f. 384–386, t. 22, f. 387–391; HASSAN et SAIFULLAH 1972b:160, f. 2.

? *P. majus* DANGEARD 1927b:359, f. 25 c; YAMAJI 1966:82, t. 39, f. 6.

? *P. spheroides* DANGEARD 1927a:5, f. 3 A–D.

The precise delimitation of this species is very difficult. Before 1907 nearly all spherical individuals of *Peridinium* were probably referred to this species but since then many others have been described. Ovoid or lenticular members of *Peridinium* were usually attributed to *P. ovatum* (POUCHET) SCHÜTT. *P. quarnerense* (SCHRÖDER) SCHRÖDER later became separated, largely on the basis of the presence of two antapical spines, the cells usually being shown as spherical. The degree of girdle displacement was illustrated as varying from almost none to considerable right-handedness with overlap of the proximal parts of the girdle in both *P. globulus* and *P. ovatum.* Although most authors illustrated a "meta" (pentagonal) first apical plate there were differences in the shape of the second anterior intercalary plate, the latter being found to vary from "quadra" (four-sided) to "penta" (five sided) by MARSHALL and LEBOUR (in LEBOUR, 1925 including reference to material from India), and the original figure of *P. globulus* showed a "hexa" (six-sided) second anterior intercalary plate.

MATZENAUER (1933) asserted, on the basis of Indian Ocean material, that smaller cells are rounder and larger cells become more ovoid in shape, this removing much of the justification for recognising *P. ovatum* as a distinct species. *P. quarnerense* (SCHRÖDER) BROCH is almost certainly synonymous with *P. cerasus* PAULSEN, the latter having priority at the species level (for further discussion, see under the latter taxon here).

P. majus DANGEARD was created for cells resembling *P. ovatum* but which, according to DANGEARD (1927b), differed by their larger size (transdiameter 120 µm), lack of antapical spines (fins?), lack of supporting spines on the girdle lists, and a "penta" second anterior intercalary plate. He raised them to the species level from an earlier (1927a) treatment at the varietal level. The plate pattern he figured is similar to that seen here on a smaller cell which also possessed girdle-list spines (fig. 301). The status of this species is uncertain at present.

In this muddled state it has been considered best, for the present, to exclude *P. cerasus* from *P. globulus* but to include *P. ovatum. P. simulum* PAULSEN, which is similar to the latter, has been kept separate here (see comments under that species). The specimen illustrated here (fig. 301, had an epitheca like *P. majus,* but did not have the other features associated with that species.

The other specimens found at the stations below varied in shape from spherical to lenticular, but all had strong girdle displacement. It was not determined whether the "quadra" or the "penta" variant was more common. In most, the sulcal lists projected to a greater or lesser extent below the posterior margin, but not more than that shown in fig. 301.

Stations: 13, 15, 17, 25–27, 29, 31, 32, 34, 46, 47, 49–51, 53, 55, 56, 58, 61, 65, 68–71, 85, 88, 90–93, 98, 99, 105, 108–110, 148, 282, 291, 325, 367, 370, 413.

The species was particularly common in the Bay of Bengal where it was one of the few to be common in the north-eastern part. It also occurred in the central and southern Andaman Sea, and was more rare in the Arabian Sea. It was recorded at three stations in the Mozambique Channel region. It was not found at any central Indian Ocean station south of the equator. This pattern suggests that it is stenothermal but fairly halotolerant, perhaps also with a neritic preference. The distribution in the Indian Ocean is very similar to that recorded here for *P. subpyriforme* (very similar to *P. quarnerense*), making one doubtful of their specific separation.

It has been found in the tropical Atlantic Ocean, the Mediterranean Sea, the western Pacific Ocean, and in the Indian Ocean by many authors, a number of whom, however, referred to the "var. *quarnerense*" (e.g. TAYLOR 1967; SOURNIA 1968b, 1970). WOOD's (1963a) lists require augmentation by the records of SILVA (1956a, 1960), NEL (1968), and HASSAN & SAIFULLAH (1972b).

Peridinium latispinum MANGIN Plate 32, Fig. 336; Plate 44, Fig. 519

SCHILLER 1935:193, f. 190 A a–d; NIE 1939, f. 17 A–F; WOOD 1954:240, vix. f. 119; TAYLOR 1973b, f. f a.

Syn.: *P. africanoides* P. DANGEARD 1927b:357, f. 22 c; MATZENAUER 1933:460, f. 39 a, b; BÖHM 1936:41, f. 16 b 1, 2.

? *P. sylvanae* P. DANGEARD 1927a:2, f. 1 A–C; – 1927b:357, f. 22 a, b; SILVA 1958:30, t. 2, f. 11, 12.

This is a medium to large species, 80 to 100 µm in length excluding the antapical spines. Neither MANGIN nor DANGEARD observed the "meta" first apical plate and it was NIE (1939) who first determined the full tabulation of the species. The second anterior intercalary plate is "penta" and is displaced towards the left side. Typically the cells have a pyriform shape, the apex tapering smoothly to form the apical horn. Occasionally, particularly in megacytic cells, the horn may have an abrupt "affixed" appearance. The apical horn is often finned at the plate sutures.

With the scanning electron microscope it has been possible to examine the unusual lists and fins of this species (cf. fig. 519). The most distinctive feature of the species is the more ventral projection of the left antapical spine in comparison with the right. The left sulcal list is much more strongly developed than the right throughout its length, only the posterior part of the right sulcal list becoming appreciably extensive as it extends onto the antapical spine. As BÖHM (1936) first observed, each spine bears three fins, one being an extension of the sulcal list, the other two being laterally directed. The edges of these fins are distinctively serrated in appearance. The accessory list close to the right margin of the posterior flagellar pore is quite large and lies much closer to the left than the right sulcal list.

P. africanoides DANGEARD is undoubtedly the same species. *P. sylvanae* DANGEARD is probably the same, but as originally figured it has a rounder shape with shorter antapical spines, an "affixed"-looking apical horn, and a "hexa" second anterior intercalary plate. Only the latter offers a good reason for separation, but "penta" to "hexa" variation is quite common in this section of *Peridinium.*

Recently BALECH (1971a) has described *P. joergensii* (based on *P. pedunculatum* of JÖRGENSEN). It strongly resembles *P. latispinum* but is somewhat smaller, the cell body not exceeding 74 µm, with a rather angular shape. The spines are long and are not apparently as displaced with regard to each other as in *P. latispinum.*

It is noted elsewhere that the *P. pyrum* BALECH (see fig. 337 here) may well be a small variant of *P. latispinum.*

Stations: 16, 20, 23, 24, 30, 32, 37, 38, 41, 46, 47, 51, 91, 101, 106, 144, 323, 358, 362, 370, 398.

This species exhibited an interestingly idiosyncratic distribution. The great majority of stations were near land, and it was absent from the many central and southern Indian Ocean stations. It was scattered throughout the Andaman Sea, was not as common and more neritic in the Bay of Bengal, occurred at two stations off the south and west coasts of India, and at one (323) further south from India not far from the Chagos Archipelago. It was also present at a cluster of stations at the southern end of the Mozambique Channel.

This distribution is suggestive of a stenothermal tropical species with a strong neritic preference. It was originally described from the tropical Atlantic Ocean. In the western tropical Pacific Ocean BÖHM (1936) found it to be one of the commonest species of *Peridinium.* It has been previously recorded from the Indian Ocean by MATZENAUER (1933) and SILVA (1956a, 1960) under the name of *P. africanoides*, and by TAYLOR (1967).

Peridinium longicollum PAVILLARD Plate 32, Fig. 346.
– 1916, t. 2, f. 3; SILVA 1949:348, t. 5, f. 24.
Non DANGEARD 1927b:358, f. 329 a–c (= *P. tenuissimum* KOFOID).
Syn.: *P. mediterraneum* (KOFOID) BALECH 1964a:184, t. 2, f. 26–35.
  P. steinii mediterraneum KOFOID 1909a:40, t. 2, f. 1–7.
  P. steinii var. *mediterraneum* (KOFOID) SCHILLER 1935:198, f. 193 a, c (non d–f); RAMPI 1950b:233, f. 7; WOOD 1954:241, f. 120 b; TRÉGOUBOFF et ROSE 1957:110, t. 23, f. 11.
  ? *P. pedunculatum* SCHÜTT ... MARGALEF 1964, f. 2 c.

This taxon, recognised at the species level by some, and at an infraspecific level by others, is very similar to *P. steinii* JÖRGENSEN from which it has been separated chiefly by its more rounded body with a longer, more abruptly tapered apical horn, and much longer antapical spines. The cell body plus horn, but excluding spines, attains a length of 60 µm. *P. tenuissimum* KOFOID is similar in size and shape, but has a "para" first apical plate.

In asserting its difference from *P. steinii,* BALECH (1964a) raised *P. steinii mediterraneum* KOFOID to the level of species. However that rank was pre-occupied by PAVILLARD's taxon, considered by BALECH, SCHILLER and others, to be synonymous. Consequently PAVILLARD's name should be used when referring to this taxon at the species level.

This taxon was the first member of *Peridinium* to be subjected to detailed structural study (by KOFOID 1909a).

MARGALEF (1964) has interpreted *P. pedunculatum* SCHÜTT in the same manner as this species. Unfortunately SCHÜTT (1895) gave no tabulation for his species, leading to a varied interpretation by later authors. In his figures the apical horn was more abruptly "affixed" than here.

Station: 113.

A few cells were found at one station near the Maldive Islands, southwest of India. The species has not been recorded as such from the Indian Ocean, but as a variety of *P. steinii* it has been recorded by SOURNIA (1968b). It is known from the Mediterranean Sea, and the coasts of Portugal, Australia and California.

Peridinium orientale MATZENAUER Plate 32, Fig. 347
– 1933:460, f. 368; SCHILLER 1935:271, f. 275.

This species, first described from the Indian Ocean, most closely resembles another very small member of this section, *P. sourniai* nom. nov., from which it can be distinguished by its slightly larger size (length 30–40 µm without spines), much shorter antapical spines, and more roundly pyriform shape. An examination of one of the "Anton Bruun" specimens revealed a "hexa" dorsal intercalary plate, a feature which, if constant, could also serve to distinguish them. The girdle has right-handed displacement.

Station: 153.

Only two specimens could be found in a sample from north of Mauritius. MATZENAUER (1933) observed it in the Red Sea, the southern Bay of Bengal, and the East Indies. It has not apparently been observed by other authors.

Peridinium pacificum KOFOID et MICHENER Plate 32, Fig. 343
– 1911:283.
Syn.: *P. pellucidum* auct. non SCHÜTT . . . MATZENAUER 1933:461, f. 42 a–c; MARGALEF 1951:56, f. 2, g.
? *P. capdevillei* BALECH 1959b:25, t. 2, f. 46–52; – 1971a:150, t. 30, f. 578–588, t. 31, f. 589–593.

This, like *P. corniculum*, is another species not illustrated in the original publication but identified here with the aid of unpublished drawings by Josephine MICHENER. In this case the figure (dated March, 1908) is named so that there can be no doubt as to its association with the published description. The only anomaly noticed is that the antapical horns are approximately one girdle-width in length, instead of 1.5 as in the description. Not evident in the description is the fact that the species has a "meta" first apical plate. From a rough sketch the second anterior intercalary plate appears to be "quadra" but this may be unreliable as there is an obvious error involving the first apical plate in the sketch.

The species is similar to *P. pellucidum* and its numerous, troublesome relatives except that the "meta" first apical plate, combined with the girdle displacement (1–2 girdle-widths, ascending) can be used to easily recognise it. The length, without spines, varies from 40–62 µm and the transdiameter from 50–70 µm. From MATZENAUER's description and figures it is evident that he found *P. pacificum* in the Indian Ocean (SCHILLER 1935 included MATZENAUER's specimens with *P. pellucidum*).

There is also a resemblance to *P. granii* which has, however, more widely placed antapical spines. *P. mediocre* BALECH has less girdle-displacement and no evident left antapical projection of the cell body. *P. patagonicum* BALECH and *P. capdevillei* BALECH are also similar. BALECH (1971a) has shown a displacement of approximately one girdle width for the latter and it is possible that it is synonymous with *P. pacificum*. It has a "quadra" second anterior intercalary plate.

Stations: 56, 85, 142.

It was found at two stations in close proximity to each other in the northern Bay of Bengal and at one station to the south of India. MATZENAUER's records may not all be applicable to this taxon as some may have referred to true *P. pellucidum*. However it is evident that he did find the present taxon at least once in the northern Indian Ocean.

Peridinium paradoxum sp. n. Plate 29, Figs. 307 a, b

This taxon is very distinctive, bearing several unusual features. It could not be attributed to any species known to the author. Its principal distinguishing features are: its unusual shape (very similar to *P. dakariense*), rounded with an indented posterior margin, very strong right-handed girdle displacement with torsion resulting in the ends of the girdle overlapping ("overhang"), a very short sulcus with the posterior flagellar pore (its margins much thickened) displaced towards the ventral side. The plate arrangement is "meta-hexa", another similarity with *P. dakariense.* Very small sulcal fins can give the appearance of two small antapical spinelets if the cells are tilted. A short, tubular apical pore is present.

It is largely the girdle torsion (with accompanying distortion of the epithecal plates) and the position of the posterior flagellar pore, which distinguishes this species from *P. dakariense,* its most apparent close relative. However, there are also strong resemblances between this species and the taxon GAARDER called *P. globulus* var. *quarnerense* f. *spirale*, the latter having a similar distorted girdle. GAARDER (1954) mentioned that the second anterior intercalary of the latter could vary from "penta" to "hexa".

Length: 82–94 μm (without spines).
Transdiameter: 76–82 μm.
Type locality: Andaman Sea (station 25).

Stations: 25, 35.
Three cells, all megacytic, were observed in samples from two stations, both in the Andaman Sea.

Peridinium pyrum BALECH Plate 32, Fig. 337
– 1959b:24, t. 2, f. 38–42; – 1971a:93, t. 16, f. 269–276, t. 17, f. 277–283.

This species is very like a small variant of *P. latispinum.* It has much the same pyriform shape and, most significantly, has the same displaced antapical spines, the left spine being much more ventrally placed than the right horn. The antapical spines are smaller, and also tend to be more dissimilar in length, than in *P. latispinum* (bearing in mind that in ventral view the left antapical spine looks shorter in any case, due to its angle to the viewer). The fins are very delicate and were not shown in the original figures, although BALECH figured them in his later, more detailed study (1971a). Like *P. latispinum* they have serrated edges. The length of the cells, excluding the spines, is 37–59 μm, the transdiameter being 31–48 μm. The tabulation is "meta-penta".

P. unipes BALECH (1962a) is fairly similar in size and shape, but it has a relatively longer apical horn and the fin-less antapical spines are apparently not displaced in relation to each other. *P. joergensii* BALECH (1971a) is also similar, but has longer antapical spines, being even more like *P. latispinum.*

Stations: 43, 55, 70, 100, 101.
All of the stations were in the Bay of Bengal, being a little further offshore than those at which *P. latispinum* was found. They co-occurred at station 101.

Previous records of the species are limited to the temperate and subantarctic South Atlantic Ocean. The species appears to be thermotolerant.

Peridinium simulum PAULSEN Plate 29, Fig. 304
– 1930:58, f. 30 A, B; BALECH 1959b:21, t. 1, f. 11–19; HALIM 1960a, t. 2, f. 28; HERMOSILLA 1973b:21, t. 5, f. 1–17.
Syn.: *P. ovatum* auct. non SCHÜTT . . . SILVA 1949:348, t. 5, f. 25, 26.
P. globulus auct. non STEIN . . . KISSELEV 1950, f. 298 *a* (ex BROCH).

This species can be distinguished from *P. globulus,* according to PAULSEN, by its size (diameter 80–94 μm, apico-antapical height 46–67 μm: smallest values from this material) and its more compressed, lenticular shape. It is evidently very closely related and the specimens referred to this species by PAULSEN had all been assigned to *P. globulus* by previous authors. The narrow, strongly-curved sulcus seems to also be a distinctive feature separating it from *P. ovatum* (POUCHET) SCHÜTT, which also lacks girdle distortion, having only moderate right-handed displacement.

P. cepa BALECH is somewhat similar in shape, but lacks the strongly curving sulcus and has long fins/spines associated with the lower part of the sulcus.

As indicated by PAULSEN (1930) *P. majus* DANGEARD is also very similar, differing by its possession of a pentagonal second anterior intercalary plate. It has a larger transdiameter, exceeding 100 μm, and it does not have the distorted "overhanging" girdle of *P. simulum.*

Stations: 367, 369.
It was found at only two stations, both situated at the southern end of the Mozambique Channel. It has not been formally recorded from the Indian Ocean. The specimens referred to this taxon by PAULSEN (1930) were from the Mediterranean Sea, and SILVA's (1949) record under another name was from the coast of Portugal.

Peridinium sourniai nom. n. Plate 32, Fig. 356; Plate 33, Fig. 375?
Syn.: *P. bimucronatum* SCHILLER 1935:266, f. 265 a, b.
P. bispinum SCHILLER 1935:266, f. 266 a, b; BALECH 1971a:108, t. 20, f. 358–364.

This minute species (body length 22–30 μm, transdiameter 20–23 μm) is readily distinguishable by its small size combined with a pyriform body with two medium-length, straight antapical spines. Its tabulation (meta/penta) was determined by BALECH. The "penta" dorsal intercalary plate and the length of the spines serve to distinguish it from *P. orientale* MATZENAUER which has shorter spines, is somewhat larger, and appears to have a "hexa" second anterior intercalary plate (see notes under that species here). Both have right-handed girdle displacement. *P. hirobis* ABÉ is of the same size, but has longer spines and a "hexa" second anterior intercalary plate.

SCHILLER's original descriptions of both the above species are invalid according to the ICBN (Art. 34) because they were only tentatively proposed ("ad interdum"). He suspected that they were both the same taxon. A new name is here proposed for the unified taxon. It is named after Alain SOURNIA in recognition of his contributions to tropical phytoplankton biology, and to the knowledge of Indian Ocean dinoflagellates in particular.

The specimen shown in fig. 375 differs in its shape, being broader in the epitheca, and has very short horns. It seems to be similar to the *Peridinium* sp. in BALECH (1971a, pl. 20, f. 365–367). No plates could be determined on the present specimen.

Stations: 298, 327, 374.

A few cells were found at one station south of India, one north of Mauritius, and one near the African coast at the southern end of the Mozambique Channel. It would not be expected to be efficiently retained by the nets used due to its small size.

The species was originally described from the Adriatic Sea, and BALECH (1971a) found it off the coast of Argentina. It has not apparently been observed previously in the Indian Ocean.

Peridinium steinii JÖRGENSEN Plate 32, Figs. 349 a, b

SCHILLER 1935:196, f. 192 a–h; SILVA 1949:347, t. 5, f. 22, 23; KISSELEV 1950:184, f. 304; RAMPI 1950b:233, t. 7, f. 28; MARGALEF et DURÁN 1953:26, f. 4 j–1; WOOD 1954:240, f. 120 a; MARGALEF 1957a:47, f. 2 f; HALIM 1960a, t. 3, f. 8; BALLANTINE 1961:219, f. 21, 22; WOOD 1968:109, f. 329; MARGALEF 1969a, f. 3 E; HERMOSILLA 1973b:40, t. 19, f. 1–12.
Vix MARGALEF 1957a:47, f. 2 f.

This is a medium-sized, pyriform species superficially resembling members of the section *Protoperidinium*, such as *P. pallidum*, but it is readily distinguished from them by its "meta-penta" configuration, this apparently not being subject to much variation. *P. pyriforme* PAULSEN is fairly similar in body shape, with a "meta-penta" tabulation, but it has much shorter antapical spines. The most similar taxon is *P. longicollum* PAVILLARD (see comments under that species here). The latter is considered to be a distinct species chiefly because of its much longer antapical spines, its body being generally rounder with a more abrupt and longer apical horn than *P. steinii.*

The dimensions of this species are usually given as: length (without spines) 47–58 μm, transdiameter 21–39 μm (MARGALEF & DURÁN 1953). However, gross cell enlargement accompanies infection by a parasitic dinoflagellate, *Amoebophrya ceratii* (fig. 349 b). The infected cell was 80 μm in length (excluding spines) and 58 μm in transdiameter. Such gigantism accompanying infection, with no dislocation of the plates, was reported earlier for cells of *Gonyaulax catenella* by TAYLOR (1968).

Station: 67.

Only one cell was found in a station in the north-western Bay of Bengal. There have been numerous references to the presence of the species in the Indian Ocean (cf. WOOD 1963a plus SILVA 1956a; DURAIRATNAM 1964; PRAKASH & SARMA 1964; TAYLOR 1967; SOURNIA 1968b, 1970; and NEL 1968), but it is not clear if all these records exclude or include *P. longicollum.* The species has been found in all oceans in temperate as well as tropical waters.

Peridinium subpyriforme P. DANGEARD Plate 29, Figs. 305 a–d, Plate 32, Figs. 348 a, b?

– 1927b:358, f. 21; ABÉ 1936b:40, f. 30–37; SILVA 1949:349, t. 5, f. 31, 32; KISSELEV 1950:212, f. 374.
Syn.: *P. globulus* var. *quarnerense* auct. nonnull. .... SILVA 1952b:603, t. 6, f. 9.

This medium-sized globular species (length 40–67 μm) has been described in detail by ABÉ (1936b), and the specimens observed here are very similar to his description. The species is very similar to *P. quarnerense* (SCHRÖDER) BROCH and was included with it (as *P. globulus* var. *quarnerense* SCHRÖDER) by SCHILLER (1935). The difficulties in recognising *P. quarnerense* are discussed here under *P. cerasus* PAULSEN, the latter also being very similar but distinguished by its well-developed apical horn and antapical spines, the latter not being spines of the main part of the sulcal lists but instead being set further apart, more posteriorly.

P. patens DANGEARD is similar to *P. subpyriforme*, differing only in the possession of a "hexa" second interior intercalary plate instead of a "penta" plate. As this depends on only a very slight difference in the position of sutures, this separation is of doubtful value.

Stations: 14, 16, 46, 54, 55, 57, 59, 60, 64, 66, 69, 71, 91, 94, 96, 103, 105, 144, 147, 148, 287, 301, 325, 329, 358, 365, 366, 370, 374, 415, 419, 420.

The species (probably here including cells conforming to *P. quarnerense*) was fairly common only in the northern and western Indian Ocean. It was found both to the north and south of the Mozambique Channel but not in it at the time of the cruise there (cruise VIII, September, 1964). It is probably a stenothermal species, preferring high tropical temperatures. It has been found in the tropical Atlantic Ocean, Japanese coastal waters, and in the northern Indian Ocean by MATZENAUER (1933). Probably some of the records listed by WOOD (1963a) for *P. quarnerense* also apply to this taxon.

Peridinium tubum SCHILLER Plate 32, Fig. 344
– 1935:272, f. 280 a–c; WOOD 1968:110, f. 334.
Vix STEIDINGER et WILLIAMS 1970:58, t. 34, f. 118.

This small species (transdiameter 15–27 μm) has apparently only been seen three times (it is listed but not figured by HERRERA & MARGALEF 1963, who do, however, give a size for their specimen). The specimen illustrated by STEIDINGER & WILLIAMS (1970) was 31 μm long, which is a little large for this species. Also, although it is difficult to see, it appears that in their specimen the apical horn is wider at its base than at its tip, this being one of the features which distinguishes *P. sinaicum* MATZENAUER from *P. tubum.* Girdle displacement is little or none in *P. tubum.*

Like previous authors this author was unable to make out the thecal plates and consequently the systematic position of this taxon remains uncertain. Because of superficial resemblances to members of the section Humili-piriformia it is here placed in that section although it is quite possible that it is a member of the section *Protoperidinium* (with a six-sided, "para", first apical plate instead of a five-sided "meta" plate).

