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Taxonomic notes on *Protoperidinium* (Peridiniales, Dinophyceae) species in the Thermaikos Bay (North Aegean Sea, Greece)

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Abstract

The thecal morphology and plate pattern of fourteen species of the genus Protoperidinium, found in the inner Thermaikos Bay (North Aegean Sea, Eastern Mediterranean) during the period 1989-1992, are described and discussed. These species are: P. depressum, P. oceanicum, P. oblongum, P. claudicans, P. punctulatum, P. conicum var. concavum ?, P. cf. obtusum, P. sp., P. brochi, P. divergens, P. curtipes, P. oviforme, P. pallidum and P. diabolus. Among the fourteen species, P. cf. obtusum and P. sp. are the most interesting from a taxonomic point of view. The morphology of the theca of each species combines features attributed in the current literature to two different species, P. obtusum and P. leonis. These features concern primarily the shape of the 1' plate and the morphology of the hypotheca. As a consequence of my findings, I believe that the morphology of the 1' plate and the sculpture of the epitheca may be too variable to be used to distinguish between P. obtusum and P. leonis. We also believe that P. obtusum, P. leonis as well as P. striatum require further clarification of their diagnostic characters. Taxa of similar morphology to P. sp. have been recorded in the literature and they may represent a new Protoperidinium taxon.

Keywords: *Protoperidinium*, Dinophyceae, systematics, morphology, Thermaikos Bay, North Aegean Sea.

Introduction

Protoperidinium is a large and ubiquitous genus of marine heterotrophic dinoflagellates. Species of this genus typically follow diatom blooms and are generally coastal in distribution (TAYLOR, 1990). *Protoperidinium* species have been found to feed on diatoms by means of extracellular digestion of their prey within a pseudopodial "feeding veil" (JACOBSON & ANDERSON, 1986).

Protoperidinium is characterized by the presence of a rigid cellulose wall ("theca") composed of a series of polygonal plates, the shape and arrangement of which is used extensively in the taxonomy of the genus. Important diagnostic characters used in the literature for the identification of *Protoperidinium* species include the shape of

the theca and its appendages, the shape of the 1', 2a and sulcal plates, the displacement and inclination of the cingulum, the ornamentation of the plates, the depth of the cingulum and sulcus and the color of the protoplasm of live cells (e.g. ABÉ, 1981; BALECH, 1988; DODGE, 1982; LEBOUR, 1925 & SCHILLER, 1937).

The present paper deals with the identification and description of fourteen *Protoperidinium* species from the inner Thermaikos Bay, a rather shallow (up to 45 m deep), semi-enclosed embayment of the northwestern Aegean Sea (Eastern Mediterranean). The bay is characterized by very strong seasonal signals in river run-off, heating and cooling and variable wind forcing. From May 1988 to April 1989, the temperature in the inner Thermaikos Bay ranged from 10 to 27 °C, whereas salinity varied from 24.5 to 34.5 ‰ (NIKOLAIDES & MOUSTAKA-GOUNI, 1990). The wastewater discharges of the city of Thessaloniki have frequently led to eutrophication problems that are predominantly manifested in the inner part of the bay, occasionally in the form of red tides of *Prorocentrum* and other dinoflagellate species. Intense blooms of *Mesodinium rubrum* (Lohmann) HAMBURGER & BUDDENBROCK, diatoms and coccolithophorids have also been observed in the bay (unpublished data).

Protoperidinium species are common among the heterotrophic members of the microplankton community of the inner part of the Thermaikos Bay, which is dominated by diatoms and dinoflagellates (NIKOLAIDES & MOUSTAKA-GOUNI, 1990). The occurrence of *Protoperidinium* species in the bay has been previously reported by ANAGNOSTIDIS (1968); GOTSIS-SKRETAS & FRILIGOS (1990); NIKOLAIDES & MOUSTAKA-GOUNI (1990); EVAGELOPOULOS & NIKOLAIDIS (1996). A total of 27 *Protoperidinium* taxa have been reported in lists in these investigations.

The dinophycean flora of the Aegean Sea is comparatively little known since the literature dealing with the phytoplankton of the Aegean Sea is rather scarce. Most of the studies deal with eutrophic gulfs of the Greek mainland and some of them include species lists (e.g. GOTSIS-SKRETAS & FRILIGOS, 1990; GUDENBERG, 1974; IGNADIATIS, 1984; NIKOLAIDIS & MOUSTAKA-GOUNI, 1990; UNEP/FAO, 1996). However, with very few exceptions (i.e. ECONOMOU - AMILLI, 1986; EVANGELOPOULOS & NIKOLAIDES, 1996), no taxonomic surveys of the dinophycean flora of the Aegean Sea appear to exist in the literature.

Materials and Methods

Phytoplankton samples were collected with a 55μm plankton net at a central station in the inner part of the Thermaikos Bay (Fig. 1) during the period 1989-1992. The samples were preserved with Lugol's solution or neutralized formaldehyde solution. The thecal plates were stained with a drop of hydroiodic acid solution and examined under oil immersion with a light microscope. The observation of the thecal plates was made possible by flattening the thecae by the application of light pressure on the coverslip.

The identification of the *Protoperidinium* species was based on monographs by ABÉ (1981); BALECH (1988); SCHILLER (1937), as well as many original papers by various authors.

All the figures in this paper represent Thermaikos Bay specimens. They were drawn with the aid of a camera lucida or photographed by the author.

