REPORT OF THE BIOLOGICAL SURVEY OF MUTSU BAY*

29. NOTES ON THE PROTOZOAN FAUNA OF MUTSU BAY

II. GENUS *PERIDINIUM*; SUBGENUS *ARCHAEPERIDINIUM*

By

TOHRU HIDÉMITI ABÉ

Zoological Institute, Faculty of Agriculture, Tokyo Imperial University

(With one hundred and two figures)

(Received October 25, 1935)

CONTENTS

INTRODUCTION

The genus *Peridinium* is one of the largest and most highly specialized groups of the Peridinidae, exhibiting marked morphological diversities not only in the body form but also in the development of the antapical spine, horn and list, in the plate pattern and the plate formula of the theca and in the extent of the ventral area or the longitudinal furrow. These wide

* Contribution from the Marine Biological Station, Asamushi, Aomori-ken. No. 132.

diversities naturally invites the student to subdivide the genus. There have been many investigators who proposed new classification of the genus or suggestions of one, such as PAULSEN (1908, 1913 and 1931), FAURÉ-FREMIET (1908), KOFOID (1909), BROCH (1910), JÖRGENSEN (1912), OSTENFELD (1915), BARROW (1918), LEBOUR (1922, 1925), DANGEARD (1927) and PETERS (1928). Earlier observors like SCHÜTT, BERGH and GRAN, emphasized the form of the antapical horns and the manner of the girdle displacement as subgeneric characters, and PAULSEN has followed them. But later observors all followed JÖRGENSEN in laying special weight upon the combination of the ventral and dorsal plate patterns of the epitheca. JÖRGENSEN's system has, in the main, been most widely accepted with partial alterations by subsequent investigators. He created the genus *Archaeperidinium* for species having two dorsal intercalary plates instead of three, but LEBOUR has reduced it to a subgenus and PETERS and PAULSEN agree with her. PAULSEN (1931) has divided the subgenus into two sections, Avellana and Excentrica, on the basis of the relative size of the two intercalary plates, and though he has taken many other external characters into account for the establishment and characterization of his sections, they can not be said to have received as yet a clear-cut difinition; and I propose here certain fundamental modifications of subgeneric diagnosis, which appears to me necessary from my own study.

Except by the early observors, the combination of the ventral and dorsal plate patterns of the epitheca has been used as a most fundamental character for subdivision, to the exclusion of hypothecal characters, such as the antapical horn or spine and the ventral furrow. The postcingular and antapical plates constituting the hypotheca have been believed to be conservative elements not subject to numerical change in the different species of the genus, but all the precingular, and especially the apical and intercalary series of plates to display marked variability in number and arrangement in many species. My own observations have shown the general formula of this genus to be 3–5′, 0–8_a, 6–8″, 5–6‴, 2–3⁗. *Peridinium clavus*, to be described in this paper, presents notable variability of plate number both in the epitheca and hypotheca and has the plate formula of 4–5′, 1–2_a, 7–8″, 5‴, 2–3⁗. The ventral plate pattern of the epitheca is not always constant for a certain species, and two kinds of it, "para" and "meta", had been reported in *P. divergens*, *P. granii* and *P. oceanicum*. The shape and the relative position of the middorsal intercalary plate 2_a, which, coupled with the ventral plate pattern, has been regarded as a most reliable basis for subdivision of the genus, are

also variable. According to MEUNIER (1910, 1919), LEBOUR (1922, 1925) and DANGEARD (1927), *P. ovatum* has two kinds of dorsal plate pattern, and similar variations are not rare in the genus. Therefore, no one of the characters referred to above affords adequate basis for the subdivision in view, being subject to great modifications in many species and all present in varying degrees in most species of the genus.

Furthermore, if these characters be made the basis of subgeneric diagnosis, as previous investigators have done, one would have to exclude from the genus many freshwater species having one or no intercalary plate and some varieties with an abnormal number of intercalary plates.