Station: 417.

Only one specimen, as illustrated, was found, the locality being off the east-African coast, north of the Mozambique Channel. The species was originally found abundantly at 100 m in the Adriatic Sea. In addition to the Mediterranean Sea it is also known from the Straits of Florida. It has not been found previously in the Indian Ocean.

Section *Oceanica* JÖRGENSEN

The members of this section all have an "ortho-quadra" tabulation (rarely "penta" or "hexa"), and have well-developed hollow antapical horns. An apical horn may or may not also be well developed. Girdle displacement, if present, is left-handed.

SCHILLER's (1935) treatment of this section included all the long-horned members with a "meta" first apical plate (e.g. *P. grande, P. elegans*), leading to a very confused situation in which there was no clear distinction between this section and the section *Divergentia.* Here all such species with elongate antapical horns and a "meta-quadra" tabulation (the "Divergens Complex") have been put into the section Divergentia, where they form a more homogenous and logical grouping.

As a result of the above transferral the section *Oceanica* narrows down to just *P. oceanicum* and its closest relatives: *P. claudicans, P. depressum, P. murrayi,* these forming a difficult "species complex" due to considerable morphological variability.

It can be noted in passing that the fossil genus *Deflandrea* EISENACK probably refers to cysts of members of this section (see WALL 1965; WALL & DALE 1966; WALL & DALE 1968a for the cysts of living members of the section).

Peridinium depressum BAILEY Plate 34, Fig. 383; Plate 45, Fig. 526
CANDEIAS 1934:1, f. 1 a, b, 2 a–f, 4; SCHILLER 1935:250, f. 251 a–r; BÖHM 1936:45, f. 17 b 1, 2; DIWALD 1939:179, f. 1 a, b; NIE 1939, f. 8 A–E; WAILES 1939:35, f. 105 A–C; GRAHAM 1942:18, f. 4 A, f. 14–19, 21–28; SILVA et PINTO 1948:164, t. 2, f. 7, 8; MARGALEF 1948b:47, f. 2 a; PAULSEN 1949:59, f. 24 A–C, I–K; BALECH 1949a:390, t. 1, f. 1–11, t. 2, f. 12–40 (sub. *Peridinium* cf. *depressum*); KISSELEV 1950:203, f. 31–33, 340, 344; RAMPI 1950b:236, t. 1, f. 1, 2; MARGALEF et DURÁN 1953:31, f. 7 c–g; WOOD 1954:255, f. 155 a, b; TRÉGOUBOFF et ROSE 1957:111, t. 23, f. 20; SILVA 1958, vix t. 8, f. 1, 2; CURL 1959:305, f. 113; BALLANTINE 1961:222, f. 29–31; MARGALEF 1961a:79, f. 25 e; BRUNEL 1962:196, t. 59, f. 1–4, t. 60, f. 1–11; YAMAJI 1966:89, t. 43, f. 4; WOOD 1968:100, f. 295 a, b; STEIDINGER et WILLIAMS 1970:56, t. 29, f. 96 a, b; HERMOSILLA 1973b:27, t. 10, f. 1–18.

Vix TORIUMI 1966a:3, t. 2, f. 5 a, b; HADA 1967:18, f. 29 A.
Syn.: . . . *P. saltans* MEUNIER . . . PAULSEN 1949:61, f. 24 D–H; non WAILES 1939:35, f. 106 [= *P. paulsenii* PAVILL.? *P. knipowitschii* Ussatschev?].
P. venustum KARSTEN . . . BALLANTINE 1961:222, f. 35–37.
P. obliqueforme SCHILLER 1935:270, f. 273.
P. claudicanoides GRAHAM 1942:24, f. 29 A–H.
? *Peridinium* sp. MEYER 1966:45.
P. oceanicum auct. non VANHOFFEN . . . GRAHAM 1942, f. 34 A–E (f. *spiniferum* GRAHAM), 35 A, B (f. *bisintercalares* GRAHAM), 36 A, B (f. *tricornutum* GRAHAM).

In the early literature there was much confusion between this species and *P. divergens* EHRENBERG, the latter being very similar in size and shape. Tabulation was not shown in either original description. Later it became accepted that *P. depressum* has an "ortho" first apical plate, whereas *P. divergens* has a "meta" first apical plate. Early studies on variability in the species were undertaken by PETERS (1928) and CANDEIAS (1934).

GRAHAM (1942) has also provided a detailed analysis of this species, including study of shape variability, a plate dissection (supplemented by BALECH 1949a) and a historical outline. In his treatment he excluded from the species most members with thick, cuneate antapical horns, forming a new species for them: *P. claudicanoides.* He recognised a multitude of varieties and forms, one of which (his var. *rectius*) corresponds, effectively, to *P. venustum* MATZENAUER, with straight or slightly concave sides to the hypotheca between the girdle and the antapical horns, instead of convex. It also forms an intermediate condition between the slender antapical horned specimens (*P. depressum* sensu stricto) and the broader horns of his other species, thus weakening his arguments for its separate recognition.

It appears that in tropical or warm temperate waters, such as the Indian Ocean or the Mediterranean Sea, the majority of specimens correspond to the broadly cuneate antapical horn types, whereas in the temperate and polar water forms the antapical horns are much more slender. Thus the majority of tropical and warm temperate specimens correspond either to the var. *claudicanoides* (GRAHAM) stat. et comb. n. [basionym: *P. claudicanoides* GRAHAM 1942:24, fig. 29 A–H], with a rapidly tapering hypotheca and broad antapical horns, or the var. *rectius* GRAHAM (= *P. venustum* MATZENAUER), also with broad antapical horns but tapering less gradually below the girdle. One further warm water variant is exemplified by NIE's (1939) figures. In this variant (not given a name here) the broadly cuneate antapical horns are widely set apart, girdle distortion is greatest, and the posterior rim of the fin passing around the antapico-dorsal side of the sulcus is serrated.

All these warm-water varieties have distinctly left-handed girdle displacement and, when seen in full ventral view, the left proximal side of the girdle describes an arc, curving upwards from the sulcus. In temperate and cold-water specimens this feature is much less evident. Indeed, in many figures of such specimens (e.g. LEBOUR 1925; PETERS 1928) no displacement can be seen although this may be partly due to tilting of the specimens.

Additions to the synonymy of the species given by SCHILLER (1935) are *P. saltans* MEUNIER (in view of the observations of PAULSEN 1949 and the earlier opinion of DANGEARD 1927b, who made it a form of *P. depressum*); *P. venustum* KARSTEN, which corresponds to one of GRAHAM's varieties as indicated above (and is much narrower than most members, having a transdiameter of only 50–80 µm instead of up to 173 µm); *P. obliqueforme* SCHILLER, based on an undoubtedly optically-reversed figure of MANGIN's (1928 – some of his figures in this paper were reversed, such as that of *P. obtusipes*); and *P. claudicanoides* GRAHAM as indicated above.

Stations: 44, 45, 90, 103.

Specimens were found in small numbers in samples from the Bay of Bengal, including two near the Ganges River delta. As indicated by GRAHAM (1942) the species seems to be cosmopolitan, being both thermo- and halotolerant. It has been recorded frequently from the Indian Ocean, the records of SILVA (1956a, 1960), PRAKASH & SARMA (1964), ANGOT (1965, 1970), ANGOT & GERARD (1967), DURAIRATNAM (1964), TAYLOR (1967), NEL (1968) and SOURNIA (1968b, 1970) being additional to those listed by WOOD (1963a).

Peridinium murrayi KOFOID   Plate 34, Figs. 379, 380; Plate 45, Figs. 522 a, b, 523
MATZENAUER 1933:464, f. 46 a, b; SCHILLER 1935:259, f. 256 a–e; BÖHM 1936:49, f. 18 b 1, 2; MARGALEF 1948b:47, f. 1 n–p; KISSELEV 1950:204, f. 356; WOOD 1954:256 non f. 156; KLEMENT 1964:350, t. 1, f. 4; WOOD 1968:105, f. 312; LÉGER 1973b:19, f. 8, 9.
Syn.: *P. oceanicum* auct. non VANHÖFFEN, GRAHAM 1942, f. 30 A–D, 32 A–C, 33; WOOD 1954, f. 197a.

This large species most closely resembles *P. oceanicum,* being distinguished from it chiefly by its more elongate apical horn which arises more abruptly from the epitheca than in the latter species. The antapical horns can be more divergent than in *P. oceanicum* although the specimens found here corresponded to the less divergent-horned variants observed by PAVILLARD and MATZENAUER. MATZENAUER (1933) attempted to distinguish three varieties: the var. *murrayi* (not named as such by him) in which the antapical horns diverge by 53–57°, his var. *orientalis* in which they diverge by 34–44°, and the var. *occidentalis* PAVILLARD with horn divergence of 31–32°. It is not clear yet if there is any value in distinguishing these varieties. MATZENAUER's variety is so similar to that of PAVILLARD that they should probably be combined under the latter's name referring to the specimens with slight antapical horn divergence. All the specimens in the "Anton Bruun" material were of the latter type.

WOOD (1968) erroneously states that SCHILLER considered this species as synonymous with *P. oceanicum*. However, one must admit some doubts oneself when seeing how similar BÖHM's (1936) specimens, which he referred to as *P. oceanicum* var. *typicum* BROCH (= var. *oceanicum*), are to broad specimens of *P. murrayi*. One might add the additional criterion that in *P. murrayi* the girdle is clearly at the widest point of the cell, whereas in *P. oceanicum* the sides of the epitheca are as wide or wider. GRAHAM (1942) included the slender varieties of *P. murrayi* in *P. oceanicum* but they are kept with *P. murrayi* here.

Stations: 28, 37, 38, 106, 131, 144, 147, 148, 153, 156, 282, 363, 371, 398.

The species was fairly common, being found at three stations in the Andaman Sea, several in the Arabian Sea, several in the central and southern Indian Ocean (reaching 36 °S at station 131), and three at the southern end of the Mozambique Channel. In view of the great number of species of *Peridinium* found in the Bay of Bengal its apparent absence from that region is rather striking. It has only been recorded three times previously from the Indian Ocean (cf. WOOD 1963a).

Peridinium oceanicum VANHÖFFEN Plate 34, Figs. 381, 382

SCHILLER 1935:260, f. 257 a–f, h, j, k (non g, g 1, g 2, i); BÖHM 1936:49, f. 21 a–d (vix e, f); DIWALD 1939:178, f. 11 d, e; SILVA et PINTO 1948: 169, t. 6, f. 17, 18; KISSELEV 1950:204, f. 346; RAMPI 1950b:236, t. 1, f. 5; BALECH 1951b:306, t. 1, f. 1–8, t. 2, f. 9–32; MARGALEF et DURÁN 1953: 31, f. 7 j, k; WOOD 1954:256, f. 157 b (non a); MARGALEF 1957a:47, f. 3e; MARGALEF, MUÑOZ et HERRERA 1957:6, f. 1 d; HALIM 1960a, t. 2, f. 29; BALLANTINE 1961:222, f. 32. 34 (vix 33); MARGALEF 1961a:79, f. 25 h (vix i, j); KLEMENT 1964:350, t. 1, f. 1, 2; TORIUMI 1966a:3, t. 3, f. 8 a, b; YAMAJI 1966:86, t. 41, f. 14; HALIM 1967:742, t. 7, f. 87; WOOD 1968:105, f. 313; AVARIA 1970, t. 3, f. 5; HERMOSILLA 1973b:26, t. 9, f. 1–15.

Non GRAHAM 1942:24, f. 30–36.

Syn.:. . . *P. oceanicum* var. *oblongum* auct. non AURIVILLIUS, YAMAJI 1966:87, t. 42, f. 1 (partim); HALIM 1967:742, t. 7, f. 88.
P. oblongum auct. non CLEVE . . . STEIDINGER et WILLIAMS 1970:57, t. 32, f. 107 a–d.
Peridinium sp. MEYER 1966, f. 4.

This large species is distinguished from *P. murrayi* chiefly by the presence of a shorter, less-abruptly arising apical horn combined with a larger body. The antapical horns are also relatively shorter. As indicated under *P. murrayi* there are specimens which appear to exhibit intermediate features and their allocation becomes arbitrary. More difficult still is the recognition of *P. oblongum* (AURIVILLIUS) CLEVE as a distinct species from *P. oceanicum*. The majority of authors since SCHILLER have tried to maintain the distinction (e.g. BÖHM 1936; RAMPI 1951b; WOOD 1954; MARGALEF 1961a, etc.), a few (BALECH 1951b; YAMAJI 1966; HALIM 1967) putting them together. The principal attempted distinction appears to be that *P. oblongum* lacks any apical horn and the antapical horns are not as slender as in *P. oceanicum* (it thus having a shape more like *P. claudicans* but being much larger). WALL & DALE (1968a) asserted that *P. oblongum* is smaller than *P. oceanicum* but much of their comments are based on the observations of GRAHAM (1942). The latter's treatment of *P. oceanicum* seems very peculiar to this author as none of the many specimens illustrated correspond with the conventional interpretation of *P. oceanicum*, including specimens similar to the slender variants of *P. murrayi* and others which seem much more similar to *P. depressum* than to *P. oceanicum*. Nevertheless other authors also consider *P. oblongum* to be smaller, with a length less than 170 µm.

None of the "Anton Bruun" specimens accorded with the earlier concepts of *P. oblongum* (e.g. LEBOUR's 1925, plate 1, fig. 1 a reproduced by SCHILLER). Clearly, like several other muddled, difficult-to-handle species complexes, this situation has to be further resolved. References to *P. oblongum* have been excluded from the literature citation above.

BÖHM (1936) added a var. *crassum* to the var. *oceanicum* (= var. *typicum* BROCH), distinguished by its broader than long body, shorter apical horn and minimally divergent antapical horns. None as wide as this were found in the material, the widest cells (e.g. fig. 382) with transdiameters greater than 110 µm, also being long.

Stations: 13, 19, 23, 39, 41, 43, 46, 87, 89, 144, 148, 282, 286, 287, 358, 361, 374, 396, 399, 413, 420.

The species was fairly common, but showed a marked distributional preference for land, only station 148 being far from the coast. This accords with GAARDER's (1954) finding that in the North Atlantic the species was very common "along the coastal banks of south-western Europe and north-west Africa", being only scattered elsewhere. BÖHM (1936) found it to be more common in the northern parts of the western Pacific Ocean than in the vicinity of the East Indies.

Thus the species appears to be a thermotolerant temperate to tropical neritic species. It has been frequently found in the Indian Ocean (see list in WOOD 1963a plus the records of SILVA 1956a, 1960; TAYLOR 1967; NEL 1968; SOURNIA 1968b, 1970; and THORRINGTON-SMITH 1969).

Section *Protoperidinium*

[= Sect. *Pellucidum* JÖRGENSEN]

As this section contains the type species of the subgenus: *P. pellucidum* (BERGH) SCHÜTT, the name of the section has been changed to repeat the subgeneric epithet in accordance with Art. 22 of the ICBN.

Members of this section are characterised by a "para-hexa" plate combination. They are lacking antapical horns, although antapical spines are common, and all have right-handed (ascending) girdle displacement. "Ortho" (first apical) and "penta" and "quadra" (second anterior intercalary) plate configurations have been reported aberrantly in some species.

Peridinium diabolus CLEVE Plate 32, Fig. 354; Plate 45, Fig. 525

SCHILLER 1935:204, f. 198 a–h; SILVA et PINTO 1948:167, t. 6, f. 9; KISSELEV 1950:187, f. 319; RAMPI 1950b:233, f. 12; MARGALEF et DURÁN 1953:26, f. 4 p–u; WOOD 1954:243, f. 125; TRÉGOUBOFF et ROSE 1957:110, t. 23, f. 13; HALIM 1960a, t. 3, f. 3; – 1967:739, t. 8, f. 116, 117; NORRIS 1966, f. 2; STEIDINGER, DAVIS et WILLIAMS 1967, t. 8, f. f; WOOD 1968:100, f. 296.

Syn.: *P. formosum* PAVILLARD 1909:279, f. 2 B.

P. longipes KARSTEN .... RAMPI 1950b:234, f. 13; SILVA 1956a:65, t. 11, f. 8, 9; – 1958:31, t. 3, f. 3; BALECH 1964a:189, t. 3, f. 48–55; YAMAJI 1966:86, t. 41, f. 13; STEIDINGER et WILLIAMS 1970:57, t. 30, f. 97.

Non BALECH 1959b:28, t. 3, f. 86–95 (= *P. acanthophorum* BALECH 1962a).

This is a large, highly distinctive species recognisable, particularly in tropical waters, by its greatly extended antapical spines. The left sulcal list projects posteriorly beyond the body, forming a "scoop-like" structure, almost tubular, being continuous with the accessory list on the right side of the flagellar pore. The cell transdiameter varies from 35 to 75 µm. A large specimen is illustrated here. The antapical spines occur chiefly in warmer waters, whereas shorter, less divergent-horned specimens are found in temperate waters.

It is debatable whether such variants deserve formal recognition and at which rank. There is some confusion in the systematic history of the species (the synonym above is only one of several listed by SCHILLER, although his listing of *P. longicollum* PAVILLARD seems wrong, the species being a legitimate member of the section *Humili-piriformia*). CLEVE (1900c) based his species on an earlier figure by MURRAY & WHITTING (1889, pl. 29, f. 4 b), providing two rather dissimilar original figures. His fig. 20 is similar to that of MURRAY & WHITTING, with long posterior horns (only slightly divergent). This figure can be taken to represent the var. *diabolus*. CLEVE's other figure (f. 19) showed a much shorter-spined form also with a less drawn-out apex. PAVILLARD (1909) named this as a separate species, *P. formosum*, and it is here proposed that it be recognised at the varietal level: *P. diabolus* var. *formosum* (PAVILLARD) stat. et comb. nov. [Basionym: *P. formosum* PAVILLARD 1909:279, f. 2 B].

P. longipes KARSTEN is similar to the var. *diabolus* but, like most tropical specimens, has a very long, narrow apical horn, a rather angular body, and long, strongly divergent horns. Here this is not considered to be a separate species, but is considered to be an extreme infraspecific variant. It is proposed as *P. diabolus* var. *longipes* (KARSTEN) stat. et comb. nov. [Basionym: *P. longipes* KARSTEN 1907:418, pl. 3, f. 6 a, b].

All the specimens seen here corresponded to the latter variety. In the Mediterranean Sea most specimens resemble the var. *diabolus*. The var. *formosum* is a more temperate form.

Stations: 18, 21, 31, 49, 59, 91, 104, 148, 358, 366, 369, 417–419.

It occurred at scattered stations in the Andaman Sea and Bay of Bengal (usually near the coast), one southern Arabian Sea station, and at several in the Mozambique Channel and to the north of it. It has been recorded from the Indian Ocean by numerous authors (see WOOD 1963a plus SILVA 1956a, SUKHANOVA 1962b, NORRIS 1966, TAYLOR 1967, SOURNIA 1968b, 1970, and NEL 1968). The species is inter-oceanic, its varieties extending from temperate to tropical waters. It seems to have a fairly strong neritic preference.

Peridinium heteracanthum P. DANGEARD Plate 32, Figs. 352, 353 a, b, 357
– 1927a:6, f. 4 A–D; – 1927b:371, f. 38; MATZENAUER 1933:480, f. 72; SCHILLER 1935:206, f. 199 a, b; SILVA 1960:40, t. 23, f. 7–9.

This spherical-bodied species is recognisable by its asymmetrically developed sulcal lists (the left one extends as a curving projection beyond the right one) and "para-hexa" tabulation. Both features distinguish it from the otherwise similar species *P. sphaericum* OKAMURA. The majority of globose species belong predominantly to the section Humilipiriformia, possessing a "meta-penta" or "meta-quadra" tabulation. Unfortunately the plates are often very difficult to see, leading one to rely on the left sulcal list features for routine identification. DANGEARD (1927a) observed no girdle displacement but MATZENAUER (1933) figured right-handed displacement.

The apical horn is very small and in some cases (e.g. fig. 352) almost invisible. Most cells have a transdiameter of 60–65 μm, but occasionally larger (70 μm) and smaller (45 μm) cells may be seen.

Stations: 21, 85, 87, 103, 105, 108, 144, 149, 294, 363, 398, 420.

It was found at one station in the Andaman Sea, two in the northern-most Bay of Bengal, one near Bombay, several stations to the south and west of India, at a western Indian Ocean station off East Africa, and at the southern end of the Mozambique Channel. It is undoubtedly a tropical species, described originally from the tropical Atlantic Ocean. MATZENAUER (1933) and SILVA (1960) have found it previously in the Indian Ocean. This author is not aware of any Pacific Ocean records as yet.

Peridinium inclinatum BALECH Plate 32, Fig. 351
– 1964a:187, t. 2, f. 36–40, t. 3, f. 41–47.
Syn.: *P. sphaericum* OKAMURA non MURRAY et WHITTING . . . . SCHILLER 1935:214, f. 210 a–f; KISSELEV 1950:213, f. 375; SILVA 1960:41, t. 23, f. 10; Vix BALLANTINE 1961:222, f. 23, 25 (non 24); Non WOOD 1968:109, f. 328 (= *P. ovum* SCHILLER).
P. sphaeroidea ABÉ 1927:397, f. 17; MATZENAUER 1933:479, f. 71 a–c (incl. var. *gracilis* MATZENAUER); SILVA 1949:352, t. 6, f. 13, 14; non DANGEARD 1927b:372, f. 39 c, f (= *P. nipponicum* ABÉ?)
P. nipponicum auct. non ABÉ; BÖHM 1936:37, f. 13 c.

A medium-sized (transdiameter 54–66 μm), spherical-shaped species, readily recognisable from other species it resembles (such as *P. ovum* SCHILLER) by the "stepped" appearance of its girdle when seen in ventral view, resulting from an angular down-sloping of the right end of the girdle as it approaches the sulcus, and by the well-developed, divergent antapical spines. The latter can be seen to possess fins.

Stations: 31, 95, 398.

A rare species, occurring only at one station each in the Bay of Bengal, Andaman Sea, and the Mozambique Channel. It has been recorded from the Indian Ocean by MATZENAUER (1933 as *P. sphaeroidea*), SILVA (1960), BALLANTINE (1961), TAYLOR (1967), SOURNIA (1968b), and ANGOT (1970), the latter authors referring to it under OKAMURA's name.

Peridinium nipponicum ABÉ Plate 32, Fig. 359
SCHILLER 1935:207, f. 202 a–d (non e, f); KISSELEV 1950:213, f. 369.
Vix STEIDINGER et WILLIAMS 1970:57, t. 32, f. 106.
Non MATZENAUER 1933:480, f. 73 a, b (= *P. ovum* SCHILLER); BÖHM 1936:37, f. 13 c (= *P. inclinatum* BALECH); HADA 1967:18, f. 28 D (= *P. ovum* SCHILLER).
Syn.: *P. sphaeroidea* auct. non ABÉ; DANGEARD 1927b:372, f. 39 e, f.

This medium to small ovoid species can be distinguished from *P. ovum* SCHILLER, which it greatly resembles, by a difference in antapical spine development. According to its discoverer it possesses four antapical spines of different lengths. Interpreting this in the light of more recent knowledge it might be asserted that there are two fairly long antapical spines with fins (somewhat longer than in *P. ovum*), with well developed spiny fins between. These fins projecting down between the large spines give the impression of two additional short spines. One may be a sulcal list projection and the other part of a lateral fin on the left antapical spine (as it appeared to be here), or both may be parts of the sulcal lists. It is necessary to resolve these questions and to decide if it is reasonable to separate *P. nipponicum* from *P. ovum*.

The specimen illustrated here is unusually narrowly oval for the species, others being more similar to *P. ovum* in shape.

Stations: 32, 64.