Results and Discussion

Protoperidinium depressum (Bailey) Balech (Figs. 2-3, 34)

The theca is compressed and rounded at the plane of the cingulum; it also presents a

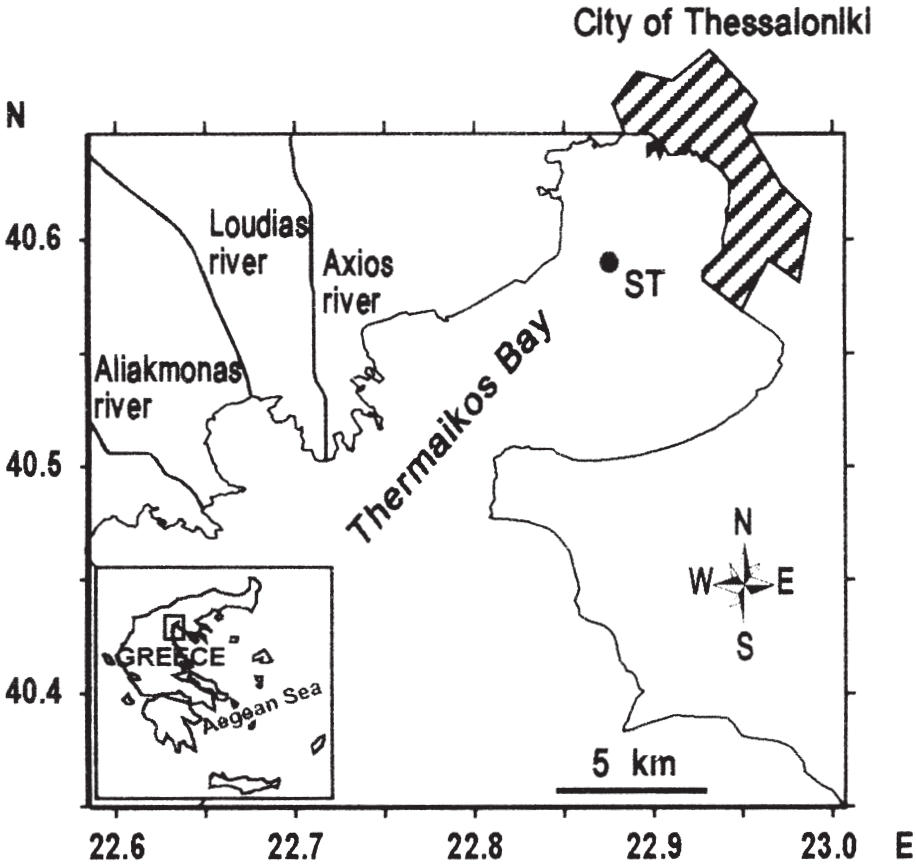


Fig. 1: Map of the Thermaikos Bay, showing the sampling station (ST).

strong ventral indentation that gives it a bilobial form. The epitheca forms a robust apical horn. The 1' plate is ortho-type whereas the 2a is quadra-type. The cingulum is narrow, left-handed, not excavated and bears wide lists. The left arc of the cingulum has an apical direction, whereas the right arc has an antapical direction. The hypotheca forms two robust, conical, pointed, diverging antapical horns. The left antapical horn is a little shorter than the right one. The sulcus is deep and forms a strong indentation of the antapical margin of the hypotheca, between the horns. The left sulcal list is well developed. The ornamentation of the plates is reticulated.

Theca length: 129-149 μm; width: 100-129 μm.

Protoperidinium oceanicum *(Vanhöffen) Balech (Figs. 4-6, 35)*

The theca is centrally rounded. The epitheca forms a long apical horn. The 1' plate is ortho-type, whereas the 2a plate is quadra-type. The cingulum is narrow, left-handed, not excavated and bears wide lists. The hypotheca forms two long, tubular, pointed, somewhat diverging antapical horns. The left one is a little shorter and thinner than the right. The sulcus is deep and forms a strong indentation of the antapical margin of the hypotheca, between the horns. The ornamentation of the theca is reticulated with spiny junctions.

Theca length: 163-187 μm; width: 86-102 μm.

Protoperidinium oblongum *(Aurivillius) Parke & Dodge (Figs. 7-9, 36)*

The theca is centrally rounded and dorso-ventrally compressed. The epitheca forms an apical horn. The 1' plate is ortho-type, whereas the 2a is quadra-type. The cingulum is left-handed and not excavated. The hypotheca forms two long, tubular, pointed, somewhat diverging antapical horns. The left one appears in some specimens to be a little shorter than the right. The sulcus is deep and forms a strong indentation of the antapical margin of the hypotheca, between the horns. The ornamentation of the plates is reticulated.

Theca length: 82-115 μm; width: 53-71 μm.

Taxonomic remarks

Some authors, for example LEBOUR (1925) or DODGE (1982), have regarded *P. oblongum* as a different species from *P. oceanicum*, mainly because of its shorter dimensions, less elongated body form and neritic distribution in comparison to the oceanic latter species. Others, for example HALIM (1967) or BALECH (1988), have regarded *P. oblongum* merely as a neritic variety of *P. oceanicum*.

Our findings corroborate the distinction of *P. oceanicum* and *P. oblongum* as two separate species. In the Thermaikos Bay, *P. oceanicum* is bigger and more elongated than *P. oblongum*. Moreover, the middle part of *P. oceanicum* appears more globular and the horns more slender than in *P. oblongum*. No forms of intermediate size have been observed.