The girdle and the ventral area are not only the distinguishing characters of the Dinoflagellates, but also have fundamental relations to the morphology and phylogeny of the group. The ventral area of *Peridinium* has profound effects upon the structure of the hypotheca which exhibits some form variations referable to several types. Accordingly it is natural to assume that the skeletal morphology of these parts of the body having direct relations with the motile organ serves to afford above all a reliable basis for the subdivision of the genus. It is hard to suppose that in the presence of so many prominent variable characters as those directly or indirectly correlated with the motile organ, some of the vegetative body parts outside the ventral area should have been selected to direct the progress of evolution. A detailed examination only serves to emphasize this conclusion, and it may be added that a thorough analysis of the cingulum and the ventral area is exceedingly difficult on account of their complexity but especially of their diversity, the small size of the constituent plates and their firm adhesion one to another.

The cingulum of this genus is relatively simple in structure and in its plate pattern. But the ventral area exhibits marked variations not only in its structure, extent and form as a whole, but also in its plate pattern and development of its side lists coupled with those of the antapical appendages. The ventral furrows of *P. avellana* and *P. oceanicum* are similar in being compact and deeply excavated, but differ profoundly in plate pattern and structural relations; *P. conicum* and *P. pentagonum* differ from them in having an expanded ventral area.

So far, we have had no detailed description or accurately analysed figure of the ventral area of the genus *Peridinium*, except those of *P. steini* by KOFOID. But the plates of the ventral area are indicated in part in WOLOSZYNSKA's figures of freshwater species, and the expanded posterior plate of the ventral area is plainly illustrated in most of the published

figures of *P. divergens*, *P. pentagonum* and allied species.

Thus the ventral area of *Peridinium* exhibits wide diversity in structure and is to be regarded as the most highly specialized, and functionally, morphologically and genetically important, part of the skeleton. Disregarding these facts, previous observors have wholly neglected the ventral area in the matter of subdiving the genus. This is presumably due to the fact that the plate pattern of the epitheca was overestimated by JÖRGENSEN and his followers, that these patterns can be easily detected and definite numbers of combinations of its ventral and dorsal patterns distinguished, and that certain sets of these combinations are easily misconstrued as having definite relations with some other thecal structures. It may be said that the intrinsic difficulty of analysing the ventral area has served to divert the attention of investigators to characters of less importance.

Thus recognizing the fundamental importance of the skeletal morphology of the ventral area for the taxonomy of the genus, and finding three intercalary plates in some species whose ventral area exhibits a fundamental similarity with that of another species undoubtedly to be included in *Archaeperidinium*, I feel constrained to include these species with three intercalaries in the subgenus *Archaeperidinium*, in disregard of the widely accepted definition of the subgenus, and necessitating an alteration of subgeneric definition. My observations have led me to conclude that the plate pattern and structural relation of the ventral area constitutes the most ready means not only of distinguishing this genus from any other of the Peridinidae, but also of any group or section of this genus from the others.

With regard to KOFOID's account of *P. steinii* already referred to, it seems to me highly probable that he did not analyse the ventral area into separating its component elements, but distinguished "the subdivisions of this region" merely by the sutures, as may be seen from his statements that the boundaries of the subdivisions "are marked only by faint ridges and a slight change in the texture of the wall", and that "they are to be regarded as plates of small size and subordinate relations." But in my opinion, the plates that go to make up the ventral area can be determined with certainty only by their actual separation in species having a deeply excavated or complicated ventral fullow, like those of the Avellna group.

PURPOSE AND SCOPE OF THIS PAPER

This paper embodies some of the results of my investigations on *Peridinium* from Asamushi, carried out for several years with interruptions. The source of the material is primarily the plankton collected in Mutsu Bay by Dr. S. KOKUBO during the early springs of 1925, 1926 and 1927, and in the summer of 1927, and certain collections made by myself in the Inland Sea in the summer of 1930. In this paper are described three groups and ten species of which six species are new, and one previously described species, *Spherodinium asymmetrica*, has been transferred to the genus *Peridinium*. Another species in the same materials but of another season will be described later.