It occurred at one station in the Andaman Sea (at which *P. ovum* also occurred) and at one station near the east coast of India. It was originally described from Japanese waters. Subsequent records are suspect (MATZENAUER's 1933, Indian Ocean record being rejected). It has only been recorded from the Indian Ocean by WOOD (1962, in 1963a) and TAYLOR 1967).

Peridinium ovum SCHILLER Plate 32, Fig. 350

SCHILLER 1935:208, f. 205 A–h; DIWALD 1939:167, f. 5 a–c, 11 f, g; RAMPI 1950b:234, t. 2, f. 29; WOOD 1954:244, f. 128 a (vix b); – 1968:106, f. 317; STEIDINGER et WILLIAMS 1970:57, t. 33, f. 108; BALECH 1971a:158, t. 34, f. 658–666.

Syn.: *P. sphaericum* auct. non OKAMURA; WOOD 1954, f. 132 a; BALLANTINE 1961, f. 24; YAMAJI 1966, t. 40, f. 10; WOOD 1968:109, f. 328.
P. nipponicum auct. non ABÉ; MATZENAUER 1933:480, f. 73 a, b; HADA 1967:18, f. 28 D.
P. rectum auct. non KOFOID . . . . SILVA 1949:351, t. 6, f. 5, 6.

This is a medium-sized (length without spines 40–62 μm), ovoid species, most similar to *P. ellipsoides* DANGEARD (1927b = *P. ellipsoideum* DANGEARD 1927a). SCHILLER (1935) considered the two species to be synonymous. As BALECH (1971a) has pointed out, the latter has much shorter antapical spines but in other respects it is very similar.

P. rectum KOFOID and *P. oviforme* DANGEARD are similar in shape but have "meta-penta" tabulation, belonging to the section *Humili-piriformia* (KOFOID originally showed no tabulation for *P. rectum*, the "meta" plate being a later interpretation).

P. nipponicum ABÉ is another "para-hexa" species which is very similar to *P. ovum*. It supposedly differs in the nature of the antapical spines and sulcal lists (see comments here under that taxon).

Stations: 27, 30, 32, 35, 44, 95.

Found only at stations in the Andaman Sea and the Bay of Bengal. The species is a tropical to subtropical interoceanic taxon but has been found previously in the Indian Ocean only by MATZENAUER (1933 – as *P. nipponicum*), BALLANTINE (1961 – as *P. sphaericum*) and TAYLOR (1967).

Peridinium pallidum OSTENFELD Plate 32, Fig. 345

SCHILLER 1935:209, f. 206 a–m; DIWALD 1939:168, f. 17 a–d; WAILES 1939:40, f. 122; GRAHAM 1942:32, f. 42 A–H, 43 A–D; SILVA 1949:351, t. 6, f. 7, 8; KISSELEV 1950:188, f. 314; RAMPI 1950b:234, f. 18; WOOD 1954:244, f. 129 b (vix a); SILVA 1955:141, t. 4, f. 16–18; HALIM 1960a, t. 3, f. 2; BRUNEL 1962:199, t. 64, f. 4; WOOD 1968:106, vix f. 318; MARGALEF 1969a, f. 3 F; STEIDINGER et WILLIAMS 1970:57, t. 33, f. 109.

This species has a pyriform body with "para-hexa" tabulation. It is very similar to *P. pellucidum* (BERGH) SCHÜTT, the only distinctions being that *P. pallidum* is usually flattened dorso-ventrally, the width being approximately two-thirds the transdiameter, whereas *P. pellucidum* is circular in cross-section. Although the size ranges overlap, *P. pallidum* is larger (length without spines 53–107 μm, as opposed to 40–68 μm for *P. pellucidum*). GRAHAM (1942) doubted that such a distinction could be made. He also provided a detailed plate analysis of the species. *P. pallidum* contains numerous chloroplasts, whereas *P. pellucidum* lacks them.

The specimens observed here all exhibited flattening to a greater or lesser extent.

P. schilleri PAULSEN was united with *P. pallidum* (as a variety) by SCHILLER (1935). It is here considered as a separate taxon due to its rotund shape, lacking dorso-ventral flattening, combined with a strongly developed, ventrally projecting accessory lobe of the left sulcal list (see further comments under that taxon.

Stations: 19, 46, 62–66, 87, 99, 100, 102, 133, 134.

It occurred at stations in the Andaman Sea, Bay of Bengal, and at two southern Indian Ocean stations near 30 °S. The species is known from cold-temperate to tropical waters in all oceans. LEBOUR (1925) considered it to be more oceanic in distribution than *P. pellucidum*. Records are rare from the Indian Ocean (see WOOD 1963a plus NEL 1968).

Peridinium schilleri PAULSEN Plate 32, Fig. 340; Plate 46, Figs. 527 a, b

– 1930:56, f. 27.

Non *P. schilleri* BÖHM 1931a:193, f. 9 (= *P. margalefii* SILVA).

Syn.: *P. pallidum* OSTENFELD var. *schilleri* (PAULSEN) SCHILLER 1935:211, f. 207 A–C; RAMPI 1950b:234, f. 19; MARGALEF et DURÁN 1953:27, f. 4 n, o (subsp.); vix STEIDINGER et WILLIAMS 1970:57, t. 33, f. 110.
P. tristylum auct. non STEIN . . . . BALECH 1951b:325, t. 7, f. 115–137; SILVA 1955:141, t. 5, f. 1, 2.

As indicated under *P. pallidum* this species is here considered distinct from the latter because of its rounded body, lacking dorso-ventral flattening (see fig. 527 b) and because of the presence of a much larger, ventrally-projecting, posterior left sulcal list. The areolation observed on the specimens here was relatively coarse. In her material GAARDER (1954) observed one instance of a "meta-hexa" combination.

P. schilleri BÖHM is a completely different species and the name is preoccupied by that of PAULSEN.

Stations: 55, 64, 103, 153, 161.

Found only at a few stations in the northern Bay of Bengal and at one station near Mauritius. The taxon has not been recorded previously from the Indian Ocean (either as a species or as a variety). It is known from the North and South Atlantic Ocean (where GAARDER 1954 found it to have quite a similar distribution to *P. pallidum* in her "Michael Sars" material) and the Mediterranean Sea.

Peridinium tenuissimum KOFOID Plate 32, Fig. 355

MATZENAUER 1933:477, f. 68; SCHILLER 1935:215, f. 211 a–c; WOOD 1954:246, f. 133; – 1968:109, f. 331.
Syn.: ? *P. acanthophorum* BALECH 1962a:34, t. 3, f. 78–83.
P. longipes auct. non KARSTEN; BALECH 1959c:28, t. 3, f. 86–95.

This species resembles a much smaller version of *P. diabulus* CLEVE, but it is not only smaller (length without spines 45–60 µm, transdiameter 25–34 µm) but also has a rounder body, lacking the concave posterior profile of *P. diabolus.* The construction of its spines and its sulcal fins appears to be very similar to the latter.

This author finds *P. acanthophorum* BALECH difficult to separate from *P. tenuissimum.* BALECH did not compare the taxa when he created his species. The main difference in his description is that his specimens were broader than those described here and in earlier works, having a transdiameter of 40–50 µm, thus overlapping in this dimension with *P. diabolus.* This will require further examination in order to clarify the situation.

Stations: 71, 88, 95.

Specimens were found only at three Bay of Bengal stations. However several other authors have recorded the species from the Indian Ocean (see WOOD 1963a plus SOURNIA 1966a, TAYLOR 1967, and NEL 1968). It is a rare, tropical, inter-oceanic species.

Peridinium tristylum STEIN Plate 32, Figs. 348 a, b

SCHILLER 1935:216, f. 212 a–d; WOOD 1968:110, vix f. 332. Non BALECH 1951b:325, t. 7, f. 115–137; SILVA 1955:141, t. 5, f. 1–3; HERMOSILLA 1973b:47, t. 23, f. 10–16.

This is a rare species, evidently closely related to *P. schilleri* PAULSEN with which it was confused by BALECH (1951b, as indicated also by MARGALEF & DURÁN 1953) and SILVA (1955). The original figures of STEIN (1883, pl. 9, f. 15–17) are peculiar in that the cells are shown to be very elongated. A "para-quadra" combination was shown. No one else seems to have seen precisely the same shape and this might perhaps be due to distortion in the original figures. Instead, the few figures which can be affirmed as the same taxon found here all correspond to the var. *ovata* SCHRÖDER, the latter not being nearly as elongate as the original specimens.

It has been possible to examine both *P. schilleri* and *P. tristylum* with the scanning electron microscope (cf. pl. 46, fig. 527 a, b for the former) although cost has prohibited publishing all these figures. *P. tristylum,* in addition to having three much longer posterior spines (the centre one of which is in fact a profile of a greatly extended "scoop-shaped" right sulcal list, the left sulcal list also being posteriorly extended but not as thick in profile), has a different body shape. In *P. schilleri* the epitheca has relatively straight sides with almost no apical horn region whereas the specimens observed here had an apex drawn out into a short apical horn which blends smoothly with the epitheca. More distinctively the hypotheca of *P. schilleri* is much fuller and hemispherical, whereas it narrows rapidly (although still convex), after the girdle in *P. tristylum.* The markings on the surface are more strongly developed in *P. schilleri* than in *P. tristylum.* Both are reticulated and both seem to be "para-hexa" most commonly, and are thus also similar to *P. pallidum* (see discussion under that species here). *P. okamurai* ABÉ is also similar, having a shape resembling STEIN's figures, but it apparently lacks posterior extensions of the sulcal lists.

Stations: 103, 155, 286, 324, 420.

A few cells were found at each of several stations scattered over the Bay of Bengal, Arabian Sea, the central Indian Ocean and close to Mombassa in East Africa.

Earlier records are in doubt because of possible confusion with *P. schilleri.* However it does seem to have been found in the Mediterranean Sea and in the tropical Atlantic Ocean. WOOD (1963a) has listed the few Indian Ocean records ostensibly of this species to which those of TAYLOR (1967) and SILVA (1960) should be added.

Section *Tabulata* JÖRGENSEN

Members of this section all lack antapical spines of any appreciable size and do not have antapical horns, the majority being globose in shape. They have an "ortho" first apical plate, and have three anterior intercalary plates, the latter feature distinguishing them from some similar members of the subgenus *Archaeperidinium*, with only two anterior intercalary plates. The second anterior intercalary plate can be "quadra," "penta" or "hexa." Girdle displacement, if present, is left-handed. The genus *Scrippsiella* resembles members of this section, and some members of the section Conica could almost be assigned here (e.g. *P. achromaticum*) if the antapical lists and spines were a bit more reduced, this indicating the strong arbitrariness still inherent in the system.

Peridinium trochoideum (STEIN) LEMMERMANN Plate 33, Figs. 374 a–d
SCHILLER 1935:137, f. 134 c–e (vix a, b, non f, g); WAILES 1939:34, vix. f. 102; KISSELEV 1950:157, f. 244; SILVA 1952a:36, t. 3, f. 4–6; BIECHELER 1952:71, f. 4 A, B, 41/1–3 (vix f. 4); MARGALEF et DURÁN 1953:26, f. 4, a; YAMAJI 1966:83, t. 40, f. 2; WOOD 1968: 110, f. 333; STEIDINGER et WILLIAMS 1970:58, t. 34, f. 117 a, b; HERMOSILLA 1973b:41, t. 19, f. 13–18.
Syn.: . . . *P. faeroense* PAULSEN 1905:5, f. 5; – 1908:64, f. 85; LEBOUR 1925:113, t. 19, f. 2 a–d.
Scrippsiella faeroense (PAULSEN) BALECH et SOARES 1966:106, f. 11–20.

This is a small, ovoid species (length 15–42 µm). FINE & LOEBLICH (1974) had difficulty in distinguishing a culture attributed to this species from one supposedly representing *Scrippsiella sweenyae*. Although fairly similar in shape *P. trochoideum* does not appear to have the straight epithecal sides of *S. sweenyae* and should differ in cingular plates. DICKENSHEETS & COX (1971) could not distinguish between cultures of *P. trochoideum* and *P. faeroense* (= *S. faeroense*), despite detailed examination, leading to the conclusion that earlier authors (e.g. SCHILLER 1935) were correct in considering them synonymous, and this strongly indicates that *Scrippsiella* is probably the most appropriate location for *P. trochoideum*. Although plate dissections are difficult among these small species it is usually possible to determine if there are more than three girdle plates by examining the dorsal side of the thecae. If girdle-plate sutures are visible on the dorsal side the cells are almost certainly not members of the subgenera *Archaeperidinium* or *Protoperidinium* (see, e.g., fig. 377 b in comparison with 374 b). Thus in *P. trochoideum*, in addition to moderate convexity of the epithecal sides, no girdle sutures are usually visible on the dorsal surface. [For other differences between *S. sweenyae* and *P. trochoideum* see BALECH 1959a.] *P. nudum* MEUNIER is more rounded than *P. trochoideum* but is otherwise very similar to it.

The specimen illustrated here is somewhat different from the usual appearance of the species in that the first apical plate is narrower, the precingular sutures being set quite high.

Station: 20.

A few cells were found near the coast in the eastern Andaman Sea. The species is often found in reduced salinity regions and is very rare away from the coast, HULBURT's (1965) Gulf Stream record being anomalous. It appears to be thermotolerant. It has only been recorded from the Indian Ocean by SUBRAHMANYAN (1958), SUBRAHMANYAN & SARMA (1967, both references as *Glenodinium*) and SILVA (1956a, 1960).

Subgen. *Minusculum* (LEBOUR) BALECH

LEBOUR (1925, p. 137) created a new genus for a species (below) differing from other members of *Peridinium* in the possession of one less precingular plate (six instead of seven). In other respects it resembles the marine species of *Peridinium* (its cingular and sulcal plates have not been examined in detail as yet). *P. adulterum* BALECH (1971a, p. 125) also belongs to this subgenus sharing not only the same number of precingular plates, but also the unusually large size of the sixth precingular plate and also the curvature of the first apical plate. *P. defectum* BALECH is another member, possibly conspecific with *P. minusculum* (see below).

Peridinium minusculum PAVILLARD Plate 32, Fig. 358
SCHILLER 1935:194, f. 190 B a–e; KISSELEV 1950:183, f. 302; MARGALEF et DURÁN 1953:27, f. 5 o.
Syn.: *Glenodinium bipes* PAULSEN 1904:21, f. 3, 4.
Minuscula bipes LEBOUR 1925:138, t. 29, f. 3; WAILES 1939:41, f. 124.
? *Peridinium defectum* BALECH in BALECH et EL-SAYED 1965:118, t. 3, f. 42–50.

This very small species has a very distinctive shape and tabulation. The first apical plate is set towards the left side and is strongly curved. The sixth precingular plate is very large. As indicated above there is no seventh precingular plate. Three anterior intercalary plates are present according to PAVILLARD (1917), who carried out the first detailed plate analysis (SCHILLER did not use his excellent figures), and LEBOUR (1925).

P. defectum is very similar in shape and is also small. It has the unusual first apical plate, the large sixth precingular plate, and lacks a seventh precingular plate. It differs in that it appears to have only two anterior intercalary plates. Also, although, like PAVILLARD, BALECH reported the presence of five postcingular plates, he included in this a plate which PAVILLARD assigned to the ventral area. *P. minusculum* has a length (excluding spines) of 20–35 µm, that of *P. defectum* being given as 30–42 µm.

P. adulterum is also small, but has a very rotund shape.

Stations: 48, 374.

Being very small such cells might not be expected to be retained by the nets used here. Nevertheless several cells were found at a station in the Bay of Bengal close to the Burmese coast, and in the south-west Indian Ocean off the coast of Southern Africa. The species is evidently thermotolerant, occurring in both cold temperate and tropical waters. *P. defectum* BALECH is an Antarctic taxon, found first in the Weddell Sea. *P. minusculum* has been found in the Indian Ocean only by TRAVERS & TRAVERS (1965), TAYLOR (1967) and SOURNIA (1968b), these records antedating WOOD's (1963a) checklist.

Scrippsiella BALECH ex LOEBLICH III

In the introductory comments on the genus given here it was explained that in order to avoid the creation of more than two hundred new combinations for the majority of the marine species of *Peridinium* (transferring them to *Protoperidinium* BERGH) one must recognise this genus not only by the number of girdle plates (five plus "transitional" plate) but also the nature of the cyst (calcitic).

LOEBLICH III (1965) provided Latin diagnoses for the genus and its type species, stating that BALECH used botanical classification and that both were invalid without Latin. Examination of BALECH's paper reveals that the foundation for LOEBLICH's conclusion (unusual in the light of BALECH's habitual use of the zoological conventions) is BALECH's statement: "The general characteristics of this organism place it in the Peridiniaceae" (his italics, p. 199). This use of a botanical family name requires that LOEBLICH III's validation be recognised in formal usage.

WALL & DALE (1968b) and WALL (1971a) have indicated that the cysts of the type species (*S. sweenyae*) have an outer calcareous wall with a "microgranular" texture. The archeopyle is apical.

At the time of writting only three species have been assigned to this subgenus: *S. sweenyae* BALECH, *S. saladense* BALECH and *S. faroense* (PAULSEN) BALECH, the latter being probably synonymous with *Peridinium trochoideum* (DICKENSHEETS & COX 1971) and the latter probably should be placed here.* The existence of girdle sutures visible on the dorsal side of the theca of *P. bangoei* SCHILLER in positions corresponding with those of members of this subgenus, suggests that it has more than three cingular plates and may also belong here. This also applies to the unidentified species below.

Scrippsiella? sp. Plate 33, Figs. 377 a, b

This very small taxon resembled *S. sweenyae* but was much smaller (length 15–16 µm, transdiameter 12 µm) than the figures for the latter given by BALECH (1959a: length 24–32.5 µm, transdiameter 19–24 µm). Also the epitheca was more convex, being shaped more like *P. trochoideum.* The apical horn was small, and there appeared to be a small apiculus at the antapical end. The girdle was slightly left-handed. The tabulation was "ortho-hexa", three anterior intercalary plates being present.

As it may simply be a variant of *S. sweenyae,* and as only two specimens were seen, a new species has not been created.

Stations: 298, 342.

The illustrated specimens were found at a station north of Mauritius and at one further east.

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* Subsequent to forwarding this to the publisher STEIDINGER & BALECH (Phycologia, in press) have transferred *P. trochoideum* to *Scrippsiella,* and have also added *P. subsalsum* OSTENFELD to this genus as a result of the analysis of detailed plate analyses. This in turn raises the possibility that *P. sociale* (HENNEGUY ex LABBÉ) BIECHELER and *P. gregarium* LOMBARD & CAPON, both of which closely resemble *S. subsalsa,* may also be eventually shown to be closer to *Scrippsiella* than *Peridinium.*

Genus *Zygabikodinium* LOEBLICH et LOEBLICH III

Syn.: *Diplopeltopsis* PAVILLARD

As PAVILLARD's generic name is pre-occupied by that of a lichen it has been renamed by LOEBLICH & LOEBLICH (1970a). Although theoretically zoologists can continue to use PAVILLARD's name it has been stressed at several places in this text that this type of confusion can most readily be avoided if dinoflagellate specialists do not accept homonymy in either the plant or animal kingdoms.

LOEBLICH and LOEBLICH III (1970a) have designated *Z. lenticulatum* (MANGIN) LOEBL. et LOEBL. III as the type.

Zygabikodinium lenticulatum (MANGIN) LOEBLICH et LOEBLICH III Plate 28, Figs. 295, 297, 300
– 1970a:541.

Syn.:. . . .*Peridinium lenticulatum* MANGIN 1911:30, f. iii, iv.
Diplopsalis lenticula forma *minor* PAULSEN 1907:9, f. 9 . . . . WOOD 1954:222, f. 87 a, b; STEIDINGER et WILLIAMS 1970:49, t. 18, f. 53.
Diplopeltopsis minor (PAULSEN) PAVILLARD 1913:7; LEBOUR 1922:801, f. 11–15; – 1925:102, t. 15, f. 2 a–e; WAILES 1928, t. 3, f. 17–19, t. 11, f. 11; – 1939:29, f. 84 A–C, 85 B; BALECH 1959b:20, t. 1, f. 10; WALL et DALE 1968a:280, f. 7, t. 4, f. 21, 22; WALL 1971a, t. 2, f. 19, 20; vix CANDEIAS 1938:242, f. 4; HADA 1970:17, f. 15.
Glenodinium lenticulum forma *minor* (PAULSEN) SCHILLER 1935:105, f. 96 a–e; KISSELEV 1950:136, f. 218.
Diplopsalis minor (PAULSEN) SILVA 1955:132, t. 4, f. 1–4; WOOD 1968:54, f. 133.
? *Diplopeltopsis minor* var. *occidentalis* WAILES 1928:7, t. 11, f. 12; – 1939:29, f. 85 A.
Non MARGALEF et MORALES 1960:5, f. 2 d (opt. rev.?).

Although the taxon has been best known under the name *Diplopeltopsis minor*, LOEBLICH & LOEBLICH III (1970a) have correctly indicated that not only the generic name must be changed but also the specific epithet, because that of MANGIN (1911) has priority at that level. SCHILLER (1935) recognised the synonymy but did not give correct priority. The only unfortunate aspect of these changes is the increased possibility of nomenclatural confusion with *Diplopsalis lenticula* BERGH.

This species has a transdiameter ranging from 28–66 μm, the largest specimens being in warmer waters. In colder waters the size is usually between 40 and 55 μm. Its epithecal tablature is rather similar to *Peridiniopsis asymmetrica*, having the same arrangement of one large and one small anterior intercalary plate. However, it can be readily recognised by its seven precingular plates (instead of six), combined with a single antapical plate. The left sulcal list is well developed, being keel-like in shape. The cells are usually lenticular.

BALECH has recognised two other species whose thecal surfaces are more strongly marked with granulations or small bumps. WAILES (1928) has recognised a var. *occidentalis* which has only one anterior intercalary plate, large, and symmetrically positioned.

WALL & DALE (1968a) have found that the resting spores of this species are small, oblate, and split open along the upper margin of the girdle.

Stations: 44, 102.

The species was found only at two stations, both in the Bay of Bengal. These warm-water records are atypical in view of previous distributional data.

In comparison with *Diplopsalis lenticula* and *Peridiniopsis asymmetrica*, this species has a strong preference for colder waters, both in the northern and southern hemispheres. BALECH (1957) reported it from the Antarctic, from near Argentina and off Adélie Land. WOOD (1954 and in 1963a) has also found it in the Antarctic and in the Indian Ocean off the west coast of Australia. The other Indian Ocean records listed by him do not refer to this taxon.

Family Podolampadaceae LINDEMANN [= Podolampaceae]

The outstanding feature of members of this peridinoid family is their lack of a girdle. Nevertheless authors detailing the plates of members of this group recognise both pre- and postcingular series of plates (in the broad sense) based on apparent homologies. BALECH (1963a) has discussed the apparent relationships of this family to others close to it.

Genus *Blepharocysta* EHRENBERG

Syn.: *Lissodinium* MATZENAUER

This genus has been subjected to detailed examination by NIE (1939), GAARDER (1954), BALECH (1963a) and ABÉ (1966).

Blepharocysta okamurai ABÉ Plate 28, Fig. 289
– 1966:144, f. 33–38.
Syn.: *B. splendor-maris* auct. non EHRENBERG: – SCHÜTT 1895 pro parte: t. 20, f. 61/15; OKAMURA 1907:127, t. 5, f. 34 a–d; LINDEMANN 1928:101, f. 88 a, b; RAMPI 1943:148, f. 8, 9; BALECH 1963a pro parte: 16, f. 34, 35, 38–44.