Protoperidinium claudicans *(Paulsen) Balech (Figs. 10-11, 37)*

The theca is centrally rounded. The epitheca forms a short apical horn. The 1' plate is ortho-type, whereas the 2a is penta-type. The cingulum is left-handed and not excavated. The hypotheca forms two relatively short, tubular, pointed antapical horns with the left one being always shorter than the right. The sulcus forms a shallow indentation of the antapical margin of the hypotheca, between the horns. The ornamentation of the theca is reticulated.

Theca length: 77-89 μm; width: 51-60 μm.

Protoperidinium punctulatum *(Paulsen) Balech (Figs. 12-14, 38-40)*

The epitheca has a conical form. The 1' plate is ortho-type, whereas the 2a plate is penta or hexa-type. The cingulum is circular and excavated, whereas its lists are indistinct. The hypotheca is hemispherical with an antapical indentation formed by the sulcus; its height is similar or a little shorter than that of the epitheca. The sulcus is deep and narrow and widens only a little at its lowest part, forming a rounded lower margin; it extends to the antapical surface of the hypotheca. The ornamentation of the theca consists of small, robust spines.

Theca length: 48-58 μm; width: 53-64 μm.

Taxonomic remarks

In the Thermaikos Bay, *P. punctulatum* specimens have a rounded, not abruptly widened lower part of the sulcus that is, according to BALECH (1971), the most important character that distinguishes this species from *P. subinerme* (Paulsen) Balech and other related taxa.

Protoperidinium conicum *(Gran) Balech* ***var. concavum*** *Matzenauer ? (Figs. 15-16, 41)*

The epitheca has a conical form and straight lateral sides. The 1' plate is ortho- type and wide; the sutures of its two upper sides are contiguous with the two sutures between the 1", 2" and 6", 7" plates, respectively; its two lowest sides are concave. The 2a plate is hexa-type. Its lowest two lateral sides are very short. The cingulum is circular and excavated. The hypotheca has concave lateral sides and forms two robust antapical horns with spines at their tips. The lateral margins of the horns are convex. The sulcus is deep and forms a strong indentation of the antapical margin of the hypotheca, between the horns. The

ornamentation of the theca is reticulated with spiny junctions.

Theca length: 73-91 μm; width: 65-81 μm.

Taxonomic remarks

The distinction of *P. conicum* var. *concavum* from the type species (*P. conicum*) is based on the form of the lateral sides of both the epitheca and hypotheca, i.e. concave in the variety, straight in the type species (MATZENAUER, 1933).

Of the Thermaikos Bay specimens, only the hypotheca has concave lateral sides. Specimens with similar thecal morphology have also been reported by BALECH (1988).

Protoperidinium cf. obtusum *(Karsten) Parke & Dodge (Figs. 17-19, 42-43)*

The epitheca has a conical shape. The 1' plate is ortho-type, wide and symmetrical or slightly asymmetrical, with the upper triangle being slightly shorter than the lower one. The 2a plate is hexa-type. The cingulum is left-handed, inclined and excavated. The hypotheca forms two short antapical horns with small spines at their tips. The 1''' plate is more elongated than the 5'''. The hypotheca has a reticulated ornamentation with spiny junctions, whereas the ornamentation of the epitheca is intermediate between a reticulated and a striated type.

Theca length: 60-80 μm; width: 57-77 μm.

Taxonomic remarks

P. obtusum, as well as other species of similar morphology, such as *P. leonis* (Pavillard) Balech and *P. striatum* Böhm, require further clarification of their diagnostic characters, since they have often been confused in the literature and their state is still uncertain. The diagnostic characters that have most commonly been used for the identification of the members of this species complex include the shape of the 1' plate, the inclination and displacement of the cingulum, the shape of the hypotheca and of the sulcal plates and the sculpture of the thecal plates.

In the original drawings by KARSTEN (1906) for *P. obtusum*, the surface of the epitheca has longitudinal striations, the cingulum is inclined and the theca is ventrally depressed. However, Karsten misinterpreted the epitheca form as being apically rounded (ABÉ, 1981). *P. obtusum* is also considered to have an asymmetrical 1' plate, a descending cingulum and rudimentary antapical horns (BALECH, 1988).

According to the original description by PAVILLARD (1916), *P. leonis* has well developed antapical horns, with strong spines at their tips, and the cingulum is perpendicular to the longitudinal axis of the theca. The theca is only slightly depressed ventrally: the cingular section is almost rounded. *P. leonis* is also considered to have a symmetrical 1' plate (ELBRÄCHTER, 1975).

P. striatum, according to the original description by BÖHM (1931), is different from *P. obtusum* because it does not have an apically rounded epitheca; it is also different from *P. leonis* because of the striated surface of the epitheca. Judging from the original drawings, this species also has a narrow 1' plate and an oblique and descending cingulum. However, due to the misinterpretation by KARSTEN, the shape of the epitheca can not be used to distinguish between *P. obtusum* and *P. striatum*. Therefore, the state of *P. striatum* is rather uncertain.

Despite the current, rather well established view that *P. obtusum* and *P. leonis* are distinguished mainly by the shape of the 1' plate and the sculpture of the epitheca, different approaches are often encountered in the literature:

In HANSEN & LARSEN'S (1992) illustration of *P. leonis*, the 1' plate is clearly asymmetrical and STEIDINGER & TANGEN (1996) describe *P. obtusum* and *P. leonis* as both having a 1' plate with shorter anterior margins.