ACKNOWLEDGEMENT

Grateful acknowledgement is here made to Prof. T. KABURAKI for the privilege of a research table under his control, and my special thanks are tendered to Prof. S. GOTO* for his kindness in revising this paper at my request. And above all I have to thank Prof. K. OKAMURA* for his kindness in placing all his literature on Dinoflagellates and Microplankton at my disposal; but for his help I could not have brought this paper to the present state of completeness. I should like to express my hearty thanks to Prof. S. HATAI and Prof. S. HÔZAWA for helpful suggestions and interests they have given me during the progress of the work, and sincere gratitude is here also expressed to The SAITO Hoonkai for the financial aid to my exploration at the Asamushi Biological Station and also for the publication of this manuscript.

Subgenus *Archaeperidinium* (LEBOUR)

Unlike PAULSEN and others, I would limit the extent of this subgenus to species having definite morphological differentiation of their ventral area to be described further on.

This subgenus includes species with globular body of various sizes, without antapical spines or horns. The apical horn is absent or is small but sharply differentiated. The cingulum is deeply concave or flat, with corrugated or smooth wall, and is circular or descending. The ventral area forms either a deeply concave longitudinal furrow withaut prominent

* It is a sorrowful duty that I have to express my hearty condolence to late Prof. S. GOTO and Prof. K. OKAMURA who died shortly before the press of this manuscript.

side list and reaching to the antapex, or the side lists may be low and the ventral area may be flat and short, the flagellar pore bearing a large fan-shaped wing projecting sinistro-ventrally from its right edge, the reverse of what occurs in *Diplopsalis*. The plate formula is 4–5′, 1–3$_a$, 7–8″, 5‴, 1–2⁗. The anterior intercalary plates are normally two in number in the majority of species, and one large plate may appear as a variation in certain species, while three plates occur as a definite character in certain other species. Three groups or sections Avellana, Monovela and Excentrica, based npon the skeletal morphology of the ventral area, are distinguished in this subgenus. The first two groups with still unsettled characters suggest some close genetic relationship between themselves, while the third is an independent group with well fixed characters and of different genetic relationship, and its inclusion in this subgenus is an arbitrary procedure based primarily on the presence of two anterior intercalary plates.

PAULSEN (1931) includes seven species in his Avellana section, and two in the Excentrica section, as follows: —

Section I. Avellana. *P. abéi* (*P. biconicum* ABÉ 1927, non *P. biconicum* DANGEARD, April 1927), *avellana* MEUNIER, *levanderi* ABÉ, *minutum* KOFOID (*monospinum* PAULSEN), *quinquecorne* ABÉ (?), *thorianum* PAULSEN, *ventricum* ABÉ.

Section 2. Excentrica. *P. excentricum* PAULSEN, *groenlandicum* WOLOSZYNSKA.

The system proposed in this paper is as follows: —

I. Group Avellana (PAULSEN). Type species is *P. avellana*. This includes most of the known marine species of *Archaeperidinium* with deeply indented ventral area occupied by four symmetrically arranged plates.

II. Group Monovela. Type species is *P. monovelum*, n. sp. The known species to be included in this group are *P. minutum* and *P. monospinum*, the latter according to PAULSEN identical with the former.

III. Group Excentrica (PAULSEN). Type species is *P. excentricum*. I will provisionally exclude *P. groenlandicum* W. from this group, as I can not get a satisfactory figure of it.