ABÉ separated this species from *B. splendor-maris* EHRENBERG, the type species, by the former's smaller, more oval shape, the approximately median position of the suture between the precingular and postcingular plates and the consequent relative narrowness of the latter in relation to the former. Further, he considered the central member of the posterior-most plates (termed "hypothecals" by him in addition to two antapical plates, other authors terming them all antapicals) to be smallest in *B. okamurai* and *B. paulseni* SCHILLER. The latter species is very similar to *B. okamurai* but may be distinguished from it by its lack of an anterior intercalary plate (unless this was omitted by SCHILLER) and more anterior position of the suture between the precingular and postcingular plates.

Unfortunately under routine analytical conditions these distinctions are sometimes difficult to make, rendering distributional data less valuable and it is possible that some of the specimens included here were of *B. splendor-maris.*

Stations: 58, 66–70, 85, 100, 105, 113, 143.

Rare, occurring at a few central Bay of Bengal stations and at two stations south of India during cruise II (May, July, 1963). This species has not been recorded from the Indian Ocean previously.

Genus *Podolampas* STEIN

Previous authors have generally neglected mention of the synonymy of this genus with *Parrocelia* GOURRET. As both were described in the same year, 1883, it becomes a matter of detailed publication date to determine priority of these and also another major contribution which appeared in 1883, that of POUCHET. From private communications of C.A. KOFOID in the author's possession the month of STEIN's publication can be determined as November, but it has not as yet been possible to determine that of GOURRET's publication. As it was the last part of the journal issued for the year it is likely that it was issued late in the year. Furthermore, GOURRET referred it to the appearance of POUCHET's (1883) article which seems to have been the first of the three to appear. This matter should be resolved, if possible, as it involves the priority of several of GOURRET's taxa. The practice has been to assign priority to POUCHET and then to STEIN.

Relatively recently this genus has been examined in detail by BALECH (1963a) and ABÉ (1966). Both of these authors apparently missed the earlier study by NIE (1942).

Podolampas antarctica BALECH Plate 27, Fig. 283
in BALECH et EL-SAYED 1965:121, t. 4, f. 56–64.

This species is very similar to *P. spinifera* as is evident from a comparison of the figures on plate 27. It has a similar body shape and is the only other species which possesses a small apical spine. It is distinguishable most readily by the presence of three antapical spines rather than one as in *P. spinifera.* The supernumery spines occur on the outer edge of the right antapical list and in the centre between the central list moieties of the left and right antapical spines. The right antapical spine of the illustrated specimen was less developed than that of the type. Also list areolation was less strongly developed. It may later prove necessary to unite the two taxa although their distributions (see below) also indicate a separation.

Station: 306.

In view of the original description of this species from the Weddell Sea, its occurrence at one of the most southerly stations in the material suggests that it may prove a useful indicator species, provided it is not confused with *P. spinifera.* It has not been recorded previously from the Indian Ocean.

Podolampas bipes STEIN Plate 27, Figs. 287, 288; Plate 45, Fig. 524

SCHILLER 1936:474, f. 544 a, b; RAMPI 1941b:146, f. 2, 5; NIE 1942:56, t. 1, f. 1–14; SILVA 1949:363, t. 6, f. 17; MASSUTI et MARGALEF 1950, f. 75; KISSELEV 1950:260, f. 434; TRÉGOUBOFF et ROSE 1957:119, t. 27, f. 16; HALIM 1960a, t. 3, f. 32; BALLANTINE 1961:225, f. 63; BALECH 1963a:9, t. 1, f. 8–14; ABÉ 1966:150, f. 55–68; YAMAJI 1966:107, t. 51, f. 19; STEIDINGER, DAVIS et WILLIAMS 1967, t. 4, f. a; STEIDINGER et WILLIAMS 1970:60, t. 36, f. 125.

Syn.: *Parrocelia ovalis* GOURRET 1883:81, t. 3, f. 48, 48a.

Podolampas reticulata KOFOID 1907b:187, t. 2, f. 11; BALECH 1963a:11, t. 2, f. 15–19; STEIDINGER et WILLIAMS 1970:60, t. 36, f. 126 a, b.

Podolampas bipes forma *reticulata* (KOFOID) SCHILLER 1936:474, f. 545; WOOD 1954:317, f. 251b.

Generally this species exists in two highly distinctive states arising chiefly from differences in the structure of the antapical spines and their associated fins. Some authors have considered them separate species but here, in view of ABÉ's (1966) claim of discovering intermediates, they are included together. They could be considered as formae as SCHILLER has done, but, as formae are here restricted to phenotypic responses to specific local environmental conditions (see the general section) they have been termed varieties.

P. bipes var. *bipes* is recognised by relatively strong antapical spines with accessory lists which have smooth margins. Reticulation is usually absent on the lists or is very faint and restricted to a small distal portion of the lists. The large precingular plates have a basic reticulation on them which is only faintly developed.

P. bipes var. *reticulata* (KOFOID) stat. nov. (basionym = *P. reticulata* KOFOID) is very similar to the var. *bipes* in thecal features although the ground reticulation is more strongly developed on the precingular plates. The antapical spines are usually shorter than the var. *bipes* and the margins of the lists associated with them are irregularly serrated. The lists are usually reticulated over most of their distal portions.

The species is distinctive in its large size, with much broader dimensions than any other species. The precingular plates, in particular, are large and covered with pores sloped to the surface so that they present an echinulate appearance.

Stations: *P. bipes* var. *bipes*: 13, 17, 19, 29, 35, 38, 42, 49, 51, 52, 54, 58, 59, 62, 63, 68, 69, 71, 92, 95, 99–103, 109, 116, 142, 148, 153, 157, 420.

P. bipes var. *reticulata*: 35, 37, 43, 51, 52, 68, 71, 418.

The var. *bipes* was the commonest representative of *Podolampas* in the material. It occurred sporadically at widespread stations north of 33 °S but was absent from the cruise V samples (Jan.–April). The var. *reticulata* was relatively rare, five of its eight recorded stations being the same as those from which the var. *bipes* was recorded, arguing against the taxa being environmentally induced variants. With the exception of station 418 near Mombassa the var. *reticulata* was found only in the Bay of Bengal and Andaman Sea.

The Indian Ocean records provided by WOOD (1963a) require augmentation by those of ZERNOVA (1962), TAYLOR (1967), SOURNIA (1967a, 1968b, 1970), NEL (1968), and ANGOT (1970).

Podolampas elegans SCHÜTT Plate 27, Figs. 280, 281

SCHILLER 1936:475, f. 546; RAMPI 1941b:146, f. 1, 4; KISSELEV 1950, f. 435*б* (sub. *P. palmipes*); GAARDER 1954:55, f. 73 a–e; SILVA 1958:33, t. 3, f. 10; TRÉGOUBOFF et ROSE 1957:119, t. 27, f. 17; CURL 1959:306, f. 125; WOOD 1963b:50, f. 186; BALECH 1963a:6, t. 1, f. 1–7; ABÉ 1966:149, f. 52–54; STEIDINGER et WILLIAMS 1970:60, t. 36, f. 127.

A medium-sized, relatively broad species recognisable form *P. palmipes* by its two equally developed, long antapical spines, widely spaced apart. The inner flanges of the antapical lists are relatively narrow, that associated with the left antapical spine possessing a distinctive lobe situated below the flagellar pore. Both the narrowness of the antapical lists and the shape of the lobe distinguish this species from the specimen in fig. 282 whose identity is unknown.

Stations: 54, 55, 62, 66, 71, 97.

Recorded from a few stations in the central Bay of Bengal during Cruise I. This restricted distribution was unusual as the species has been recorded by several authors not only from the northern Indian Ocean (see WOOD 1963a) but also from the Mozambique Channel region (SOURNIA 1967a, 1968b, 1970) and further south off South Africa by TAYLOR (1967).

In the "Michael Sars" N. Atlantic material GAARDER (1954) found *P. elegans* to be the most common representative of the genus.

Podolampas palmipes STEIN Plate 27, Figs. 278, 279 (286?)

SCHILLER 1936:475, f. 547 a, b; RAMPI 1941b:147, f. 3, 6; MARGALEF 1948b:50, f. 3d; KISSELEV 1950:262, f. 435 *a* (non *б*); SILVA 1952a:40, t. 3, f. 17; GAARDER 1954:57, f. 74 a, b; WOOD 1954:317, f. 252 a, b (253?); TRÉGOUBOFF et ROSE 1957:119, t. 27, f. 19;

VIVES et LOPEZ-BENITO 1957:52, f. 1 n; BALECH 1963a:12, t. 2, f. 20–27; ABÉ 1966:147, f. 45–51; YAMAJI 1966:18, t. 51, f. 18; STEIDINGER et WILLIAMS 1970:60, t. 36, f. 128 a, b.
Vix NIE 1942:57, f. 15, 16.

This medium-sized species is relatively more slender than *P. bipes* and *P. elegans* but more broadly pear-shaped than *P. spinifera.* Because of flattening in these species care must be taken that the cells are seen in full ventral view when making such a discrimination. There are two antapical spines with associated lists, the left spine being markedly longer and more strongly developed than the right spine. Allowance for redevelopment of the spines after fission must be made as this can markedly alter their relative lengths. The specimen in fig. 279 was apparently in a monospinous condition immediately following fission. NIE (1942) is the only author to show both antapical spines as approximately equal in length and for this reason his identification is questioned above. His illustrated specimen was similar to that in fig. 282 here. The figures of WOOD (1954) are optically reversed.

The specimen in fig. 286 has a distinctly disjunct apical horn rather than the smoothly formed epithecal curve of *P. palmipes.* The suggestion of a girdle-like structure, apparently internal, is interesting in view of the assumption that such a region corresponds to an absent girdle, the thecal plates being termed precingulars and postcingulars in all species of *Podolampas* even though a girdle has not been seen in any species. The size and inequality of the antapical spines suggest an affinity with *P. palmipes* but the identification is tentative.

Stations: 28, 30, 35, 59, 62, 64, 71, 102, 103, 105, 327, 405, 412. (Fig. 286; 321).

Like other species of the genus this species occurred at sporadic stations in the central Bay of Bengal. However the other Indian Ocean stations off southern India and in the Mozambique Channel correllate with GAARDER's (1954) observation that the species is more common near land. It has been recorded frequently from the Indian Ocean (WOOD 1963a plus ZERNOVA 1962; SOURNIA 1966a, 1967a, 1968b, 1970; TAYLOR 1967; NEL 1968; and ANGOT 1970).

Podolampas spinifera OKAMURA Plate 27, Figs. 284, 285.
SCHILLER 1936:476, f. 548; RAMPI 1939b:468, f. 17; – 1941b:148, f. 10; MARGALEF 1948b:50, f. 3e; TRÉGOUBOFF et ROSE 1957:119, t. 27, f. 18; WOOD 1963b:50, vix. f. 187; BALECH 1963a:14, t. 2, f. 28–33; ABÉ 1966:145, f. 39–44; YAMAJI 1966:107, t. 51, f. 17; STEIDINGER, DAVIS et WILLIAMS 1967, t. 4, f. b; STEIDINGER et WILLIAMS 1970:60, t. 36, f. 129. (*P. spinifer* auct. nonnull.).

A slender species recognisable from all other members of *Podolampas* by the possession of a single posterior spine and also a small, curved apical spine (otherwise known only from *P. antarctica* BALECH). The posterior fin associated with the spine is apparently tripartite and curved in a scoop-like shape. Its edges may be thickened so that they may appear as secondary, marginal spines. WOOD (1963b) has referred to intergrade forms between this species and *P. palmipes* although he did not provide details. The specimen figured by him lacked an apical spine.

Stations: 32, 33, 54, 58, 94, 98, 99, 104, 116, 326.

This species has a similar general distribution to *P. bipes* (and for that matter, most other species of *Podolampas* which are inter-oceanic, warm-water forms) in that it occurred most commonly at central Bay of Bengal stations and a few stations to the south of India. Although rarely recorded from the Indian Ocean prior to WOOD (1963a), it has subsequently been identified by SOURNIA (1966a, 1967a, 1968b, 1970) from the Madagascar region and TAYLOR (1967) from the South West Indian Ocean.

Podolampas sp. Plate 27, Fig. 282
Vix NIE 1942, f. 15, 16 (sub *P. palmipes* STEIN)

This specimen, as indicated under *P. elegans,* resembles the latter in the characteristics of antapical spines but not in the details of the lists associated with them. Between the two spines the lists are broadly developed and the lobe of that associated with the left antapical spine has a straight margin adjacent to its neighbouring list. The narrow appearance of the cell is a result of its rotation towards the right side. The specimen of NIE referred to above resembled this specimen in antapical list development but NIE's figure was apparently a mid-ventral view.

Station: 51a.

A single specimen was observed at a station near the coast of Burma.

Family Ptychodiscaceae LEMMERMANN

Although LINDEMANN (1928) recognised only the genus *Ptychodiscus* within this family, his grounds for recognising other similarly constructed dinoflagellates in another separate family, the Kolkwitziellaceae (ovoid in shape rather than apico-antapically flattened) seem to be superficial, particularly in view of the considerable shape plasticity known to occur in *Ptychodiscus* (see BOALCH 1969 and below). LOEBLICH III (1970) has transferred one of the group of general involved, *Lophodinium*, to a new family for species bearing multiple cryptic, delicate plates, partly on the assumption that the ridged, non-plated type specimen was a cyst.

Here at least three genera are considered to belong within this familial group, all possessing a flexible, tough outer region not apparently subdivided into plates although it may or may not bear reticular markings and ridges. It is not clear if this structure is the homologue of a theca, of a cyst wall, or of an entirely different structure (perhaps like the "pellicle" referred to by LOEBLICH III 1970). Here it is conceived of as a type of strengthened deposition within the outer layer of the amphiesma. The flagella exit through a single large aperture, this latter feature serving to distinguish members of this family from those of the Gymnodiniales in which the outer regions also are semi-rigid (e.g. *Balechina* – see section on the outer layers of dinoflagellates in the introduction). GAARDER (1954) found that the wall of *Ptychodiscus* could be entirely dissolved by sodium hypochlorite, and this is probably also the case with *Berghiella* although it was not tried. The genera represented in the material are *Berghiella* and *Ptychodiscus. Kolkwitziella* LINDEMANN is also probably a member of this family. *Lophodinium* LINDEMANN is possibly also a member, although the genus is poorly defined.

Genus *Berghiella* KOFOID et MICHENER

To this author's knowledge no one has either observed the type species or assigned any other species to this genus since it was first described by KOFOID & MICHENER (1911). Undoubtedly this lack of records results not only from the rarity but also from the lack of illustrations in the original publication. Elsewhere in the present work (e.g. *Gonyaulax*) taxa from the same work have been recognised as the result of close resemblance between the descriptions of KOFOID & MICHENER and members of the "Anton Bruun" material. The recognition of *Berghiella* here is a similar case.

Because the genus is obscure and the diagnosis is brief and highly relevant it is quoted in full here: "With the form of a spheroidal *Gonyaulax* with very abruptly differentiated low cylindrical apical horn with truncate apex. Girdle with hyaline lists, descending, displaced less than a girdle width, not impressed. Ventral area not delimited posteriorly. Absolutely no trace of subdivision of theca into plates or regions. Type species *B. perplexa*." (KOFOID & MICHENER 1911, p. 301).

By comparison with the specimen here assigned to this genus (fig. 441) one notes two departures from the generic diagnosis. Firstly, the girdle is not displaced; and secondly, it is impressed. They are not considered significant here because of the slightness of displacement in the type species (only 0.33 of a girdle width) and the flexibility of the theca. There are other similarities in the description of the type species. For example, mention is made of a narrow "crease" running forward from the ventral area towards the cell apex. This is also present in the present species.

Berghiella josephinae sp. n. Plate 37, Fig. 441

This is a distinctly formed species possessing a thick, flexible, pellicle-like wall bearing very fine reticulae over its surface. The sub-spherical body possesses a short, truncated apical horn and a well-defined, impressed median girdle, not displaced. The girdle is delimited by thick ridges produced by folding of the wall. In the type specimen the upper limit of the left side of the girdle lacked the ridge for one-third of the distance around the girdle. However it is not known if this is teratological or not. In addition to the very fine reticulae, closely-set linear markings are visible in the vicinity of the girdle. A thin fold or ridge passes from the apex of the ventral area (indenting the epicone) towards the apex of the cell. A small flap-like structure is located near the flagellar aperture (single). Chloroplasts are not obvious in preserved material. Length 70 µm, breadth 70 µm.

The species is named in honour of Josephine Rigden MICHENER, co-author of the genus, and the originator of much of the early careful observation used by C.A. KOFOID in his dinoflagellate studies.

It differs from *B. perplexa* by lacking girdle displacement, by having an impressed girdle (variable?) and by the girdle lists being stout ridges bearing markings instead of being thin, hyaline structures.

Station: 32.

The type locality is a station in the northern Indian Ocean. Only one specimen was observed (normally a new species would not be created for a single species but the distinctiveness of this taxon seems to transcend customary limitations).

Genus *Ptychodiscus* STEIN

BOALCH (1969) has recently reviewed this genus which is one of several which possess a flexible, thick pellicle not apparently divided into component plates. With the light microscope no surface markings are visible in this genus, apart from ridging within the girdle, this being one feature which distinguishes it from *Bergbiella,* a second being the presence of a keel-like carina. From the position of the single large flagellar aperture it can be concluded that the carina is situated on the apical, and not the antapical end. Only one species is known from this genus if the recommendations of BOALCH are accepted, the variety of appearances recorded so far being attributed by him to varying degrees of swelling and shrinkage before, or as a result of, fixation.

Ptychodiscus noctiluca STEIN Plate 37, Figs. 438–440; Plate 40, Fig. 487

SCHILLER 1935:75, f. 60 d, e non a–c; BALECH 1967a:78, t. 1, f. 1–3; BOALCH 1969:781, t. 1, f. A–Q; STEIDINGER et WILLIAMS 1970: 62, t. 39, f. 141.

Syn.: *Diplocystis antarctica* CLEVE 1900a:924, f. a–d.

Ptychodiscus carinatus KOFOID 1907b:168, t. 1, f. 8, 9; PAVILLARD 1916:12; SCHILLER 1935:77, f. 61 a, b.

Ptychodiscus inflatus PAVILLARD .... SCHILLER 1935:77, f. 62 a, b; RAMPI 1950a:6, f. 22; GAARDER 1954:58, f. 75; MARGALEF 1957b:90, f. 2 c; TRÉGOUBOFF et ROSE 1957:108, t. 23, f. 3. ? BALECH 1962b:141, t. 19, f. 277–280.

BOALCH (1969), as indicated above, has included all the known species of *Ptychodiscus* in this one taxon (although excluding MURRAY & WHITTING's, 1899, specimens, which he did not consider as belonging to this genus). The apical/antapical variation exhibited by the species, ranging from great flattening (*P. carinatus* KOFOID) to a swollen appearance (*P. inflatus* PAVILLARD), was attributed by him to fixation and preservation artifacts. The more flattened state is exhibited when the cells are alive.

Numerous small chloroplasts are present. Sometimes these are more ovoid (f. 487), somewhat resembling blue-green algae.

Stations: 13, 21, 30, 37, 301.

Most of the cells were found in the Andaman Sea, the only exception being a station near Mauritius.

The species appears to be relatively eurythermal, tolerating a range from the tropical regions of the three major oceans to cold water such as that off the Faroe Islands or the subantarctic sector of the Pacific.

Family Pyrocystaceae (SCHÜTT) APSTEIN

This family consists of members in which planktonic cyst stage (– s) of the life cycle have become predominant, the motile gymnodinoid or gonyaulacoid swarmers having a highly ephemeral existence. Some are parasitic. Many are dominant members of the tropical plankton. Two genera are at present assigned to the family – *Dissodinium* PASCHER and *Pyrocystis* J. MURRAY ex SCHÜTT. In view of the strong likelihood of diphyletism this family should probably be abandoned.

Genus *Dissodinium* PASCHER

Syn.: *Diplodinium* KLEBS non *Diplodinium* FIORENTINI

This genus consists essentially of gymnodinoid dinoflagellates in which one or two consecutive cyst stages, usually planktonic, are predominant in the life cycle. The most commonly observed cysts are crescentic (lunate) in shape but spherical cysts are known for some species as well. TAYLOR (1972a) recently emended the genus to clarify its distinction from *Pyrocystis* (the latter has strongly thecate motile cells with *Gonyaulax*-like tabulation). Although it was stated that two consecutive cyst stages are present it appears that in some members of the genus direct development of motile cells from a single cyst is possible (e.g. BOUQUAHEUX 1972). The report by SWIFT & REMSEN (1970) of delicate thecal plates in the motile stage of *D. pseudolunula* was due to the presence of a contaminant (SWIFT 1973).

It is possible that other species with crescentic cysts, at present assigned to *Pyrocystis,* may also prove to have gymnodinoid motile cells. At present two species, *D. pseudocalani* (GÖNNERT) DREBES (1969, 1972), and *D. pseudolunula* SWIFT (1973), have parasitic stages confirming VON STOSCH's (1967) earlier suggestion of this likelihood. It is these species that show two successive cyst stages most clearly and it may be necessary later to draw a generic distinction between them and other members of *Dissodinium* (see discussion of the problem by SWIFT 1973 and DREBES 1974).*

SCHILLER, in his monograph (1937), doubted the species distinction of many of the crescentic (lunate) cysts on the basis of size because, if the length of the outer convex surface was measured instead of the greatest linear dimension, the distinctions claimed by the original authors seemed less convincing. However it has been found that the use of the maximum linear dimension, being a function of both the curved length and the degree of curvature, has permitted the same distinctions to be drawn between crescentic cysts as those made by the original authors (notably PAVILLARD 1931, 1935), and consequently they have been retained. As it is potentially confusing care should be taken in distinguishing between curved length and the maximum linear dimension in describing the crescentic cysts. BOUQUAHEUX (1972) has used a multidimensional approach to describe the cysts of *D. elegans.* A further discussion of this problem is given here under the genus *Pyrocystis.*

Dissodinium bicorne (KOFOID et SWEZY) comb. n. Plate 38, Fig. 453

Basionym: *Gymnodinium bicorne* KOFOID et SWEZY 1921:191, f. BB 10, t. 2, f. 14. [Non *Pyrocystis bicornis* BLACKMAN ex MURRAY et WHITTING 1899:338, nomen nudum]
WAILES 1928, t. 1, f. 55 (sub *Gymnodinium lunula* SCHÜTT), t. 2, f. 13, non t. 1, f. 51, vix t. 1, f. 54; – 1939:18, f. 44.

This rarely recorded species has crescentic cysts similar to *D. lunula* but they were described as more curved than *D. lunula* by the original authors. They are within the smallest size range of the latter taxon, ranging from 50 to 100 μm in maximum linear dimension. The crescentic cysts give rise to single, relatively large motile cells resembling *Gyrodinium,* the girdle displacement being about two girdle widths. Although the crescentic cysts are more curved than *D. lunula* and smaller than those of *Pyrocystis robusta* they might be confused with *D. pseudolunula,* the latter having a similar curvature and size. However it gives rise to quite different gymnodinoid motile cells and the cysts have pigmented chloroplasts (see comments under *D. lunula*). The specimen figured by WOLOSZYNSKA (1929, pl. 15, fig. 3) may correspond to this taxon but no size information was given by her. One of SCHÜTT's (1895) miscellaneous crescentic cysts labelled *D. lunula,* his fig. 80.8, may correspond to this taxon but the swarmer is not shown in ventral view. It is possible that *D. bicorne* may prove to be an aberrant form of *D. lunula.* SCHILLER (1937) made them synonymous, but made no mention of the differences noted above.

Stations: 63, 64, 99, 103.

Rare, at a few stations in the Bay of Bengal. Known previously from the Pacific coast of North America, but not recorded from the Indian Ocean.

Dissodinium elegans (PAVILLARD) MATZENAUER Plate 38, Figs. 458, 459
– 1933:441. (454. . . .457?)