ABÉ (1981) described a Pacific form of *P. obtusum* with an oblique and descending cingulum, small antapical "cones" and a deep

ventral depression on the theca. However, he does not comment on the symmetry of the 1' plate, the shape of which is symmetrical in his drawings. The thecal wall is covered with coarsely polygonal meshes, but the precingular plates have many longitudinally arranged ridges in earlier stages of growth. Abé's figures are very similar to BALECH'S (1988) for *P. obtusum*, with the exception of the shape of the 1' plate. Nonetheless, according to BALECH (1994), *P. obtusum sensu* Abé is not *P. obtusum* Karsten and might be *P. okamurai* Yoneda & Marukawa.

ABÉ (1981) also described a Pacific form of *P. leonis* with a 1' plate that has symmetrical premedian lateral angles. The cingulum is oblique and descending and the theca is ventrally flattened at the height of the cingulum. The posterior part of the sulcus is much larger than that of his Pacific form of *P. obtusum*. The thecal wall is covered with coarsely polygonal meshes. Nonetheless, Abé's form can not be regarded as *P. leonis* because of the asymmetrical 1' plate and the oblique cingulum.

The specimens of the Thermaikos Bay identified as *P.* cf. *obtusum* have an inclined cingulum, rudimentary antapical horns and spines, a hypotheca outline and a sulcus area of similar morphology to that of *P. obtusum*. (see drawings by BALECH, 1988 and ABÉ, 1981). Nevertheless, they have an 1' plate that is symmetrical, like *P. leonis*, or slightly asymmetrical. Furthermore, the precingular plates have an ornamentation that consists of longitudinally elongated meshes and thus cannot be considered either of the striated nor of the reticulated type.

To sum up, the morphology of the 1' plate and the sculpture of the epitheca may be too variable to be reliable diagnostic characters for the identification of *P. obtusum* or *P. leonis*. In our opinion, the morphology of the sulcus area and the general morphology of the hypotheca could be more valuable for the identification of both *P. obtusum* and *P. leonis*. The same emphasis on the importance of the morphology of the sulcus area to the taxonomy of the armoured dinoflagellates has been indicated in other genera, too (ABÉ, 1981; BALECH, 1988; GRAHAM, 1942).

***Protoperidinium* sp.** *(Figs. 20-22, 44-45)*

The epitheca has a conical shape. The 1' plate is ortho-type, narrow and strongly asymmetrical: the upper triangle is much shorter than the lower and the right triangle is longer than the left one. The 2a plate is hexa-type. The cingulum is slightly left-handed, inclined and excavated. The hypotheca forms two conical, often diverging antapical horns with spines at their tips. The hypotheca has reticulated ornamentation with spiny junctions, whereas the epitheca has striated ornamentation.

Theca length: 51-78 μm; width: 44-64 μm.

Taxonomic remarks

The morphology of the specimens from the Thermaikos Bay does not conform well with the original descriptions of *P. obtusum* or *P. leonis* either. This is mainly due to the combination of a very asymmetrical and narrow 1' plate, the striated epitheca, an inclined cingulum, a cell body somewhat longer than broader and the well-developed antapical horns with robust terminal spines.

Several taxa reported in the literature have identical morphology with that of the specimens from the Thermaikos Bay. Such examples are JACOBSON'S (1987) *Protoperidinium* sp. *A* from Massachusetts or MARTIN'S (1929) *P. leonis* from New Jersey. The figures published by SCHILLER (1937) for *P. leonis* f. *matzenaueri* (Matzenauer) Schiller from the Indian Ocean and by SUBRAHMANIAN (1971) for *P. marielebourae* (Paulsen) Balech, *P. leonis* and *P. leonis* f. *matzenaueri* also from the Indian Ocean, represent taxa that are in evident contradiction with Pavillard's description and drawings for *P. leonis*. However, they are identical to *P.* sp.

P. sp. probably represents a new *Protoperidinium* species that belongs to the *P. obtusum-P. leonis* species complex and is easily distinguished by its elongated and very asymmetrical 1' plate. This species combines features considered characteristic of *P. obtusum* (e.g. the asymmetry of the 1' plate) and *P. leonis* (e.g. the well-developed antapical horns). However, a description of the sulcal plates is needed for the determination of the status of this species. Such a description was not possible in this study due to lack of suitable material.

Protoperidinium brochi *(Kofoid & Swezy) Balech (Figs. 23-24, 46)*

The theca is centrally rounded. The epitheca forms an apical horn. The 1' plate is meta-type, whereas the 2a is quadra-type. The cingulum is very slightly right-handed and not excavated. The hypotheca forms two conical and diverging antapical horns. The sulcus is deep and forms a strong indentation of the antapical margin of the hypotheca, between the horns; it is wider at its central part and the Sd plate extends to the right, outside the sulcal furrow. The ornamentation of the theca is reticulated with spiny junctions.

Theca length: 73-92 μm; width: 49-64 μm.

Protoperidinium divergens *(Ehrenberg) Balech (Fig. 47)*

The theca is centrally angular. The epitheca forms an apical horn. The 1' plate is meta-type, whereas the 2a is quadra-type. The cingulum is circular and excavated. The hypotheca forms two conical and diverging antapical horns. The sulcus is deep and forms a strong indentation of the antapical margin, between the horns; it is wider at its central part and the Sd plate extends to the right, outside the sulcal furrow. The ornamentation of the theca is reticulated with spiny junctions.

Theca length: 75-95 mm; width: 50-65 mm.