Syn.: *Pyrocystis elegans* PAVILLARD 1931:38, t. 1, f. 21 A, B; SCHILLER 1937:493, f. 569; MARGALEF 1948b:45, f. 1 c; MASSUTI et MARGALEF 1950, f. 39; RAMPI 1950c:247, f. 13; SILVA 1956:70, t. 12, f. 6; TRÉGOUBOFF et ROSE 1957:124, t. 28, f. 15; BOUQUAHEUX 1972:4, f. 2 A–F, f. 3, t. 2, f. a–f.

MATZENAUER's combination has been accepted here in view of BOUQUAHEUX's (1972) description of gymnodinoid motile cells (one or two) arising in cysts of this type. The cysts are lunate although she observed strong variability in the smaller cysts. The cysts range in size from 200 to 370 μm (greatest dimension). The largest ones are more curved than *Dis-*

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* G. DREBES and M. ELBRÄCHTER (pers. comm.) favour restriction of *Dissodinium* to include only parasitic species, although it could also be emended to exclude such species. If this distinction is made formally, it will have to include a redesignation of types bearing in mind that the type of *Dissodinium* (*D. lunula*) was based on mixed material (cf. p. 176–177).

sodinium gerbaultii, which they resemble but which are slightly larger again. They can be distinguished from *D. lunula* in that they are usually larger in maximum linear dimension than the primary (spherical) cysts of that species. There appears to be a size cluster near 200 µm and another near 300 µm and the distributional data for these has been separated below. Cysts corresponding to extreme variants observed by BOUQUAHEUX have also been observed here (figs. 454—456), the smallest (length 85 µm) being asymmetrically fusiform.

Stations: (Large form) 24, 34, 50, 53, 62, 102, 108, 153, 288, 292, 294, 320, 329, 334, 340, 417, 418, 420.
(Small form) 14, 33, 36, 37, 57, 60, 62, 68, 69, 91, 100, 102.

The larger form was found scattered throughout the area studied north of 20 °S but the small form was limited to the Bay of Bengal/Andaman Sea region. The species is known from the Mediterranean and warmer Atlantic and Pacific waters and has been recorded from the Indian Ocean by MATZENAUER (1933), SILVA (1956a, 1960) WOOD (1962, cited in 1963a), TRAVERS & TRAVERS (1965), and SOURNIA (1968b). It has not been found further south than Mozambique as yet.

Dissodinium gerbaultii (PAVILLARD) comb. n. Plate 38, Figs. 444, 445
Basionym: *Pyrocystis gerbaultii* PAVILLARD 1935:4, f. 2; SCHILLER 1937:493, f. 570; SOURNIA 1967b:430, f. 5.
Vix YAMAJI 1962:36.

This rare tropical species is known only in its crescentic secondary cyst stage, but SOURNIA (1967b) has observed a pair of apparently gymnodinoid daughter cells within one of the cysts. The latter observation has led to the proposed new combination. The crescentic cysts are the longest of that type which have been described so far, measuring 480 to 550 µm in maximum linear dimension. They are also less curved than the next longest crescentic cysts, those of *D. elegans.* All the secondary cysts of *D. gerbaultii* in the "Anton Bruun" material had small, sharply pointed, apical papillae, a feature not referred to in earlier descriptions.

Stations: 13, 14, 18, 52, 53, 56, 62, 63, 92, 101, 103, 114, 116, 135, 142, 153, 287.
Present in small numbers at scattered stations north of 20 °S. TRAVERS & TRAVERS (1965) and SOURNIA (1967b, 1968b, 1970) have recorded it from the Mozambique Channel region, these being the only records of the species other than the type description from material collected by the yachtsman Alain GERBAULT between the Galapagos and Marquesas Islands during his solo circumnavigation of the world.

Dissodinium lunula (SCHÜTT) PASCHER Plate 38, Figs. 451 (452?)
Syn.: *Gymnodinium lunula* SCHÜTT 1895, t. 25, f. 80.3, 80.4. Non DOGIEL 1906, t. 1, f. 1—25; KOFOID et SWEZY 1921:221, f. I, t. 5, f. 55; LEBOUR 1925:36, t. 4, f. 1 a—g; et auct. nonnull.
Pyrocystis lunula (SCHÜTT) SCHÜTT .... SWIFT et DURBIN 1971, f. 1, 2, 27, 28, vix 31, 32, non 7—9, 26, 29, 30; DREBES 1974:1, f. a—c. Non SCHILLER 1937:488, f. 599/1—11; KISSELEV 1950, f. 35/1—11; et auct. nonnull.

Recently it has been suggested that two species have been confused under the above name due to similarity in the external morphology of their crescentic cysts (both less than 180 µm in length from tip to tip, sharply pointed and not markedly swollen in the central region). SWIFT (1973) has proposed a new species: *D. pseudolunula,* apparently parasitic at some stage during its life-cycle, whose crescentic stage can be distinguished from that of *D. lunula* by the lack of obviously pigmented chloroplasts (pigmentation only developing in the motile cells)*, the cytoplasm retracting rapidly from the cyst apices (not leaving four horn-like extensions of cytoplasm as in *D. lunula*). It may be added that the latter may also be more strongly curved than *D. lunula* if the type figures are restricted as suggested here (see below).

Unfortunately it is now difficult to determine which earlier references apply to which taxon as the above features are often not shown. Some of the figures selected by SWIFT from SCHÜTT's (1895) monograph to act as types for *D. lunula,* largely on the basis of apparently uniflagellate swarmers, are possibly other species (e.g. SCHÜTT's figs. 80.6 and 80.7 are of a strongly curved cyst 294 µm in maximum linear dimension, probably corresponding to *D. elegans,* and his fig. 80.8 may be referrable to *D. bicorne*). His figs. 80.3 and 80.4 seem best suited to act as the iconotypes for this species, being of the right size (length 176 µm) and moderate curvature, possessing chloroplasts.

It appears that most of the early detailed life-cycle studies (by KOFOID & SWEZY 1921, LEBOUR 1925, etc.) and some more recent culture observations have been based on *D. pseudolunula* (e.g. the cyst-wall structural study of SWIFT

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* M. ELBRÄCHTER informs me that a few easily overlooked chloroplasts are present in the primary cyst.

& REMSEN 1970; bioluminescence observations by SWIFT & TAYLOR 1967, and SWIFT & REYNOLDS 1968; and some of the developmental observations of DREBES 1970 and SWIFT & DURBIN (1972). Consequently caution must be used in applying this earlier data and the records of authors such as WAILES (1928, 1939), SILVA (1949, 1968), MASSUTI & MARGALEF (1950), WOOD (1954), MARGALEF, DURÁN & SAIZ (1955), TRÉGOUBOFF & ROSE (1957), YAMAJI (1966), HADA (1967), and SOURNIA (1967b) need evaluation to determine to which species they refer.

SWIFT (1973) has questioned the existence of spherical primary cysts in *D. lunula*, although he allows the possibility in view of observations of such a stage in *D. elegans*. In the "Anton Bruun" material spherical cysts of compatible size were seen (fig. 452). Unfortunately, due to the decolourising effect of formalin it was not possible to determine if these round cysts were pigmented.

Distinctions between *D. lunula* and other species with crescentic stages can be made by external morphological features (see comments under *D. bicorne, D. elegans, Pyrocystis robusta* and *P. obtusa*). The spherical primary cyst of *D. lunula*, if it exists (as postulated here: fig. 452), is much smaller than that of *P. noctiluca*, being less than 200 μm in diameter.

Stations: 62, 63, 70, 72, 87, 95, 99, 101, 102, 298, 333, 340, 348.

Found in small numbers at scattered stations in the central and western Bay of Bengal and in the west central Indian Ocean. There is a possibility of confusion between the primary cyst of this species and the secondary cysts of *P. noctiluca*. For example MATZENAUER (1933) referred to a small globose form with a tight ("straffe") wall under the latter species. This may have been *D. lunula*. Other Indian Ocean records listed by WOOD (1963a), plus SUKHANOVA (1962b), TAYLOR (1967), SOURNIA (1968b, 1970 – tentative) and NEL (1968) are subject to the limitations discussed above.

The type locality of the species is the tropical Atlantic Ocean. SWIFT (1973) believes that *D. lunula* is a warm, oceanic species, not growing below 25 $^{o}/oo$, the numerous cold temperate records referring in fact to *D. pseudolunula*.

Genus *Pyrocystis* J. MURRAY ex SCHÜTT*

The taxonomic difficulties involved in the treatment of this genus, ecologically important in tropical oceanic waters, have been recently discussed by TAYLOR (1972a) and SWIFT & WALL (1972). The presence of thecate cells with a tabulation resembling *Gonyaulax*, sometimes arising in pairs within planktonic secondary cysts of *P. noctiluca* and *P. fusiformis* (the type species), required emendation of the generic diagnosis (TAYLOR 1972a) so as to clearly distinguish it from *Dissodinium* PASCHER and *Gonyaulax* DIESING (see comments here under *Dissodinium*). The former has cysts of very similar morphology to those of *Pyrocystis* but has gymnodinoid motile cells whose thecal plates, if present, are too delicate for observation with the light microscope without special preparation. The recognition of *Pyrocystis* as distinct from *Gonyaulax* in view of the predominance and particular morphology of the cysts in the former is in accord with the recommendations of WALL & DALE (1968b). The latter authors have called for the recognition of cyst types in generic distinctions in order to unify the work on fossil forms (mostly cysts) with that on recent species. Although it is too soon to be certain it appears likely that fusiform cysts are limited to this genus, and lunate (crescentic) cysts to *Dissodinium*. Spherical cysts can occur in both genera.

At present only *P. noctiluca, P. fusiformis* and *P. acuta* have been shown to possess strongly thecate motile cells. In the case of the first- and last-named species the tabulation on the motile cell is that of *Gonyaulax*. In the case of *P. fusiformis* the tabulation observed by KOFOID & MICHENER differed from *Gonyaulax* in having reduced tabulation on the hypotheca and a girdle which is only slightly displaced. V. MEUNIER and E. SWIFT (1976 – Phycologia, in press) have observed *Gonyaulax*–like thecae resembling those of *P. noctiluca* in a culture attributed to *P. fusiformis*. The reason for the discrepancy between their observations and those of KOFOID & MICHENER is not clear.

Some species still included under *Pyrocystis* here produce crescentic cysts very similar to those of *Dissodinium*, e.g. *P. hamulus* and *P. robusta*, and, should they be shown in future to have gymnodinoid motile cells, it will be necessary to transfer them to *Dissodinium*.

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* R. ROSS of the British Museum has kindly assisted the author in unravelling the applications of the Botanical Code to this genus. The first appearance of a generic diagnosis, and hence valid publication of the genus, is in SCHÜTT (1896), being lacking from MURRAY's earlier notes (1876, 1885). As two species were described in the initial publication Art. 42 does not apply. Unfortunately, by recognising the later data as the valid beginning of the genus, it then antedates a genus of echinoderms.

There are other unsatisfactory aspects of the taxonomy of the species which need to be resolved in future. SWIFT & WALL (1972) questioned the inclusion of two cyst stages in the generic emendation as they have obtained an apparently complete life cycle in *P. acuta* which alternated solely between short-lived thecate motile cells and a single, rapidly expanding cyst stage. TAYLOR (1972a – unaware of their observations) referred to the two cyst stages because of the observations of MURRAY (1885) showing globular cysts forming within larger cysts in *P. noctiluca,* and also because of the observation here that most cysts in the field often seem to fall into two size categories. Secondary cysts have not been observed in any of the fusiform taxa. Certainly it is now evident that secondary cysts are not obligate in cultural strains. However MURRAY's observations are yet to be explained. Furthermore, although two successive cyst stages have been well documented in *D. pseudolunula,* BOUQUAHEUX (1972) observed a similar phenomenon in *D. elegans* to that observed by SWIFT & WALL (1972), only one cyst stage alternating with the motile cells although the number of motile cells (one or two) corresponding with slightly different cyst morphologies. Although thecate cells form in *Pyrocystis,* naked aplanospores are more common in culture.

There also seems to be a possibility of several species sharing morphologically similar cysts. This may be one reason for the apparently wide distribution of *P. noctiluca.* Size has been used as an important criterion in the past (see comments here under *Dissodinium* for SCHILLER's criticism) and still seems to corroborate the existence of certain cyst morphotypes within restricted size ranges. However, the cysts of other species, most notably *P. fusiformis,* seem to vary in size through a considerable range. The observation of species in culture should help to resolve these problems.

Distributional aspects of this genus are discussed later in the section on general distribution in the Indian Ocean.

Pyrocystis apiculatus sp. n. Plate 39, Fig. 474

Cysts 370 to 420 µm in length, broadly ellipsoid in shape with an evident apiculus at one pole. Numerous chloroplasts and oil droplets are usually present. Other life cycle stages are unknown.
Iconotype: Plate 39, Fig. 474.
Type locality: Station 418 off the east coast of Africa near Zanzibar.

This species most closely resembles *P. fusiformis* forma *biconica* KOFOID from which it differs by its larger size and the presence of an apiculus. It is likely that several of the early references to the former may actually refer to this species and it may be conspecific with *Pyrocystis ellipsoides* (HAECKEL) LEMMERMANN (see also MATZENAUER 1933, p. 440, f. 4) although this is impossible to determine. The latter taxon, based on *Photocystis ellipsoides* HAECKEL (1890, p. 30 footnote), is so vaguely founded (ellipsoid cells) that it would perhaps be best to consider it a nomen nudum together with *Nectocystis murrayana* HAECKEL. SCHILLER (1937) omitted any mention of them or LEMMERMANN's (1900) combinations.

Stations: 116, 418, 420.

It occurred in small numbers at one station near the Chagos Archipelago in the north central Indian Ocean, and at two stations off the east coast of Africa.

Pyrocystis fusiformis WYVILLE-THOMSON ex BLACKMANN* Plate 39, Figs. 466–468, 471–473.
SCHILLER 1937:486, f. 557 a, b, d, e, non c; RAMPI 1950c:247, f. 12; MASSUTI et MARGALEF 1950, f. 37; MARGALEF et DURÁN 1953:24, f. 2 r–t; WOOD 1954:318, f. 256 a, b; SILVA 1956a:70, t. 12, f. 5; – 1958:34, t. 3, f. 1; TRÉGOUBOFF et ROSE 1957:124, t. 28, f. 14; MARGALEF 1961b:142, f. 3/12; YAMAJI 1962:116, f. 6; – 1966:73, t. 34, f. 5; SOURNIA 1967b:430, f. 4; STEIDINGER et WILLIAMS 1970: 62, t. 39, f. 142 non 144; SWIFT et DURBIN 1971, f. 3, 4, 10–12, 16, 17–21; BOUQUAHEUX 1972:2, t. 1 a–f; TAYLOR 1972a:49, f. 2, 6–9.
Syn.: *P. lanceolata* SCHRÖDER . . . . FORTI 1922:26, t. 1, f. 5; MATZENAUER 1933:441, f. 6; SCHILLER 1937:490, f. 562; RAMPI 1950c: 247, f. 11; YAMAJI 1966:73, t. 34, f. 6.
Non GAARDER 1954:59, f. 76 (= *P. acuta* KOFOID).

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* The first appearance of the species name is in J. MURRAY (1876) in which the latter attributed it to WYVILLE-THOMSON by the letters "Wy.-T.," without further comment. Neither this publication, nor MURRAY's later (1885) figures of the species, makes the species legitimate, as the genus was not validly published until SCHÜTT (1896). Thus, although validly published in 1876 (since the Code's special provisions for microscopic algae allows for a named figure to be sufficient for early publications: Art. 44, Note), the name only became legitimate after 1896. BLACKMANN (1902) was the first to use the name after the generic diagnosis had been provided. LOEBLICH & LOEBLICH's (1970b) attribution of the name to "J. MURRAY in THOMPSON [sic] and MURRAY 1885" is incorrect, and this reference should not have been used in designating *P. fusiformis* as the type of the genus.

The f. *fusiformis* can achieve considerable size. It has been reported to range from below 600 to 1600 µm in length. PAVILLARD (1931) referred to cysts smaller than 600 µm although these were possibly confused with *P. rhomboides*. However SOURNIA's (1967a) specimen, 420 µm in length, seems to be *P. fusiformis* and the figures of KOFOID and MICHENER in TAYLOR (1972a) indicate a cyst-length of 563 µm or less. In fact, in initial development after thecal ecdysis the cysts may be only 150 µm in length (BOUAUAHEUX 1972). In all the specimens observed here one end of the cyst was sharply tipped and the other more rounded. Deformations due to cover-slip pressure or fixation are common and this can produce transverse surface ridges (not cross-walls as MATZENAUER 1933, thought) or shape changes.

In the f. *biconica* KOFOID the cysts are much smaller, usually less than 300 µm in length with both ends rounded. TAYLOR (1972 a) has illustrated thecate cells in this form, but plate details were not determined.* KOFOID and MICHENER (in TAYLOR 1972a) and this author have observed thecate stages arising in cysts 500 to 600 µm in length. The thecate cells of the f. *fusiformis* have a tablature similar to *Gonyaulax* but with fewer plates on the hypotheca. SCHÜTT (1895), OKAMURA (1907) and PAVILLARD (1931) reported that the daughter cells which arise in cysts of the f. *biconica* appear to be non-thecate but these observations were apparently based on immature daughter cells in view of TAYLOR's (1972a) demonstration of a theca in this form. This may also explain BOUQUAHEUX's (1972) omission of a thecate stage in her material.

The forma *detruncata* MATZENAUER appears to warrant recognition as cells very similar to those seen by MATZENAUER (1933) were also found in the "Anton Bruun" material. They are more slender (70—95 µm in diameter) with narrowly rounded ends which are both alike. They vary in length from 730 to 1120 µm. The forma *lanceolata* (SCHRÖDER) stat. et comb. nov. [Basionym — *Pyrocystis lanceolata* SCHRÖDER 1900, p. 13, pl. 1, f. 11] has cysts with acute apices. The terminal portions may or may not be slightly contracted before expanding as moderate terminal inflations with acute apices. BOUQUAHEUX (1972) observed cells of this type in her material of *P. fusiformis*. The length/breadth ratio of this form seems to be surprisingly constant, usually being 10:1. It is the latter form which most closely resembles the related species *P. acuta* KOFOID. In this taxon the cysts are very slender over most of their length and usually slightly curved, often with subapical swellings. The thecate stage is very similar in tabulation to that of *P. fusiformis*, apparently differing in having one less postcingular plate and the presence of a large posterior intercalary plate (see SWIFT & WALL 1972 for a description of the life cycle of the species in culture). There is also a difference in girdle plate 6C.

A new species has been recognised here which resembles the f. *biconica* but which is larger and possesses a distinctive apiculus (*P. apiculata* sp. n.).

Stations: forma *fusiformis*: 13, 15, 49, 50, 53, 60, 65, 66, 69, 70, 85, 89, 98—100, 103, 106, 108, 109, 111, 112, 114, 118, 142, 150, 162, 282, 284, 286—288, 290, 294, 315, 323, 325, 332, 336, 342, 359, 371, 405, 413, 419, 420.
forma *biconica*: 98—101, 113, 116, 294, 295, 323.
forma *detruncata*: 100, 101, 116, 117, 134, 140, 154.
forma *lanceolata*: 327.

The f. *fusiformis* was a common but not abundant taxon in the material, the other forms being less frequent. The lack of records from the Andaman Sea (other than station 15) and from the northern Bay of Bengal stations suggests that it is possibly more stenohaline than *P. noctiluca*. However, recent unpublished observations by this author have recorded the variety from Phuket Island in the south-eastern Andaman Sea in late May. The forma *detruncata* occurred further south than the f. *fusiformis* but the records are too few to characterise the distribution broadly. The f. *biconica* had a similar distribution to the f. *fusiformis* but was less common. The forma *lanceolata* was observed at one station south of India.

The species has been commonly recorded from tropical and subtropical waters. The Indian Ocean records listed by WOOD (1963a) require amplification by those of SILVA (1956a), SUKHANOVA (1962a, b), ZERNOVA (1962), TSURUTA (1963), ZERNOVA & IVANOV (1964), SOURNIA (1966a, 1967a, 1968b, 1970) and TAYLOR (1967, 1972a, 1973b).

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* V. MEUNIER and E. SWIFT (1976 — Phycologia, in press) report that cysts resembling this form occur occasionally in cultures of *P. noctiluca* (containing thecate cells) and this form may simply be a shape distortion of the latter's primary cysts, explaining its size distribution.

Pyrocystis hamulus CLEVE Plate 38, Figs. 446–450
SCHILLER 1937:490, f. 563 a, b, 564, 565; WOOD 1954:320, f. 259 a–c; SILVA 1955:115, t. 1, f. 14; – 1956a:71, t. 15, f. 8; YAMAJI 1962: 36, 116 (2); – 1966:74, t. 34, f. 7, 8; HALIM 1967:750, t. 10, f. 150.

This is a rare, distinctive tropical species. The cysts are narrow along most of their length with a lenticular swelling in the mid-body. The closest species seems to be *P. acuta* KOFOID from which *P. hamulus* differs by its more tapering shape. The species often occurs in pairs, the cysts connected by crossing over near the tips, and several varieties have been recognised on the basis of the curvature of the cysts.

The variety *inaequalis* SCHRÖDER was originally distinguished by the cysts being strongly bent on either side of the central swelling. However the type specimen of the species was of this form, albeit single, and so this should constitute the var. *hamulus* whether it occurs singly or in pairs. One of the arms of a cyst may be curved while the other is straight. In the variety *semicircularis* SCHRÖDER the curvature is rounded so that the pair circumscribe a circular or broadly oval space.

The specimen in fig. 447 exhibited an unusual variation in having the "arms" of the cyst strongly reflexed. As this seems to constitute a major new variant it has been named here the variety *reflexus* var. n. It differs from the var. *hamulus* in having the arms of the cyst initially inclined from the central body in the usual manner but then arcuately reflexed over most of their length. Iconotype: Plate 38, fig. 447. Location: Arabian Sea, St. 13.

Many of the cells of *P. hamulus* have indentations at intervals along the length of the cyst walls. The presence of these is variable and the reason for them not understood. Possibly they are related to the excystment process.

Stations: var. *hamulus*: 13–16, 18, 20, 23, 25, 29, 30, 33, 47, 53, 59, 60, 62–66, 89, 91, 99, 100, 103, 104, 108, 117, 140, 142, 143, 282, 284, 294, 301, 318, 323, 328, 329, 331, 349.
var. *semicircularis*: 99, 107, 131.
var. *reflexus*: 13.

As is evident above, the var. *hamulus* was much more commonly found than the other varieties. At station 100 in the southern Bay of Bengal it was abundant. The presence of the species in both the high (Arabian Sea) and low salinity (Andaman Sea) regions suggests that it is more halotolerant than *P. fusiformis* but it is not as widespread as *P. noctiluca*.

Indian Ocean records: Those listed in WOOD (1963a) plus KARSTEN (1907), SILVA (1956), SUKHANOVA (1962b), TRAVERS & TRAVERS (1965), TSURUTA (1963), SOURNIA (1968b) and NEL (1968).