Protoperidinium curtipes *(Jörgensen) Balech (Figs. 25-27, 48)*

The theca is compressed and angular at the plane of the cingulum. The epitheca forms an apical horn. The 1' plate is meta-type, whereas the 2a plate is quadra-type. The cingulum is slightly left-handed and excavated. The hypotheca forms two conical antapical horns with robust spines at their tips. The left horn is somewhat shorter than the right one. The sulcus is deep and forms a strong indentation of the antapical margin of the hypotheca, between the horns; it is wider at its central part and the Sd plate extends to the right, outside the sulcal furrow. Between the antapical protrusion of the left sulcal list and the spine of the left antapical horn, there is one more spine-like protrusion. The ornamentation of the plates is reticulated.

Theca length: 95-107 μm; width: 77-96 μm.

Taxonomic remarks

P. curtipes is a species similar to *P. crassipes* (Kofoid) Balech. Although they have been considered in the past as conspecific, they are currently regarded as two distinct species (DODGE, 1982). PAULSEN (1930) considers the cingulum region as a distinctive character between the two species: In *P. curtipes* the cingulum is symmetrical and circular, whereas in *P. crassipes* it is asymmetrical and left-handed (one or more cingulum widths). MATZENAUER (1933) states that *P. curtipes* is more intensely compressed at the plane of the cingulum and the apical horn is more abruptly formed than in *P. crassipes*. The specimens from the Thermaikos Bay are characterized by an abruptly formed apical horn and an almost circular cingulum. Therefore, they should be classified as *P. curtipes*.

Protoperidinium oviforme *(Dangeard) Balech (Figs. 28-29, 49)*

The theca has an ovoid shape. The epitheca forms a neck-like protrusion. The 1' plate is meta-type, whereas the 2a plate is penta-type. The anterior intercalary plates are relatively large-sized and the whole series is shifted

towards the left side. The cingulum is right-handed, not excavated and it tilts up ventrally instead of dorsally. The hypotheca bears two solid spines furnished with wings. The sulcus is quite wide and shallow with a well - developed left sulcal list, that protrudes antapically and merges with the left spine. At the lowest part of the sulcus lies the ovoid flagellar pore.

Theca length: 72-80 μm; width: 40-46 μm.

Protoperidinium pallidum *(Ostenfeld) Balech (Figs. 30-31, 50)*

The epitheca has an almost conical shape and forms a short apical horn. The 1' plate is para-type, whereas the 2a plate is hexa-type. The cingulum is right-handed and not excavated and it bears wide lists. The hypotheca is hemispherical with a concave antapical margin and two solid antapical spines with wings. The left spine appears somewhat shorter than the right one. The sulcus is deep; it widens at its lowest part and is furnished with a well-developed left sulcal list that protrudes antapically, where it merges with the wings of the left antapical spine.

Theca length: 97-116 μm; width: 62-71 μm.

Protoperidinium diabolus *(Cleve) Balech (Figs. 32-33, 51)*

The theca is pear-shaped. The epitheca forms an apical horn. The 1' plate is para-type, whereas the 2a is hexa-type. The cingulum is slightly right-handed, not excavated and bears wide lists. The hypotheca is hemispherical and bears two solid antapical spines furnished with wings. The sulcus is shallow, it widens at its lowest part and bears a well-developed left sulcal list that protrudes antapically near the left spine, where it merges with its wings.

Theca length: 97-106 μm; width: 56-63 μm.

Taxonomic remarks

According to BALECH (1976), *P. diabolus* has an apical horn with a broad base and a concave antapical margin. Moreover, a minute pore lies on 1''' plate that has been observed by both BALECH (1976) and ECONOMOU-AMILLI (1986).