Pyrocystis noctiluca J. MURRAY ex SCHÜTT* Plate 38, Figs. 461–465
YAMAJI 1962:30, 36, 87, 116, t. 4, f. 10; – 1966:73, t. 34, f. 3; SWIFT et DURBIN 1971, f. 5, 6, 13–15, 22–25.
Syn.: *P. pseudonoctiluca* WYVILLE-THOMSON in J. MURRAY . . . . SCHILLER 1937:485, f. 556 a–c; KISSELEV 1950:266, f. 456 a–c; WOOD 1954:318, f. 255; TRÉGOUBOFF et ROSE 1957:124, t. 28, f. 12 A–C; R.E. NORRIS 1966:127, f. 10; SOURNIA 1967b:431, f. 7; STEIDINGER et WILLIAMS 1970:62, t. 39, f. 143 (144 sub *P. pseudonoctiluca* f. *biconica*, sic); TAYLOR 1972a:48, f. 1, 3–5; 9; – 1973b, f. 4 d; SUKHANOVA et RUDYKOV 1973, f. 1, 2.
Goniodoma concavum GAARDER 1954:27, f. 32.
Gonyaulax concava (GAARDER) BALECH 1967a:108, t. 6, f. 108–116.
Peridinium spec. KARSTEN 1907, t. 54, f. 7.
Vix *Peridinium* sp. MUÑOZ, HERRERA et MARGALEF 1956:76, f. h.

This species exists in at least two globose stages, one of which may form within the other as shown in early figures by MURRAY (1885) and has a motile state which is thecate and corresponds in plate tabulation to the genus *Gonyaulax* (see BALECH 1967a, TAYLOR 1972a and figs. 463, 464 here). The largest globose cysts are from 350 to 800 μm in dia-

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* TAYLOR (1972a) claimed that the name *P. pseudonoctiluca* WY. T. in J. MURRAY (1876) could be used because Art. 68 of the Botanical Code states that a species name is not illegitimate simply because the generic name is illegitimate. This is however, at first sight, at odds with Art. 43 of the Botanical Code: "A name of a taxon below the rank of genus is not validly published unless the name of the genus or species to which it is assigned is validly published at the same time or was validly published previously." R. ROSS (an editor of the Code at the time of writing) has pointed out that Article 68 must be read in conjunction with Art. 6, especially Note 1. In the light of the latter Art. 68 evidently applies to generic names which are validly published but are not legitimate for some other reason, whereas Art. 43 applies when the generic name does not fulfil the requirements for valid publication. It would seem that the Code could be made less liable to misinterpretation by an appropriate admonishment on the use of Art. 68 or, as ROSS has suggested (pers. comm.), by improving the logicality of the order of the Articles of the Code. MURRAY changed the epithet from *pseudonoctiluca* WY. T. (1876) to *noctiluca* MURRAY (1885), and SCHÜTT (1896) unfortunately used the latter name in conjunction with his validation of the genus.

meter, the smaller stage which forms in pairs within the large primary cysts being 150 to 200 μm in diameter. The motile cells (= *Gonyaulax concava*) are approximately 60 to 80 μm in diameter. TAYLOR (1972a) has provided early unpublished figures by KOFOID and MICHENER which depict these stages, and they were also seen unwittingly in Indian Ocean material by KARSTEN (1907). Naked aplanospores occur more frequently in cultures than thecate motile cells. The species is considered to be one of the commonest causes of bioluminescence in tropical oceanic waters.

The large globose cysts can be readily distinguished from those of *Dissodinium lunula* by size, but there is a danger of confusing the smallest cysts of *P. noctiluca* from the largest of the former as the size ranges overlap very slightly.

Stations: 13–17, 20, 21, 23–28, 30, 31, 33–37, 39, 42–44, 47, 49–51, 53–63, 65–71, 87, 89–103, 106, 108–114, 116–118, 125, 129, 130, 133–135, 140–144, 147–150, 153, 282, 284, 286, 291, 292, 294, 295, 297, 299, 302, 313, 314, 317, 318, 320, 321, 323–326, 331, 340, 344, 406.

This was the commonest species in the material. It was abundant at stations 62, 91, 99, and 100, all within the Bay of Bengal. With the exception of the south-western region the species was generally limited to stations north of 30 °S. As the species is so widespread and occasionally abundant in the Indian Ocean its distribution was illustrated and discussed by TAYLOR (1973b), and is referred to again in the latter section on general distributional features (chart 3, p. 193). In addition to being moderately thermotolerant the species must also be relatively halotolerant, causing bioluminiscence in temporary brack-water pools in the south of India (NAIR et al., 1967).

WOOD's (1963a) Indian Ocean records should be amplified by those of SENÔ (1962), SUKHANOVA (1962 a, b), ZERNOVA (1962, 1967), TSURUTA (1963), ZERNOVA & IVANOV (1964), DESROSIÈRES (1965), NAIR et al. (1967), TAYLOR (1967), SOURNIA (1967b, 1970), NEL (1968, as *P. noctiluca*), and THORRINGTON-SMITH (1969).

Pyrocystis rhomboides MATZENAUER Plate 39, Figs. 469, 470
– 1933:441, f. 5; SCHILLER 1937:489, f. 560.

A rarely observed small species resembling *P. fusiformis* f. *biconica* in size and less so in shape. It is distinguished by its regularly rhomboidal shape with relatively straight sides and acute apices. It does not usually exceed 300 μm in size and is consequently much smaller than *P. fusiformis* f. *fusiformis*. These figures are apparently the only ones other than the type figure. A two-celled stage has been seen (here, and also by MATZENAUER) but motile stages are unknown and, although thecae were not seen, the specimens seen here were considered too immature to warrant removal from the genus *Pyrocystis*.

Stations: 37, 53, 60, 62, 66, 87, 94, 100, 140, 150, 153, 286, 319, 322, 326, 334.

Present in small numbers at scattered stations north of 20 °S. It was originally described from the Arabian Sea and has been subsequently recorded from the south-western Indian Ocean (TAYLOR 1967) and the tropical western Pacific (RAMPI 1952d, BALECH 1962).

Pyrocystis robusta KOFOID Plate 38, Fig. 460
SCHILLER 1937:492, f. 568; SILVA 1949:332, t. 4, f. 1; RAMPI 1950c:247, f. 14; MARGALEF et DURÁN 1953:24, f. 2 u (sub *P. obtusa*); WOOD 1954:320, f. 260 a, b; MARGALEF HERRERA, RODRIGUEZ-RODA et LARRAÑETA 1954:90, f. 2 d; MARGALEF 1961b:142, f. 3/13; SOURNIA 1967a:431, f. 8. Vix BALLANTINE 1961:228, f. 64, 65.

A fairly small species producing strongly crescentic cysts. The central part of the cyst is relatively broad and slightly swollen, the apices being sharply pointed (by which means it is distinguished from *P. obtusa* PAVILLARD) and bent over considerably. While the larger cysts (maximum linear dimension 150 to 250 μm) are easily distinguishable the smaller cysts below 100 μm may be confused with *Dissodinium bicorne* (as may be the case in the present text). KOFOID (1907b) recorded specimens as small as 77 μm. No motile stage is known and it may be necessary to assign the taxon later to *Dissodinium*. BALLANTINE (1961) has illustrated lunate cysts formed within a spherical cyst which she tentatively assigned to this species. The diameter of the spherical cysts was much greater (400–500 μm) than the lunate stage of *P. robusta*, being closer to *Dissodinium gerbaultii* in size, but too little morphology of the lunate cysts is shown to make a reasonable judgement on the matter.

Stations: 28, 32, 48, 62, 63, 99, 100, 134, 140, 284, 324, 327, 340.

Present at scattered stations, chiefly neritic in the Andaman Sea and Bay of Bengal but also at mid-Indian Ocean stations. Although not found in the south-west in this material it has been recorded from the Mozambique Channel region by SILVA (1956a), SOURNIA (1967b, 1968b, 1970), and ANGOT (1970) and further south by NEL (1968). WOOD (1963a) has provided the few other Indian Ocean records known.

Family Pyrophacaceae LINDEMANN

This family consists of only one genus.

Genus *Pyrophacus* STEIN (emend. STEIDINGER et DAVIS 1967; emend. WALL et DALE 1971)

As indicated this genus has recently undergone examination and revision by STEIDINGER & DAVIS (1967), STEIDINGER, DAVIS & WILLIAMS (1967) and WALL & DALE (1971). As stressed by the former (and by WANG 1936) this genus is remarkable among the peridinoid genera in the degree of variability in the numbers of plates involved in each series and the formation of various intercalary plates. The latter may be formed in an asymmetrical manner on both the epi- and hypotheca although most particularly on the latter. WALL & DALE (1971) have indicated, however, that the variability falls within quantitatively definable clusters so that at present three taxa (all represented here) may be recognised at the specific level, instead of the genus being considered monotypic. Also noteworthy was the recognition by the latter of the common identity of the unusual cyst of one of the species with the fossil taxon *Tuberculodinium vancampoae* (ROSSIGNOL) WALL. As this is the type of the latter genus *Tuberculodinium* WALL must now be considered a synonym of *Pyrophacus.*

As presently conceived, the total plate variability of *Pyrophacus* can be encompassed by the formula 5–9′, 0–8a, 7–15″, 9–16c, 8–17‴, 0–9p, 3–7⁗ (LOEBLICH III 1970 gives the formula derived from STEIDINGER & DAVIS 1967). The appearance in preserved plankton samples is unusual in that the thecae are only rarely observed with cell contents, at which times the cells are lenticular in shape (see plate 34, f. 384). Most commonly entire, completely flat epi- or hypothecae are found. It seems doubtful that this is a simple response to preservation although its significance is unknown at present. Several authors, such as OKAMURA (1912), SILVA (1949), WOOD (1954) and BALLANTINE (1961) have figured the phenomenon. Coccoid cells have been observed in cultures of *P. vancampoae* but these arose as products of germination from cysts. WALL & DALE (1971) report signs that motile cells may form within them. "Spores" observed by STEIN (1883, pl. 24, figs. 11–13) apparently were division pairs within cysts retained within the parent theca, a similar phenomenon also being illustrated by MARGALEF & DURÁN (1953, fig. 13 i) and STEIDINGER & DAVIS (1967).

WALL & DALE (1971) believe that the closest generic affinities are with *Fragilidium* BALECH ex LOEBLICH III and *Helgolandinium* and support recognition of the family *Pyrophacaceae* LINDEMANN as emended. LOEBLICH III (1971) considered *Helgolandinium* to be a variation within *Fragilidium.*

Pyrophacus horologium STEIN emend. WALL et DALE Plate 34, Figs. 387, 388, 390
SCHILLER 1935:87, f. 73 a–c (vix d, e); SILVA 1949:353, t. 6, vix f. 15 non f. 16; – 1956a:59, t. 10, f. 1; KISSELEV 1950:127, f. 205 a–c; RAMPI 1950c:243, f. 7; MARGALEF et DURÁN 1953:24, f. 13 h, i; STEIDINGER et DAVIS 1967:2, f. 1–9; STEIDINGER et WILLIAMS 1970: 62, t. 39, f. 146 A, B; WALL et DALE 1971:230 (234), f. 1 A, D, f. 4 D–G, f. 9, f. 31–37; HERMOSILLA 1973b:55, t. 29, f. 8–10.
Non *P. horologium* sensu WANG 1936.

This species can, according to WALL & DALE (1971), be distinguished from both other species so far described in its possession of fewer plates (5–6′, 0–1a, 7–10″, 9c, (6s?), 8–10‴, 0–1p, 3–5⁗) on both the epi- and hypotheca. Its commonest individual plate formula is 5′, 0a, 9″, 9c, 9‴, 1p, 3⁗. It is usually smaller than the other species (transdiameter 35–136 μm) although there is overlap with the smallest specimens of the other species and one hypotheca in the present material exceeded the largest transdiameter recorded for any species (fig. 390). It measured 275 μm in lateral diameter with a dorso-ventral dimension of 225 μm. There is usually only a single posterior antapical plate (3⁗), this plate in particular undergoing extensive subdivision in the other species. The surface markings consist of densely scattered microgranules. The cysts are simple, oblate-reniform, surrounded by gelatinous material.

The name *horologicum* [sic] is an error originated by SCHILLER. SOURNIA (1967b) appears to have misread STEIN'S epithet, stating that it should be *"horlogium"*. The latter does not appear at all in this author's copy of STEIN'S work.

Stations: 13, 19, 21, 27, 28, 39, 40, 43, 44, 70, 71, 87, 115, 116, 140.

Present in small numbers at stations in the eastern Arabian Sea and Bay of Bengal, usually near the coast. Less common and abundant than *P. steinii.* The species has been frequently recorded from the Indian Ocean although in several cases it is not clear whether it is *P. horologium* sensu lato or *P. steinii* sensu lato. The references listed by WOOD (1963a) require augmentation by those of SUKHANOVA (1962b), ANGOT (1965, 1970), TAYLOR (1967), SOURNIA (1967a, 1968b, 1970) and NEL (1968).

Pyrophacus steinii (J. SCHILLER) WALL et DALE Plate 34, Figs. 384, 385, 386, 389; Plate 44, Fig. 518
– 1971:234, f. 1 B, 26–30.

Syn.: *P. horologicum* var. *steinii* J. SCHILLER 1935:87, f. 74 a, b (non c, d); KISSELEV 1950:127, f. 206 *а*, *б* non *в*; RAMPI 1950c:243, f. 8; WOOD 1954:221, f. 84 b vix c; SILVA 1956a:59, t. 10, f. 2, 3; BALLANTINE 1961:218, f. 16, 17; STEIDINGER et DAVIS 1967:4, f. 6–9 a, b; STEIDINGER et WILLIAMS 1970:62, t. 40, f. 147; LÉGER 1973a:19, f. 5 (*horlogium* sic).

P. horologium STEIN sensu WANG 1936:150, f. 22, 23; SILVA 1949:353, t. 6, f. 16; MARGALEF et DURÁN 1953:24, f. 13 b, i; YAMAJI 1966:79, t. 37, f. 6; HADA 1967:15, f. 25 (sub *horolongicum*).

This taxon can be distinguished from *P. horologium* by the characters referred to under the latter. An additional diagnostic feature of *P. steinii* is the presence of marginal striations on the precingular plates in addition to thecal granules and pores. These striations presumably led to the specific epithet of the type species with which this taxon was initially combined. There is a possibility, as indicated by WALL & DALE, of a few cells exhibiting intermediate features (with regard to plate pattern) between it and *P. vancampoae*. SILVA (1956a) indicated that some of her Portuguese specimens (1949) were of the type species, and others of this species (as the variety). The hypotheca figured in her 1949 paper is clearly of *P. steinii*, showing the common arrangement of three posterior antapical plates in addition to the coupling antapical plate and left antapical plate. WALL & DALE (1971) provide a plate formula of 6–7′, 0a, 11–13″, 12c, (? s), 11–14‴, 1–2p, 4–6⁗. The commonest individual formula they found was 7′, 0a, 12″, 12c, (? s), 12‴, 1p, 5⁗. Cyst features are as yet unknown.

Stations: 13, 39, 44, 47, 50–53, 65, 68, 69, 71, 89, 91–95, 99–101, 104–106, 108, 109, 113, 294, 295, 297, 314, 320, 325, 326, 335, 342, 370, 398, 412, 414, 420.

This was the most commonly occurring member of the genus in the Indian Ocean. It was also one of the more widespread taxa in the material being found at chiefly oceanic stations throughout the Bay of Bengal, eastern Arabian Sea, central Indian Ocean and northern Mozambique Channel. In the south central regions it did not occur further south than 27 °S.

It is probable that most of the Indian Ocean references to *P. horologium* (as *P. horologicum*) refer to this taxon in addition to those listed as var. *steinii*. More recent references not included by WOOD (1963a) are those of SILVA (1956a), DURAIRATNAM (1964) and TAYLOR (1967). It has been commonly recorded from Atlantic Ocean localities.

Pyrophacus vancampoae (ROSSIGNOL) WALL et DALE Plate 34, Fig. 391
– 1971:(231)234, f. 1 C, E, 2 A–E, 3, 4 A–C, 6–8, 10–25.

Syn.: *Pterospermopsis? Van Campoae* ROSSIGNOL 1961:134, t. 2, f. 1.

Pterospermopsis vancampoae ROSSIGNOL 1964:90, t. 2, f. 17, 18, t. 3, f. 15.

Tuberculodinium vancampoae (ROSSIGNOL) WALL 1967:114, t. 16, f. 16, 17.

Pyrophacus Form B_1 STEIDINGER et DAVIS 1967:5, f. 10–15 a, b, 16 c, d; STEIDINGER, DAVIS et WILLIAMS 1967, f. 5; STEIDINGER et WILLIAMS 1970:62, t. 40, f. 148.

P. horologium STEIN 1883, pro parte: t. 24, f. 3; MARGALEF 1948a:21, f. 1, 2; MASSUTI et MARGALEF 1950, f. 53 a, b, vix c.

P. horologium var. *steinii* sensu KISSELEV 1950, f. 206 *в* (non *а*, *б*) – icon ex STEIN 1883.

This species has the greatest number of thecal plates and also the greatest diversity in plate pattern. Its most obvious feature in this respect, if present, is the group of up to 9 posterior intercalary plates which appear as a discontinuous series between the postcingular series and the posterior antapical plates. Anterior intercalary plates are also commonly present. The plate formula as provided by WALL & DALE (1971) is: 7–9′, 0–9a, 13–15″, 12–16c, (8s?), 12–17‴, 1–9p, 5–7⁗. The commonest formula is 8′, 0a, 14″, 14c, (8s?), 14‴, 1p, 6⁗. The surface markings consist of both grana and pores. The cyst is highly distinctive, oblately discoidal in shape with 29–36 short tubercles between two wall layers.

Stations: 44, 116, 117, 129, 135, 153, 162, 294.

The Bay of Bengal station was in close proximity to the Ganges River delta but the other scattered records are for stations throughout the Indian Ocean. Several of these are near island groups, but others are not. Little can be concluded from this distribution pattern.

This is a first record of the species from the Indian Ocean. WALL & DALE (1971) have listed the following localities for recent specimens: Caribbean Sea, Bermuda, and Abidjan (Ivory Coast). It has a fossil history dating back to the Lower Miocene. To these may be added the specimens of MARGALEF (1948a) described from the Mediterranean coast of Spain.

Order Noctilucales HAECKEL

Most of the recent work on members of this order, largely on neglected genera by CACHON & CACHON (1964, 1966, 1967, 1969a), on the ultrastructure of *Noctiluca* by SOYER (1968a, b, 1969 a, b, c, 1970 a, b, c) and on nuclear organisation (AFZELIUS 1963; AFZELIUS & HALYARSON 1964; ZINGMARK 1970) supports the view that this group differs quite markedly from the Peridiniales. Most members exhibit rather elaborate ontogeny, the mature stage often being highly vacuolated and large. Contractile, muscle-like fibrils permit shape changes and the movement of tentacular structures. The unusual nuclear features exhibited by *Noctiluca* (the chromosomes undergo a relatively dispersed phase, like many euglenoids, and the nuclear membrane possesses pouch-like "blebs" at certain stages of its development) are characteristic of the trophont, and not of the spores. ZINGMARK (1970) has coined the term "nocticaryotic" for the nuclear type found in *Noctiluca*. It also occurs in several parasitic genera (J. & M. CACHON, pers. comm.).

CACHON & CACHON (1967, 1969a) recognised three subgroups within this order (although they informally termed them subfamilies within one zoological family). They are here recognised as families within one order:

A. Family Kofoidiniaceae fam. nov. (= zool. subfamily Kofoidininae J. et M. CACHON), in which the mature stage is strongly flattened laterally, the girdle running along the anterior margin, and the sulcus greatly extended, running along the posterior margin of the cell, reaching the dorsal side. Three genera are assigned here: *Kofoidinium, Pomatodinium*, and *Spatulodinium.*

B. Family Leptodiscaceae fam. nov. (= zool. subfamily Leptodiscinae J. et M. CACHON), in which strong flattening is antero-posterior. There are wing-like extensions (the velum), but they are not associated with the girdle or sulcus. The latter may be greatly reduced. The transverse flagellum is usually free distally. In *Cymbodinium* only one flagellum is present. In *Leptodiscus* and *Craspedotella* the cell may undergo rhythmic, medusa-like contractions. Other genera assigned here are: *Abedinium* (= *Leptophyllus*), *Petalodinium,* and *Scaphodinium.*

C. Family Noctilucaceae KENT, emended to omit the genera listed above and including only *Noctiluca* and *Pronoctiluca.* In this family the sulcus is well developed but the girdle is greatly reduced.

With the exception of *Noctiluca* these genera are predominantly tropical to warm-temperate in distribution. Some, e.g. *Kofoidinium,* may occur deep within or beyond the euphotic zone. Only *Kofoidinium, Noctiluca,* and *Pronoctiluca* were observed in the "Anton Bruun" material. Most do not preserve well with commercial formalin and may be easily damaged by nets.

Family Kofoidiniaceae fam. nov.

Genus *Kofoidinium* PAVILLARD

Members of this genus undergo an exceptional morphological transformation during their developmental cycle. CACHON & CACHON (1967), as a result of studies on living material, have recognised six stages, labelled "a" to "f", in three species. Features of particular interest are: the shell ("coque") which, unlike a theca, is held by only a few specialised points of contact (hooks) to the cell body (not apparently within the cell membrane); the considerable lateral flattening in the mature sporont, producing a large keel-like velum; the raising of the left side of the girdle to form an apical crest; the extension of the longitudinal sulcus in a furrow along the edge of the velum onto the dorsal surface; the existence of pigmented and non-pigmented stages, and the presence of individuals at 1200 m in the Mediterranean (FENAUX 1958).

The genus appears to be most closely related to *Pomatodinium* CACHON et CACHON and *Spatulodinium* CACHON et CACHON (not found in the material). Their classification in the Noctilucales seems well founded.

The distributions which follow are certainly under-representative as the cells are hard to recognise in rich net samples in view of their delicate and unusual shape. It is interesting that, although non-thecate, they were often found to be surprisingly well preserved. Many loose shells were observed in the samples but not recorded because of this author's ignorance of their true nature at the time of analysis (cruise I material was examined last). Because of their great delicacy they resemble almost structureless hoops, the central portion being almost invisible under low magnification. It is strongly suspected that *K. velleloides* PAVILLARD, the type species (commonly mispelled "*velelloides*"), is present in the Indian Ocean, but was not recognised early enough in the analysis to be recorded. One species, *K. arcticum* BURSA (1964) has been found in the Atlantic Ocean. The single specimen was evidently deformed due to preservation.

Kofoidinium lebourae (PAVILLARD) comb. nov. Plate 39, Fig. 477

Basionym: *Gymnodinium lebourii* PAVILLARD 1921:868, f. 1–6; LEBOUR 1925:43, t. 5, f. 3; SCHILLER 1932:376, f. 385 a, b.

Syn.: *Gymnodinium pseudonoctiluca* POUCHET pro parte, POUCHET 1885, t. 4, f. 34, 36, vix 35 non 37; – 1892, f. 1, 7–10; LEBOUR 1917: 188, f. 3.

Gymnodinium fulgens KOFOID et SWEZY 1921:209, f. X 30.

Kofoidinium pavillardi CACHON et CACHON 1967:429, f. 1–3, t. 1, f. 1–5, t. 2, f. 1–4, t. 3, f. 1, 2, t. 4, f. 1–5, t. 5, f. 1, 2, 4–6 (7, 8?).

Vix FENAUX 1958, f. 2–5, sub *K. velelloides* (sic, non. f. 1); STEIDINGER et WILLIAMS 1970:54, t. 25, f. 78 a, b.

Due to the highly detailed study of CACHON & CACHON (1967) it has been possible to recognise the probable conspecifity of this species as described in its immature state (their stages "b" to "d") with the mature "sporont". Although they were aware of this likelihood they did not select the first available name, and instead created a new taxon. This was probably due to the lack of distinct chloroplasts in the stages corresponding to the *Gymnodinium* species, those described by PAVILLARD and others supposedly having chloroplasts. However, as the appearance of chloroplasts can be variable, as indicated for *Polykrikos lebourae* by HERDMAN (1924), *Gonyaulax acatenella* by PRAKASH & TAYLOR (1966), and observed in many sand dinoflagellates (where it may be due to chlorosis – TAYLOR and K.D. BAILLIE, unpublished observations) this apparent lack cannot be accepted with certainty.

The new combination proposed above is a product of these considerations.

The mature sporont (illustrated) apparently reaches 700 μm in diameter although in the "Anton Bruun" material the largest found was 620 μm. This large size distinguished the species from *K. splendens* which does not usually exceed 400 μm in diameter. There are also differences in the shape of the left girdle crest (smoothly-rounded instead of angled when seen in side view), the ribbing within the girdle and sulcus, the type of hooks holding the shell and the shell structure itself. In *K. lebourae* the shell is delicately areolated, the areolate being approximately 10 to 12 μm in diameter.

Stations: 50, 51, 53, 54, 57, 58, 59, 61–65, 87, 92, 94, 95, 96, 99, 102, 103, 294.

It was very common and widespread in the western Bay of Bengal during the late N.E. Monsoon period (cruise I), and was found also at one station north of the Seychelle Islands. In view of the occurrence of this species below 300 to 600 metres (FENAUX 1958, CACHON & CACHON 1967) this is an interesting addition to the other deep-occurring species also found in the western Bay of Bengal at this time (see the section on possible "shade flora" in TAYLOR 1973b). SOURNIA (1972a) has recorded this species from the vicinity of Nosy-Bé (Madagascar). The first described species, *K. velelloides* PAVILLARD, is known from the Mediterranean, the Pacific and Atlantic Oceans. It is possible that some of the records lacking figures (e.g. RAMPI 1952d; BALECH 1962b) may refer to species described later. The figures of STEIDINGER & WILLIAMS (1970) of specimens of *Kofoidinium* from the Gulf of Mexico do not seem to be this taxon, but it is hard to be certain from their photographs. BALECH (1971b) has listed the species as being present in tropical Atlantic Ocean waters.

Kofoidinium splendens CACHON et CACHON Plate 39, Figs. 475, 476

– 1967:437, f. 6 a, t. 4, f. 6–8.

Syn.: ? *Gymnodinium pyrocystis* JÖRGENSEN 1912:10; KOFOID et SWEZY 1921:246; LEBOUR 1925:45.

A few specimens of this recently described species were seen, all lacking their shells. They could, however, be identified on the size and shape of the sporont. The velum is usually less than 400 μm in diameter. The periphery of the velum close to the longitudinal sulcus is marked by irregular ridges which run concentrically with it. A lenticular body is present near the ventral margin. The left girdle margin of the epicone (the upper profile when seen in the usual side view) is markedly angular. The ventral margin of the velum is smoothly rounded.

Precise distinctions between this species and *K. velleloides* PAVILLARD are difficult to make because of the incompleteness of the original description and the distorted condition of the type specimens of the latter. The identification here was based on close agreement with the description of *K. splendens* by CACHON & CACHON (1967) rather than by differences with *K. velleloides*. CACHON & CACHON (1967) have provided a more recent interpretation of the latter which includes distinctions not apparent in the type description, such as an abrupt angularity in the ventral margin of the velum. The lack of a lenticular body may also be a useful distinction. The Indian Ocean specimens harboured several zooxanthella-like bodies per cell, a feature also observed in the type material and not known from *K. velleloides* sensu lato.

A juvenile stage, corresponding to stage "b" of CACHON & CACHON (1967) has been tentatively assigned here to *K. splendens* in view of the very close similarity, despite fixation deformation, to the specimen in their figure 6 on plate 4. It is this stage which suggested a possible conspecificity with *Gymnodinium pyrocystis* JÖRGENSEN. Although the latter is almost certainly a stage "b" of a species of *Kofoidinium* the lack of a figure in any of the descriptions makes it almost impossible to decide which species it corresponds to. *K. splendens* seems the closest but the early descriptions may have also included specimens of several species. It has been considered best not to make a new combination in this case.

Stations: 95, 97, 370 (juvenile).

This species was much rarer than the former, being found in small numbers at two western Bay of Bengal stations, the juvenile specimen (stage "b") being recorded from the vicinity of the Mozambique coast. These are the first records for this species in the Indian Ocean. It was originally described from the Mediterranean Sea.

Family Noctilucaceae KENT

Genus *Noctiluca* SURIRAY ex LAMARCK

The first time this name appeared in the form of a Latin binomial was in LAMARCK's "Animaux sans vertebres" (1816). In this work LAMARCK accredited the genus name to SURIRAY. The latter author had proposed the genus in a manuscript presented to the French Academy of Science in 1810, but he did not publish the work until much later. Early authors, familiar with each other's manuscripts, usually accredited the genus to SURIRAY but the form given above is in accord with the International Codes of Botanical and Zoological Nomenclature (the ICZN does not distinguish between ex and in). In fact *Noctiluca* SURIRAY ex LAMARCK is a junior homonym, but the senior homonym, *Noctiluca* HOUTTUYN has been rejected from the zoological literature. At some future date it might be desirable to formally conserve *Noctiluca* SURIRAY ex LAMARCK.

At the time of writing the genus consists of apparently only one species (below). Apart from general floristic studies it has been subjected to detailed examination in three unrelated aspects: its role in causing "red water" phenomena (e.g. AIYAR 1936; BHIMICHAR & GEORGE 1950; GRINDLEY & HEYDORN 1970; GRINDLEY & TAYLOR 1971), its bioluminescence (NICOL 1958; ECKERT 1966), and the unusual nature of its ultrastructure (see references in the introductory comments to the order). The species can regulate its density so that it may occur distributed over wide depths (generally within the upper 50 m) or it may become buoyant, occurring directly at the surface. From unpublished observations on cells in culture it appears that, when at the surface *Noctiluca* may be a neuston-feeder, using its tentacle to "wipe-off" bacteria and small cells from the surface film (orig. obs.).

Noctiluca scintillans (MACARTNEY) EHRENBERG Plate 39, Figs. 478, 479

.... KOFOID et SWEZY 1921:407, f. KK 1–6; LEBOUR 1925:69, f. 17 a–d; WANG et NIE 1932:312, f. 24; WAILES 1939:15, f. 34; MASSUTI et MARGALEF 1950, f. 36 b, c; SILVA 1952b:600, t. 6, f. 4; MARGALEF, DURÁN et SAIZ 1955:95, f. 5 d; YAMAJI 1966:73, t. 34, f. 2.

Syn.: .... *N. miliaris* SURIRAY ex LAMARCK .... FORTI 1922:23, t. 1, f. 1 (2); SCHILLER 1933:553, f. 582 a–e; WOOD 1954:220, f. 83 a (vix b); SUBRAHMANYAN 1954, f. 2 (3); TRÉGOUBOFF et ROSE 1957:107, t. 22, f. 17 A, B (*miliaria*); QUAYLE 1969, f. 6; SWEENEY 1971:54, f. 1 A.

Although this species is common and widespread it has only been illustrated rarely, possibly due to difficulties in its depiction. Its very large, sac-like form and tentacle make it easily recognisable. In its more juvenile stages it might be confused with *Spatulodinium* although the highly modified form of the latter renders this doubtful. In the present work both a juvenile and medium-sized individual have been illustrated, both from the apical side, a feature most readily determined by the prominent apical trough. The ventral indentation is hidden from view. The formation of multiple, large feeding sacs, shown in fig. 479, is quite common in *N. scintillans.* There have been several reports of the presence of green flagellate symbionts within the main cell vacuole, particularly from populations near the East Indies (see e.g. SUBRAHMANYAN 1954; SWEENEY 1971) but none were seen in this material.

Many authors have used the name *N. miliaris* although MACARTNEY's specific epithet has clear priority. Perhaps a case could be made in zoological nomenclature for considering *N. scintillans* as a *nomen oblitum* (SOURNIA, pers. comm., cf. ICZN Art. 23b) in view of the lengthy period of disuse between EHRENBERG's combination and its revival by KOFOID & SWEZY (1921). Apart from the absence of this practise in the ICBN, it also seems best to adopt the simplest policy; namely, that of accepting the priority of *scintillans,* particularly as it has been used in two major authoritative works in this century: KOFOID & SWEZY (1921) and LEBOUR (1925), as well as in many of the other works in this century:

Stations: 22, 23, 29, 30, 31, 33, 35–43, 47, 48, 49, 51, 54, 68, 88, 94, 95, 104, 105, 155, 322, 340, 412.

The species was most commonly present at stations in the eastern Andaman Sea. It achieved large numbers at stations 39, 41, 42, and 43 near the Irrawaddy delta where it bloomed in association with a small, unrecognisably preserved flagellate on which it was feeding. It is tempting to suspect that it was a similar situation to that reported off Calicut by SUBRAHMANYAN (1954) but there is little to substantiate this other than the very small size of the flagellate. Although *N. scintillans* is essentially neritic, it can occur at extreme oceanic stations such as 322 and 340, both in equatorial waters. It has been known to bloom extensively off both the east (AIYAR 1936) and west coasts of India where it has been implicated in fishery decline (BHIMICHAR & GEORGE 1950). Blooms have been reported from many areas including St. Lucia estuary on the east coast of southern Africa; (GRINDLEY & HEYDORN 1970), the Cape of Good Hope (GRINDLEY & TAYLOR 1971), the English Channel (LEFÈVRE & GRALL 1970), the western Mediterranean (LOPEZ & ARTE 1971), and British Columbia coastal waters (QUAYLE 1969).

Genus *Pronoctiluca* FABRE-DOMERGUE

This non-photosynthetic genus is of more enigmatic systematic position than other members of the Noctilucales, showing certain resemblances, particularly in the reduction of the flagellar apparatus, including grooves, to *Entomosigma* SCHILLER and *Oxyrrhis* DUJARDIN. The flagella are anteriorly inserted in *Pronoctiluca* (PAVILLARD 1917) and *Entomosigma* whereas they are posterior in *Oxyrrhis.* Members of *Pronoctiluca* have a flexible cell wall, often granular in appearance. Delicate cyst walls are produced exterior to the wall. Large accumulation bodies are often present, usually in the posterior portion of the cell. The tentacle can be flexed considerably, appearing at various angles in preserved material. Shape changes accompany ontogeny in the type species (*P. pelagicum* FABRÉ-DOMERGUE).

The genus is here retained within the Noctilucaceae largely on the basis of the observations of CACHON & CACHON (1966), authors whose experience with members of the order is considerable. They have indicated that some early figures attributed to this genus are in reality developmental stages of *Kofoidinium.* KOFOID & SWEZY (1921) doubted that *Pronoctiluca* was a dinoflagellate genus.

Pronoctiluca pelagica FABRÉ-DOMERGUE Plate 37, Figs. 426–428, 430, 431

SCHILLER 1932:268, f. 258 a–i; KISSELEV 1950:82, f. 133; CHATTON in GRASSÉ 1952:343, f. 248 A–C; WOOD 1954:216, f. 74; SILVA 1955:115, t. 1, f. 13; TRÉGOUBOFF et ROSE 1957:106, t. 22, f. 15; TAYLOR 1967, t. 6 (93), f. 57.

This species together with others in the genus, although not exceptionally rare in tropical waters, has only been illustrated rarely. Apart from the small figures of WOOD (1954), and the photograph of TAYLOR (1967), all the references cited above reproduce figures by PAVILLARD (1917). The latter illustrated the transition of the species from a fusiform shape to a more rounded pyriform stage with flattened antapex which produces multiple delicate "cyst" walls external to it. The tentacle projects through all the walls produced. The initial cyst wall remains attached antapically to the secondary wall so that it resembles a hyaline cup enclosing the posterior part of the cell. This process may be repeated more than once. Extremely small cells (length 16 µm excluding tentacle) were also found (fig. 430). It could not be determined if these were a developmental stage of *P. pelagica* or not.

P. pelagica differs from *P. spinifera* in lacking the antapical projection characteristic of the latter. They are similar in size when mature (25 to 35 µm in length, excluding the tentacle and cyst walls).

Stations: 17, 96, 155, 282, 283, 289, 297, 298, 301, 313, 315, 322, 327, 341, 365, 369, 371, 374, 405, 411, 412, 414, 416, 417, 420.
Small form: 135, 284, 323.

It was widely distributed (in small numbers) occurring chiefly at oceanic stations. It was most common in the Mozambique Channel region and off the coast of east Africa (August to November).

The species has been found in the Indian Ocean only by WOOD (1962 in 1963a) and TAYLOR (ms. 1964, 1967). It is known from the North Atlantic, and the Baltic and Mediterranean Seas. MARSHALL (1933) found it present in small numbers throughout the year in the Great Barrier Reef lagoon.

Pronoctiluca rostrata sp. n. Plate 37, Fig. 425

Several individuals and a discarded "sheath" of a large, distinctive species of *Pronoctiluca* were found. The cells are spindle-shaped consisting of three main external components. A short, cylindrical apical region is surmounted by a relatively slender tentacle and has a distinct sulcal groove passing down most of its length. The mid-body is large, containing most of the cell contents. It is broadest in the centre, tapering equally at both ends where it attaches to the apical piece and the rostrate antapical projection. The latter appears to arise rather abruptly from the mid-body and the wall in this region appeared slightly thicker in some specimens. The tip is acutely pointed and the region of the junction may appear slightly swollen.

The surface of the wall exhibits the same finely granular appearance observed in other species of *Pronoctiluca*. Two large, unusual-looking bodies, presumed to correspond to accumulation bodies, occupied much of the mid-body in the specimens observed. No chloroplasts are evident.

Total length including tentacle: 115–128 μm
Length of mid-body: 74– 78 μm
Width of mid-body: 16– 20 μm
Length of rostrate process: 25– 28 μm
Type locality: Station 327, southwest of India. It was also found in the central Bay of Bengal (st. 17).
Comparisons: This species is larger than *P. acuta* (LOHMANN) SCHILLER (maximum length 60 μm) and differs also in that the rostrate process arises abruptly from the mid-body rather than being a gradual extension of it. The apical region appears to be very similar, however. Some of LOHMANN's figures look suspiciously like *Prorocentrum gracile*!

Pronoctiluca spinifera (LOHMANN) SCHILLER Plate 37, Fig. 429
SCHILLER 1932:270, f. 259 a–c (vix d); CHATTON in GRASSÉ 1952, f. 248 D; WOOD 1954:217, f. 75; HERRERA et MARGALEF 1963:76, f. 24m; YAMAJI 1966:73, t. 34, f. 1; TAYLOR 1967, t. 6 (93), f. 58; RAMPI 1969b:322, t. 1, f. 7; SOURNIA 1972a:156, f. 14.
Syn.: *Cystodinium* sp., BALECH 1971a:168, t. 38, f. 747.

This species is rarer than *P. pelagica*, and cyst-formation is unknown. A peculiar type of pairing has been figured by HERRERA & MARGALEF (1963). It is recognisable most readily by its antapical process which may be relatively blunt (fig. 429) or more acute (HERRERA & MARGALEF 1963; TAYLOR 1967). It differs from *P. rostrata* in being smaller and in the smoothness of the transition from the mid-body to the antapical process.

The specimen illustrated here was apparently in a stage immediately prior to ejection of the accumulation body, a phenomenon observed previously in *P. pelagica* by PAVILLARD (1917).

Stations: 108, 150.

Single individuals were observed at a station in the eastern Arabian Sea and north of the Seychelle Islands.

This species has only been recorded from the Indian Ocean by WOOD (1962, in 1963a), TAYLOR (ms. 1964, 1967), and SOURNIA (1972a). It was found at only one station over the Agulhas Bank in the southwestern Indian Ocean and at Nosy-Bé (Madagascar). It is known from the three major oceans and the Mediterranean Sea. BALECH (1971a) found cells corresponding to this taxon abundant near the Rio de la Plata in the South Atlantic Ocean.

Incertae Sedis

Family Amoebophryaceae LOEBLICH III

[= Amoebophryidae J. CACHON, zool. fam. = Coelomastigina CHATTON et BIECHELER]

This family consists of only one genus at present.

Genus *Amoebophyra* KÖPPEN

Syn.: *Hyalosaccus* KÖPPEN

All members of this genus are intracellular parasites, their hosts consisting of dinoflagellates, tintinnids, or radiolarians. The feeding state (trophont) forms a distinctive bee-hive-shaped cavity, the "mastigocoele," so named because it is lined with rows of flagella belonging to incipient daughter cells of the parasite. It is by the presence of this cavity that they can be most readily recognised within their hosts. Extrusion from the host involves a complex inversion of the parasite. It emerges in a polynucleated state which is very elongated and is termed the vermiform stage. After further nuclear divisions biflagellated spores are liberated. They are the infective stage. Ultrastructural features of members of the genus have been illustrated by CACHON & CACHON (1969b, 1970).

Amoebophyra ceratii (KÖPPEN) J. CACHON Plate 32, Fig. 349 b

1964:70, t. 1, f. 6, t. 2, f. 7–10, t. 13, f. 12–16, non t. 2, f. 11; TAYLOR 1968:2241, f. 1–10; BALECH 1971a:145, t. 30, f. 566, 567.
Syn.: *Hyalosaccus ceratii* KÖPPEN pro parte.... CHATTON et BIECHELER 1935:505, f. 1–8; GRASSÉ 1952:1020, f. 819 A–H.
[Un-named figures in CUESTA 1919, t. 52 (f. 1) B, t. 53 (f. 2 A–K); LEBOUR 1925, f. 3 a–c; BALECH 1963a, f. 37].

Under routine conditions this species is only detectable within its hosts in an advanced developmental state. It parasitises both thecate and non-thecate dinoflagellates. In the latter it develops initially in the peripheral cytoplasm whereas in thecate hosts (of the genera *Prorocentrum, Blepharocysta, Diplopsalis, Peridinium, Gonyaulax, Ceratium*) it appears to preferentially digest the host nucleus first. CACHON (1964) has described and illustrated cytological features of the development of the species, CUESTA (1919) having unwittingly also illustrated various stages, and TAYLOR (1968) has photographically illustrated its appearance within the chain-forming, toxin-producer *Gonyaulax catenella* (suggesting the possibility of a future use as a biological control agent to regulate sources of paralytic shellfish poison).

Closely related species (*A. grassei* J. CACHON and *A. leptodiscii* J. CACHON) are distinguished chiefly by their hosts (*Oodinium* and *Leptodiscus* respectively) and the appearance of their vermiform or motile stage (cf. CACHON 1964). Three other species are found in non-dinoflagellate hosts.

Stations: 29 – in *Diplopsalis* sp.
67 – in *Peridinium steinii*
29, 327 – in unidentified cysts.

Found in various dinoflagellate hosts in the Andaman Sea, the Bay of Bengal, and off the southern tip of India.

These are the first records of any member of this group from the Indian Ocean. Until recently the genus was virtually unknown outside the Mediterranean and North Seas. TAYLOR (1968) has recorded it from the North East Pacific and BALECH (1971a) has observed it in the South Atlantic Ocean. Like many parasites it is probably relatively cosmopolitan.

Family?

Genus *Bernardinium* CHODAT?

This is a very enigmatic, poorly known genus represented by only one very small fresh-water alpine species, *B. bernardiense* CHODAT. The cells are not known to have tabulation. A girdle groove passes only half-way around the body equatorially, and SCHILLER (1935) suspected that it may, in fact, have been based on poorly observed members of *Hemidinium*. The latter does, however, have very definite tabulation, the incomplete girdle forming a descending spiral rather than a level semi-circle. No sulcus was known for the type species.

The genus is here resurrected tentatively as the only appropriate designation for a large, curious taxon found in the "Anton Bruun" samples (below).

Bernardinium sp.? Plate 37, Figs. 436 a, b

Although the organism referred to here could not be identified it nevertheless had several distinctive features. It was 56 μm long with a transdiameter of 50 μm and a dorso-ventral width of 42 μm. In ventral view it was rectangular with rounded corners. The cingular groove was most unusual. It depressed the cell sharply, but not broadly, only over the ventral surface and a small part of each lateral surface. In ventral view it could be seen to undulate strongly on the right half of the cell, plunging down to an acute point assumed to be the flagellar origin. The left side of the girdle was shorter, less undulate, and slightly lower than the right. No sign of a sulcus was seen.

The cell was enclosed in a strong wall, fairly thick, but not apparently made of plates. Beneath the wall was a broad hyaline zone. The cell contents were not strongly pigmented, but this may have been due to bleaching of the chlorophyll by formalin. The most striking intracellular feature was a very prominent spherical capsule, thought to be a pyrenoid sheathed with starch, although it could have been, more improbably, a capsule surrounding the nucleus as a nucleus was not observed elesewhere in the cell.

There is a strong possibility that this may have been a cyst rather than an actively swimming cell.

Station: 322.
It was found in the central Indian Ocean to the south of India.

Family Gloeodiniaceae SCHILLER

Species possessing a palmelloid, gelatinous state, possibly also filamentous.

Genus *Gloeodinium* KLEBS

Gloeodinium marinum BOUQUAHEUX Plate 40, Fig. 486
– 1971:314, f. 1–4, t. 40, f. 4 a–c; t. 41, f. a–c, t. 42, f. a–c.
[SCHÜTT 1895, t. 26, f. 91; MARGALEF, HERRERA, RODRIGUEZ-RODA et LARRAÑETA 1954:94, f. 1 a (sub *Pelagocystis?*); GAARDER 1954:60, f. 77 a, b.]

The cysts have a very characteristic morphology, each containing a prominent nucleus with the granular interphasic appearance of the dinokaryon. Staining with aceto-carmine displays the nuclei very strongly. BOUQUAHEUX (1971) has described the ultrastructure of the cells. They are roundly oval, approximately 20–38 µm in diameter, deeply embedded in phase-transparent mucilage. They often occur in pairs within the mass, being a product of synchronous division, daughter cells becoming more widely separated with the subsequent production of further mucilage. In the "Anton Bruun" material the number of cysts per mass was observed to vary from four to thirty-two (fig. 48 b). BOUQUAHEUX (1971) found that there were two types of cycle; one in which motile cells (gymnodinoid) occurred after the 16-celled stage, and another which occurred after a 64-celled stage. The cysts are pigmented. At several stations they were quite abundant (see below).

GAARDER's illustrations of cysts are identical to those observed here insofar as the limited morphology permits identification. She speculated that they may arise from prorocentroid cells such as *Prorocentrum compressum.* MARGALEF et al. (1954, above) thought the cysts belonged to a member of the Xanthophyceae. BOUQUAHEUX (1971) described the motile cells as gymnodinoid, but did not illustrate them. Customarily this genus is thought to have *Hemidinium*-like motile cells (LOEBLICH III 1970). Consequently several genera may later be distinguished by their motile cells in a similar way to the *Dissodinium/Pyrocystis* distinction.

Stations: 13, 15, 21, 33, 37, 62, 142, 299, 313, 317, 318, 321, 327.
They occurred at several stations in the Andaman Sea, one in the eastern Bay of Bengal, and were scattered over the central Indian Ocean. They were moderately abundant at stations 142 (south of India) and 299 (north of Mauritius). GAARDER (1954) found them at one station in the Atlantic Ocean and MARGALEF et al. (1954) observed the cysts in the western Mediterranean Sea, as did BOUQUAHEUX (1971 – Villefranche Bay).

General Features

This aspect has served as the basis for a separate contribution (TAYLOR 1973b) and so only the major points have been abstracted here, with the addition of a few observations not made in the previous publication.

The present report can deal only with qualitative aspects in view of the sampling techniques used aboard the "Anton Bruun". However, some preliminary remarks may assist the reader in seeing the dinoflagellates of the Indian Ocean in a general ecological perspective.