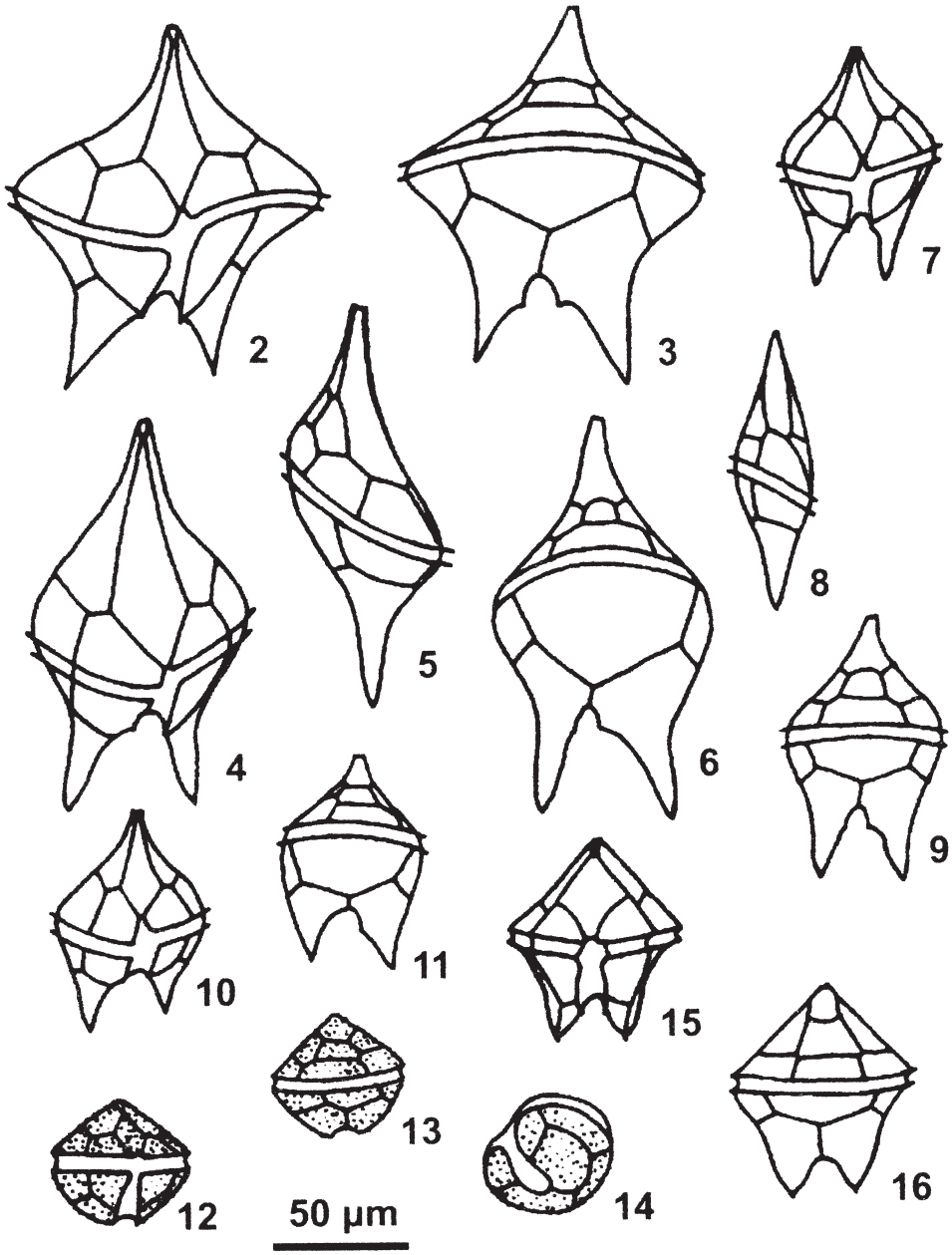
The Thermaikos Bay specimens conform well to the description of *P. diabolus* proposed by BALECH (1976), with the exception of the pore of the 1''' plate that has not been observed.

Conclusions

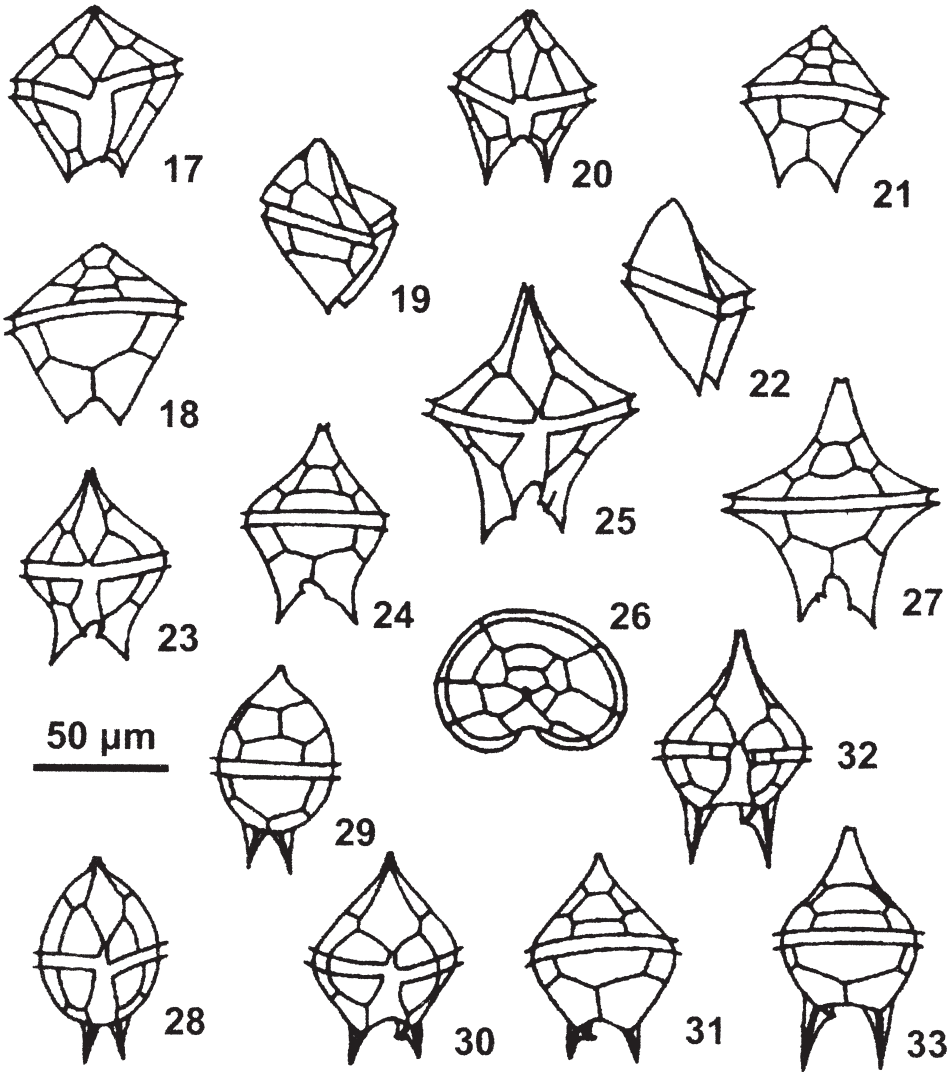
Among the *Protoperidinium* species that have been described and commented on, *P.* cf. *obtusum* and *P.* sp. are, undoubtedly, the most interesting from a taxonomic point of view:

P. cf. *obtusum* combines features attributed in the current literature to two different species, *P. obtusum* (e.g. the morphology of the hypotheca) and *P. leonis* (e.g. the symmetrical or slightly asymmetrical 1' plate). I believe that *P. obtusum*, as well as other species of similar morphology such as *P. leonis* and *P. striatum*, require further clarification of their diagnostic characters, since they have often been confused in the literature and their taxonomic state is still uncertain. I also believe that the morphology of the 1' plate and the sculpture of the epitheca may be too variable to be reliable diagnostic characters for the identification of *P. obtusum* or *P. leonis*. The morphology of the sulcus area and the general morphology of the hypotheca could be, in my opinion, more valuable for the identification of both *P. obtusum* and *P. leonis*.