From other Indian Ocean studies it is known that for coastal localities diatoms far exceed the dinoflagellates in number in samples obtained by nets (e.g. SUBRAHMANYAN & SARMA 1960) or bottles (SOURNIA 1968d), and this may apply to a lesser extent in certain oceanic areas (TAYLOR 1967; NEL 1968; THORRINGTON-SMITH 1971). However there are three circumstances in which the dinoflagellates assume a major importance. The most obvious of these is the outbreak of "red water" caused by almost monospecific blooms of dinoflagellates. The only sign of such an event during the "Anton Bruun" cruises was the presence of large numbers of *Noctiluca scintillans* (MAC.) EHR. near the Irrawaddy delta in the northern Andaman Sea. RYTHER & MENZEL (1965) and RYTHER et al. (1966) found exceptionally high primary productivity to the south of Arabia during the "Anton Bruun" cruises. In the cruise V material from the area there were large numbers of an unrecognisable flagellate, as well as large amounts of detritus, but it was not apparently due to either diatoms or dinoflagellates. Other accounts of "red water" caused by dinoflagellates are provided in the introductory section on Earlier Indian Ocean Dinoflagellate Studies.

SUBRAHMANYAN & SARMA (1965) found that nearly half of the small cells not retained by nets off the south west coast of India were dinoflagellates, raising the possibility that they are at least occasionally major constituents of the nanoplankton. Furthermore, in oceanic areas dinoflagellates, although sparse, may not be as reduced in number as the diatoms, thus increasing their relative importance (KARSTEN 1907; DESROSIÈRES 1965). In the Caribbean Sea ZERNOVA (1970) has found a similar pattern, dinoflagellates constituting the predominant oceanic biomass. It must be born in mind that, as a group, the dinoflagellates play a complex role nutritionally because of the presence of totally photosynthetic, nonphotosynthetic and phagocytic-plus-photosynthetic ("myxotrophic") members.

TAYLOR (1973b) has discussed the evidence for shade-loving dinoflagellates occurring habitually below 50 or 100 m. Such species include most of the members of the subgenus *Archaeceratium* of *Ceratium*, with their flattened, leaf-like epitheca; the *Ceratium* species with "finger-" or "paddle-like" antapical horns (*C. ranipes, C. platycorne*), many of the morphologically elaborate dinophysoid species (e.g. *Histioneis* spp., *Ornithocercus splendidus*), the genus *Heterodinium* and some noctilucoids: e.g. *Kofoidinium*. The ceratia involved all seem to possess morphological adaptations for permitting the maximum amount of light to reach their chloroplasts (GRAHAM 1941). HALIM (1967) has used the presence of such species in surface waters as being indicative of upwelling. In the "Anton Bruun" material, although the samples integrated the material from the surface to 200 m, nevertheless they showed a horizontal distribution of such species associated with areas where an upward movement of water was expected (TAYLOR 1973b).

Species Composition

The sampling and preservation methods used during the expedition introduced considerable bias in the determination of the species present. It can be expected that non-thecate species and those with a maximum dimension of less than 60 microns were greatly under-represented. On the other hand, the practice of sampling from 200 m to the surface significantly increased the representation of "shade-loving" genera such as *Histioneis* or *Heterodinium*. For example, no representatives of either genus were found by TAYLOR (1967) in a series of samples taken from the south-western Indian Ocean by similar methods but operating only to a depth of 100 m.

A relatively large number of species (286) were found, of which 36 % were first records for the Indian Ocean. Only five of these can be thought of as usually allochthonous to the Indian Ocean. Two were brackish water species occurring near the plume of the Ganges River: *Peridinium achromaticum* LEVANDER and *Peridinium divaricatum* MEUNIER. The remainder were southern subpolar species found at one station in the Subtropical Convergence Region near 40 °S: *Ceratium petersii* STEEMANN NIELSEN, *Peridinium latistriatum* BALECH and *Podolampas antarctica* BALECH.

The richness of the species representation is evidently due largely to the great area of the Indian Ocean covered by the "Anton Bruun" even though many of the species have wide distributions. For example, SUBRAHMANYAN (1958) found only 109 species present in coastal waters off the west coast of India during a five year survey, and in a more restricted locality SOURNIA (1968d) recorded 57 species, his sampling also being limited to shallow depths.

Ceratium was the most represented genus (58 species). It is in the tropics that one encounters the full range of morphological variability within the genus, from the enlarged and flattened epithecae of the members of the subgenus *Archaeceratium*, to the elongate, rod-like members of *Amphiceratium*, to the antapical horn elaborations found among some members of *Tripoceratium*. Only 10 of the marine species included by SCHILLER in his monograph (1936) are not present here.

Peridinium had almost as many species (56), but these were much less widespread in most cases. The genus as a whole tends to be more neritic than *Ceratium*. *Gonyaulax* also was represented by a moderate number of species but, although several of them can be abundant enough to cause "red water" (e.g. *G. polygramma* STEIN, *G. polyedra* STEIN), they were not particularly abundant at any station.

One of the characteristics of the tropics is the relatively large number of dinophysoid species. In the "Anton Bruun" material *Dinophysis* was represented by 24 species, although it can be noted that those formerly attributed to *Phalacroma* are here included within it. It is in the tropics that one encounters the most morphologically elaborate, bizarre members of this group, particularly in the exclusively tropical genera *Ornithocercus*, *Parahistioneis*, *Histioneis* and *Citharistes*. Here also there is a parallelism to the elongate members of *Ceratium* found in the tropical genus *Amphisolenia*. Symbiotic associations with coccoid blue-green algae are also found in the more elaborate dinophysoid genera and they may exhibit morphological adaptations to these associations although this has not been established. The nutritional inter-relationships between the symbionts, if any, are also unknown and individuals lacking the symbionts can be found.

Distributional, Regional, and Seasonal Aspects

The photosynthetic dinoflagellates seem, in general, to be able to tolerate lower inorganic nutrient levels than the diatoms, possibly due to their ability to migrate through the water column, and this makes their distribution in the tropics not as clearly associated with nutrient levels as that of other photosynthetic groups. Temperature is evidently a major factor for many species, with salinity in the middle ranges playing a more minor role (GRAHAM & BRONIKOVSKY 1944). The same species able to tolerate brackish conditions may also be found in hypersaline lagoons (KIMOR & BERDUGO 1969).

There are probably no species which are limited exclusively to the Indian Ocean. Restricted distributions are to be found among a few Indo-West-Pacific taxa and, as might be expected, these are usually neritic species. For example, *Peridinium compressum* (ABÉ) NIE is known from coastal localities on the south-east coast of South Africa, the Gulf of Aden, and Japan. *Dinophysis miles* var. *schroeteri* (FORTI) BÖHM is much more restricted in its distribution although it is more common. It occurs only in the Andaman Sea/East Indies region, an area where the presence of strong inter-oceanic currents suggests that either the taxon dies out when displaced from the region or that it represents a type of phenotypic response to an environmental factor peculiar to the region. This question is discussed more fully under the taxon earlier, and has also had attention drawn to it in a separate publication (TAYLOR 1973b). *Ceratium egyptiacum* HALIM exhibits a similar narrow distribution, occurring only near the Suez Canal. It may represent a modification of *C. humile* JÖRGENSEN which was thought, until recently, to also be an exclusively Indo-West Pacific species but is now known to occur also in the tropical Atlantic Ocean (see earlier notes). *C. dens* OSTENFELD et SCHMIDT is a similar example, with a centre of distribution from the Bay of Bengal to South China Sea, extending occasionally into the Arabian Sea and into the eastern Pacific Ocean. There is only one tentative record of *C. dens* from the tropical Atlantic Ocean (STEIDINGER & WILLIAMS 1970). *Gonyaulax hyalina* OSTENFELD et SCHMIDT is a more widely distributed Indo-West Pacific species, occurring over most of the northern Indian Ocean in the present material. Unlike the previous species *G. hyalina* is not noticeably neritic.

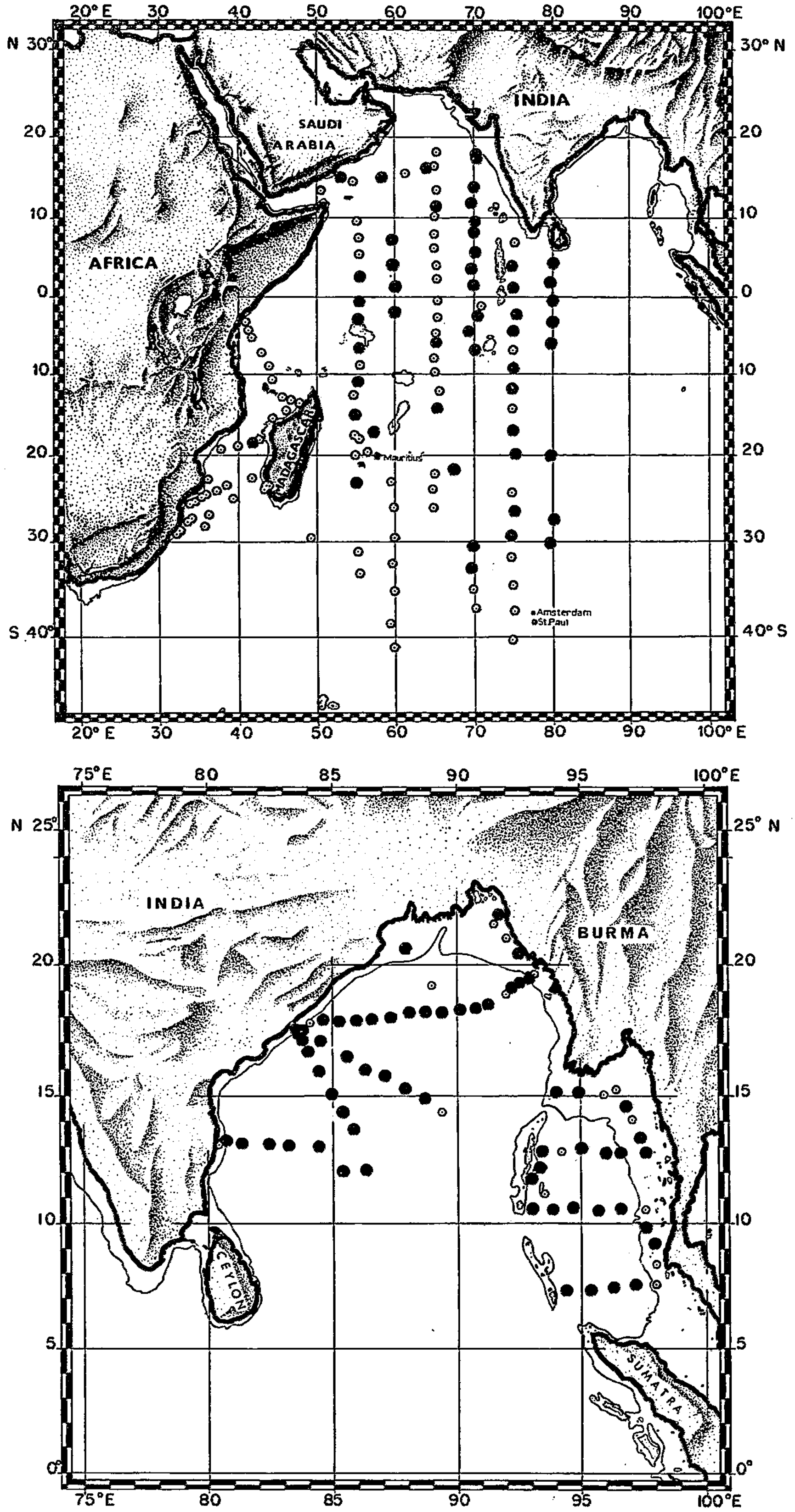

Chart 3. The Distribution of *Pyrocystis noctiluca*.

The majority of species in the material exhibited a northern and central Indian Ocean preference. The most obligate thermophiles, such as *Ceratocorys bipes, Amphisolenia thrinax, Ceratium inflatum, Gonyaulax fusiformis, Peridinium tenuissimum* and *Pyrocystis hamulus,* are found north of 20 °S, whereas the most common and widespread species tend to have a central southern limit nearer 30 °S. The latter is exemplified by *Pyrocystis noctiluca* (chart 3), one of the members of SUKHANOVA's (1962a, b) "basic tropical complex." Other members thought to compose this tropical group are *Ceratium carriense, C. massiliense* and *C. trichoceros.* DESROSIÈRES (1965) and TAYLOR (1973b) have commented on this grouping, pointing out that it includes dissimilar elements, some being thought to be relatively stenothermal (*C. trichoceros, C. carriense*) while the others are more thermotolerant. There are several other species which could be appropriately added to this grouping in view of their common and widespread occurrence in tropical and subtropical waters. For example *Ceratocorys horrida* is a common high-temperature species, *Heteraulacus polyedricus* and *Pyrophacus steinii* being more thermotolerant.

GRAHAM & BRONIKOVSKY (1944) referred to *Ceratium euarcuatum* as "one of the best indicators of warm tropical water" in their material from the Atlantic and Pacific Oceans. In the "Anton Bruun" samples it had an interesting distribution (chart 4). It was more widespread, especially in the southern central region, than one might expect from GRAHAM & BRONIKOVSKY's description, reaching 38 °S in September on cruise III. The large hiatus between 5 °S and 10 °N suggests an absence from the equatorial currents. *C. carriense,* on the other hand, although mostly absent from the South Equatorial Current, was present in the northern, eastwardflowing currents. The lack of records of both from the mid-Mozambique Channel (although found at both ends of it) is seen in the distribution of many other species.

It is evident from the studies of SOURNIA (e.g. 1968d) that relatively poor dinoflagellate populations are present at inshore locations in the Mozambique Channel region for most of the year. At Nosy-Bé, Madagascar, maximum numbers occur in winter (May to September). During "Anton Bruun" cruises VII and VIII (September, October) the open Channel stations were relatively poor in dinoflagellates. The distribution of several other species of *Ceratium,* found commonly both north and south of the Channel, showed a striking absence in the central stations. Examples of these were *C. macroceros* (EHR.) VANH., *C. gibberum* GOURRET, *C. tripos* var. *indicum* (BÖHM) comb. nov., and *Peridiniopsis asymmetrica* MANGIN. The most widespread species in the material, *Pyrocystis noctiluca* MURRAY, was found at only one station west of Madagascar, although it has been found in the Channel and to the south at other times by several authors (SOURNIA 1967b, 1970; TAYLOR 1967 and NEL 1968). The period when the samples were taken in the Mozambique Channel was prior to the summer rains, and the water was relatively cool with a high salinity. MENACHE (1963) found that during one October-November period the dynamic topography in the Mozambique Channel, plotted relative to the 1000 decibar level, indicated that an anticyclonic gyre was present instead of a smooth southward flow through the Channel, and it may be this type of circulation which contributes to the sparseness of the dinoflagellates.

It must be borne in mind that samples taken inshore in less than 25 m of water may not be indicative of the fluctuations of dinoflagellates only a short distance further out from the coast. Unpublished observations by this author in the vicinity of Phuket Island, Andaman Sea, showed that dinoflagellates were very sparse from inshore samples where the depth was less than 25 m. Only a few miles further offshore in 30 to 80 m of water, the number and variety was greatly increased.

The majority of species found here occurred at one or more stations within the Andaman Sea or the Bay of Bengal. It appears that the period following the North East Monsoon (cruise I, March to May) is one of great richness in dinoflagellates in the offshore waters of this region. This applied particularly to samples from the Andaman Sea and the central east coast of India. Indicative of this was the recognition of 88 dinoflagellate taxa from one sample (station 103). ZERNOVA & IVANOV (1964) found large numbers of dinoflagellates in the Andaman Sea during the N.E. Monsoon, with lower numbers in the Bay of Bengal.

By contrast, the Arabian Sea samples were disappointingly sparse. There were no samples from the south coast of Arabia during cruise IVa when extremely high productivity was measured (RYTHER & MENZEL 1965), apparently associated with the eastward-flowing Somali Current. However RYTHER et al. (1966) found that productivity was still high during cruise V in the same area. An examination of the samples from that area (284–287) showed that thecate dinoflagellates did not contribute greatly to this high productivity, although there were the poorly-preserved remains of a small flagellate, coccolithophorids, and large amounts of detritus. Cruise II was undertaken off the west coast of India during the S.W. Monsoon, but the stations were further offshore than the coastal areas of upwelling and high productivity known to occur at such times (cf. BANSE 1968). Diatoms have been found to be a major constituent of such blooms. Increases in the number of species of dinoflagellates were found here near the island chains of the Laccadives and Maldives.

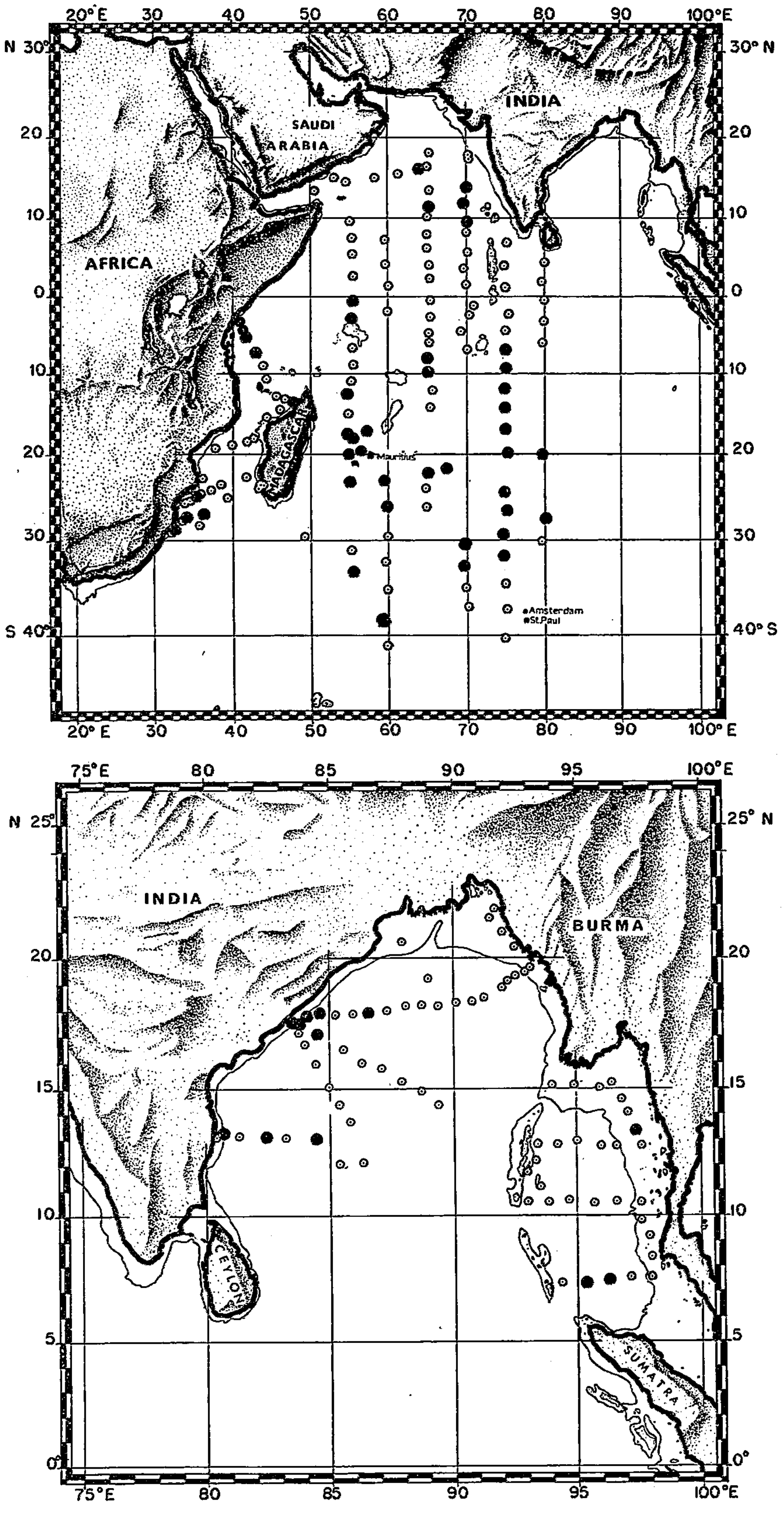

Chart 4. The Distribution of *Ceratium euarcuatum.*

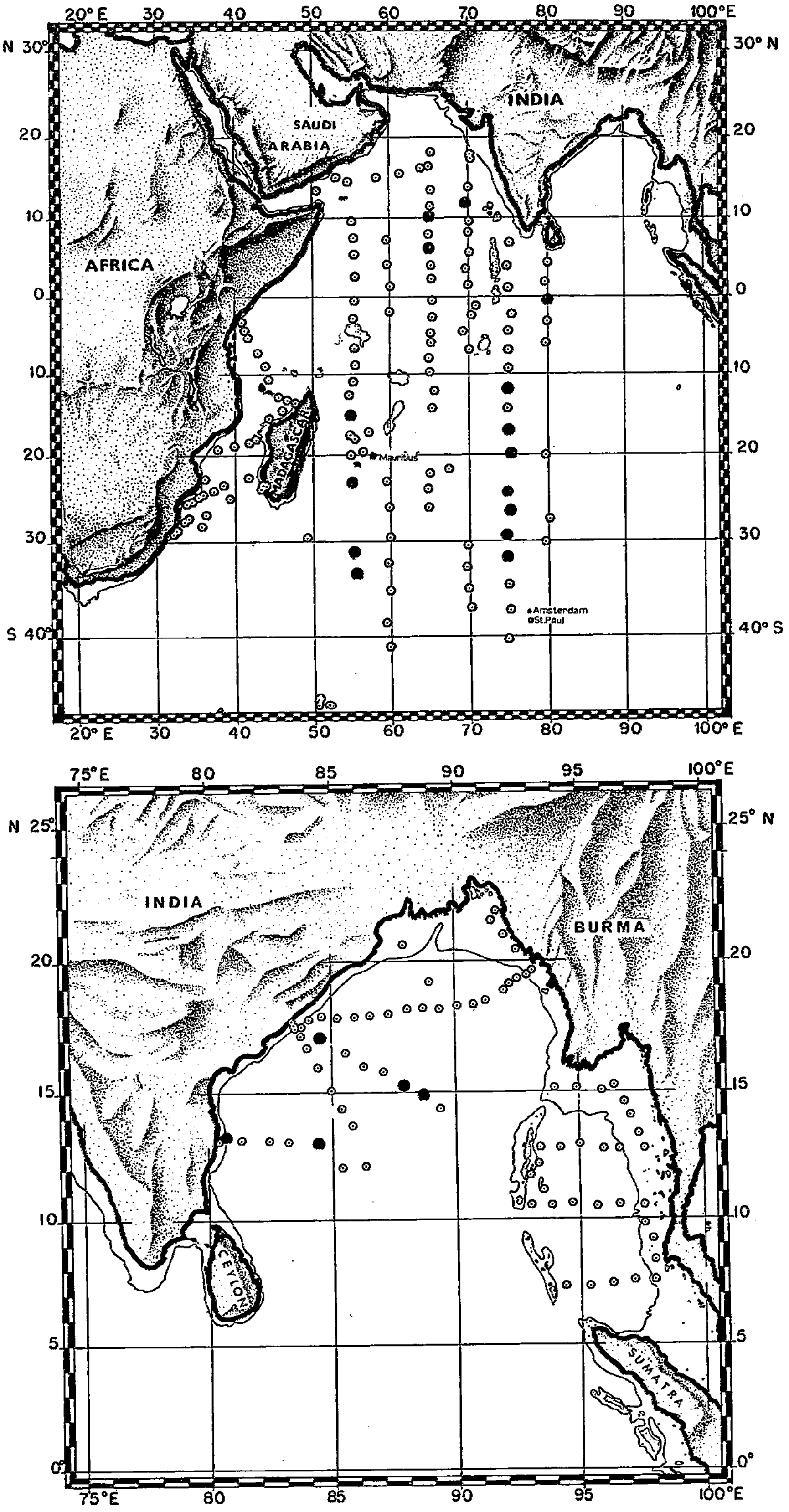

Chart 5. The Distribution of *Cladopyxis brachiolata.*