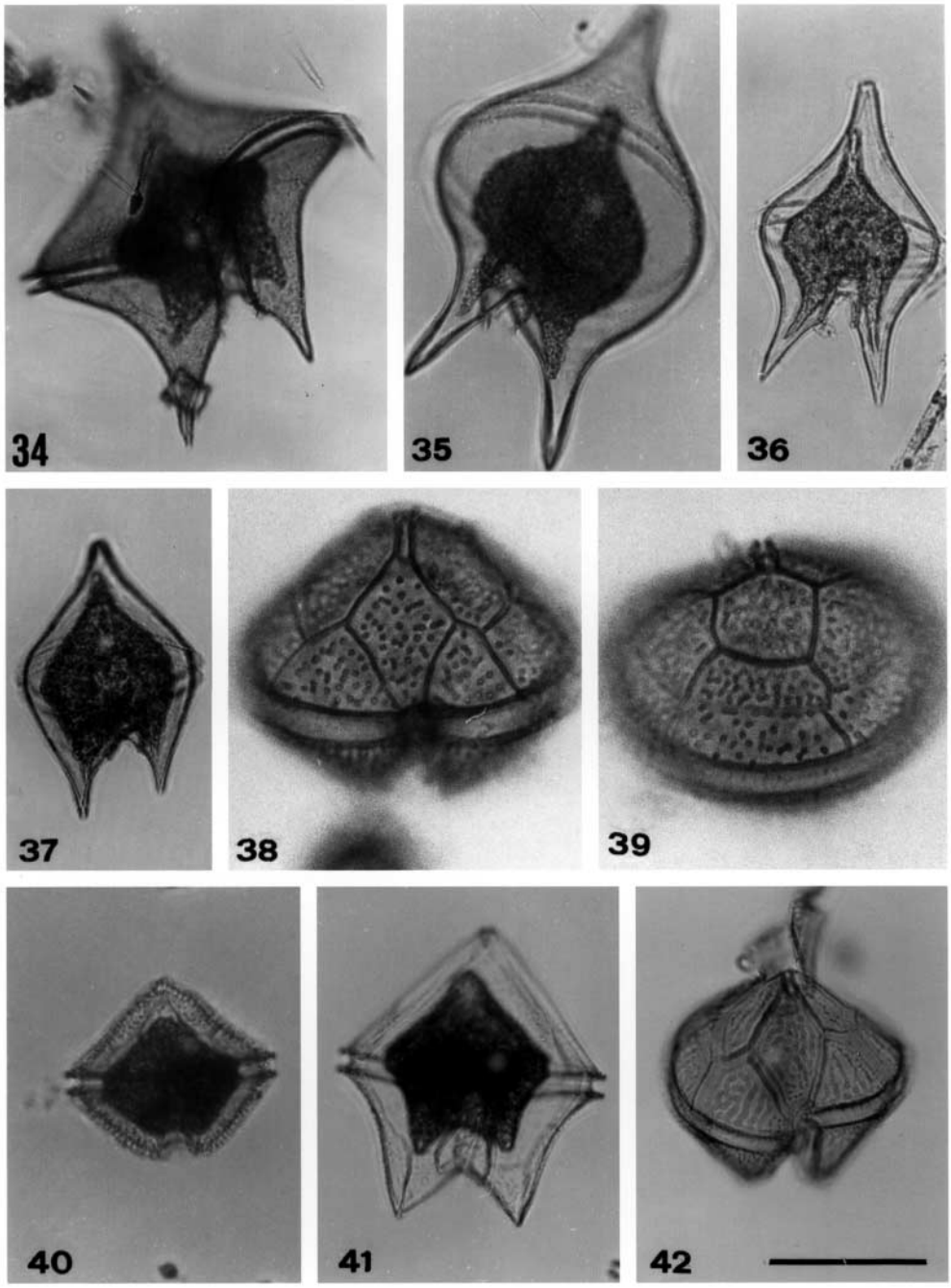
P. sp. probably represents a *Protoperidinium* taxon new to the science that belongs to the *P. obtusum-P. leonis* species complex and is easily distinguished by its elongated and very asymmetrical 1' plate. This taxon, like the aforementioned *P.* cf. *obtusum*, combines features attributed in the current literature to *P. obtusum* (e.g. the asymmetry of the 1' plate) and *P. leonis* (e.g. the well developed antapical horns). However, a description of the sulcal plates is needed for the determination of its taxonomic status.



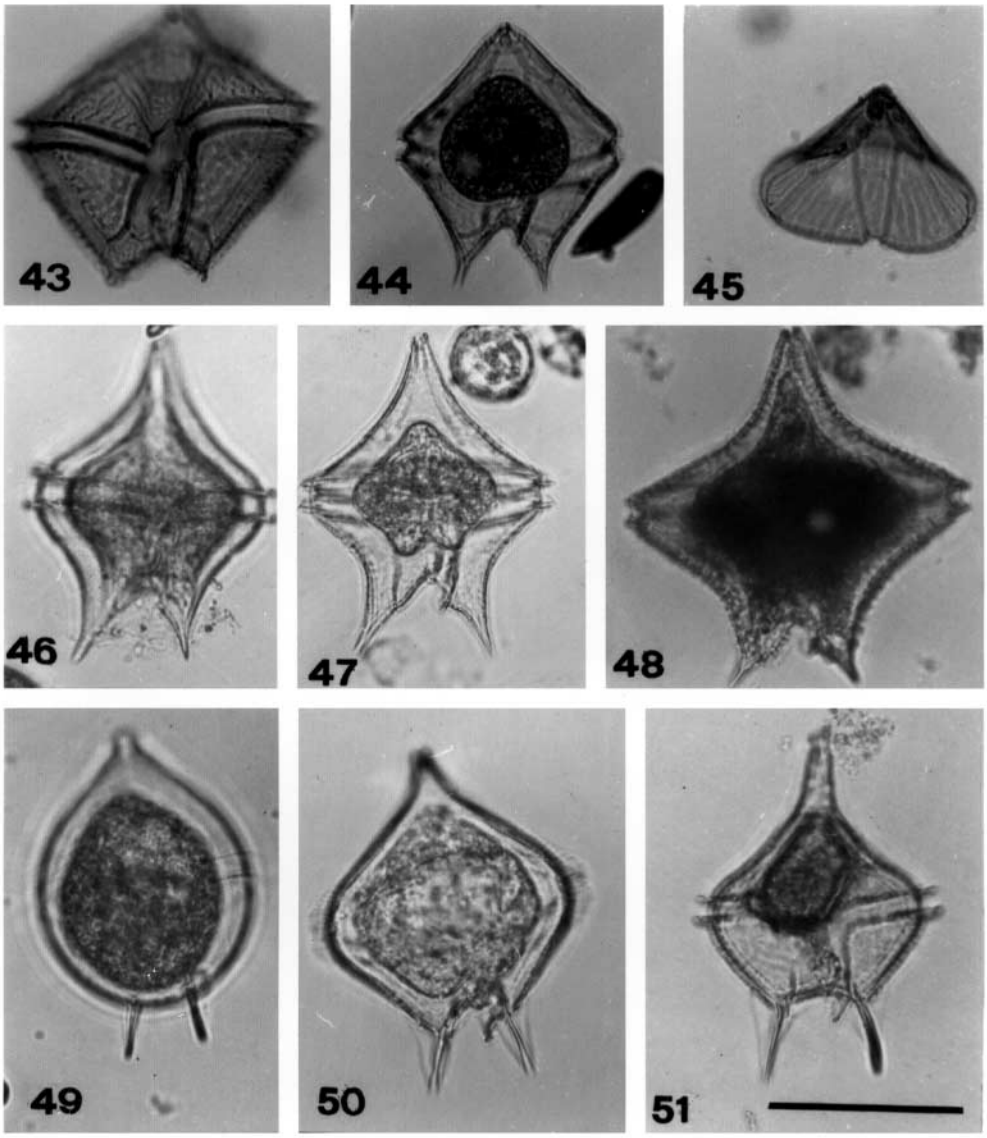
Figs 2-16: Theca outlines and plate patterns of *Protoperidinium* species in the Thermaikos Bay: Figs. 2-3. *P. depressum*, Figs. 4-6. *P. oceanicum*, Figs. 7-9. *P. oblongum*, Figs. 10-11. *P. claudicans*, Figs. 12-14. *P. punctulatum*, Figs. 15-16. *P. conicum* var. *concavum* ?



Figs. 17-33: Theca outlines and plate patterns of *Protoperidinium* species in the Thermaikos Bay: Figs. 17-19. *P.* cf. *obtusum*, Figs. 20-22. *P.* sp., Figs. 23-24. *P. brochi*, Figs. 25-27. *P. curtipes*, Figs. 28-29. *P. oviforme*, Figs. 30-31. *P. pallidum*, Figs. 32-33. *P. diabolus*.



Figs. 34-42: *Protoperidinium* species in the Thermaikos Bay: Fig. 34. *P. depressum*, Fig. 35. *P. oceanicum*, Fig. 36. *P. oblongum*, Fig. 37. *P. claudicans*, Fig. 38. *P. punctulatum*, ventral view of the epitheca, Fig. 39. *P. punctulatum*, dorsal view of the epitheca, Fig. 40. *P. punctulatum*, ventral view of the theca, Fig. 41. *P. conicum* var. *concavum* ?, Fig. 42. *P.* cf. *obtusum*, ventral view of the epitheca. Scale bar = 50 μm (Figs. 34-37, 40-42) or 85 μm (Figs. 38-39).



Figs. 43-51: *Protoperidinium* species in the Thermaikos Bay: Fig. 43. *P.* cf. *obtusum*, ventral view of the hypotheca, Fig. 44. *P.* sp., Fig. 45. *P.* sp., ventral view of the epitheca, Fig. 46. *P. brochi*, Fig. 47. *P. divergens*, Fig. 48. *P. curtipes*, Fig. 49. *P. oviforme*, Fig. 50. *P. pallidum*, Fig. 51. *P. diabolus*. Scale bar = 50 μm.

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