Ventral area

According to BARROW (1918), "the plates of the ventral area seem never to have received a definite nomenclature, probaly because of the great difficulty in determining them," and "on account of the considerable variability of form and extent of the ventral area in different species it is to be expected also that the plates of which it is formed will display

much variation, and this has been demonstrated for shape as well as number in several forms already worked." But he himself overlooked or perhaps was forced to neglect the significance of the ventral area in considering the interrelationships of the various groups of the genus *Peridinium*, emphasizing only the "variation in the arrangement of the major plates of the theca exclusive of those of the ventral area." KOFOID (1909), the first and sole observor who worked out the detailed structure of the ventral area of this genus, has correctly distinguished in the ventral area of *P. steini* four plates, anterior, median, sinister and posterior.* The number and general relations of these plates in the ventral area are essentially similar in his figures and description as in mine, the difference being in the relations of these plates to the flagellar pore and the presence of an additional minute plate at the proximal region of the girdle. In his figures, the anterior plate is separated from the flagellar pore by a space, and the posterior plate lies behind and around the pore. But my own observations have clearly snown that the four plates are all oriented with reference to the flagellar pore, the three anterior plates lying in contact with the flagellar pore and the posterior connected with it by a narrow groove; in other words, the flagellar pore lies between the two middle plates and the anterior plate extends from the anterior end of the ventral area adjacent to the apical plate I′ till it meets the anterior ridge of the pore. The left (Sinister) plate and the right plate, the "median plate" of KOFOID (1909), lie billaterally in the median region of the ventral area. The flagellar pore is a reniform or short or elongated oval opening leading into a short canal formed by median extensions of the two plates. There is a short or elongated narrow groove, the "flagellar trough" as I would call it, extending from the flagellar pore to the posterior plate, between the two median plates. In fact, the posterior plate is not in direct contact with the flagellar pore, but through the intermediation of the flagellar trough. There is some reason to believe that this trough is phylogenetically a part or appendage of the flagellar

*After the completion of this manuscript, I received LI-SUN TAI and SKOGSBERG's report on Dinophysoidae, "Studies on the Dinophysoidae, Marine Armored Dinoflagellates, of Montrey Bay, California." (Archiv f. Protistenk. Bd. 82, 1934), in which they recognized four plates constituting the longitudinal furrow or sulcus. And our unpublished records, worked out some years ago, also proved the fact that the floor of the sulcus of some of the group is consisted of four minute plates in a similar combination. This marked similarity in the structural relation of their ventral area is very taxonomically significant, substantiating our assumption that the structural relation of the ventral area may be one of the most fundamental characters in the taxonomy of the armored Dinoflagellata.

pore. The flagellar pore has on its right edge a narrow or broad list or wing, the flagellar fin, most prominently developed in the Monovela group and least in the Avellana group of *Archaeperidinium*. In the former group, the flagellar fin is broad and extends backwards apparently along the right edge of the flagellar trough, but is restricted basally to the right edge of the flagellar pore, and there is no fusion between the edge of the flagellar trough and the inner margin of the flagellar fin. Sometimes, a corresponding small, shorter fin is present on the left edge of the pore, and the two fin are to be mistaken for spines in an antero-ventral view of the body.

In addition to these four plates, there is at the proximal end of the girdle a fifth plate not pointed out by any previous observors; but figures suggestive it are given by KOFOID for *P. minutum*, by WOLOSZYNSKA (1916) for *P. wierzejskii* and several other species. In most of my materials, it is a minute narrow plate lying transversely in the girdle between the anterior plate of the ventral area and the first girdle plate, and the proximal part of the posterior girdle margin, exactly corresponding to the posterior margin of this platelet is oblique for a short distance; therefore I will call it the "transitional plate". The question whether it is a component of the ventral area or merely a girdle plate will be discussed in another paper. But it often develops to a considerable size in the girdle in the Monovela group, while in *P. excentricum* it is a large plate lying entirely within the ventral furrow. At the beginning of my work, I was in doubt as to whether it was a suture zone or a distinct plate, but its constant presence in all the species whose ventral area I have suceeded in analysing, its too considerable size in some species to be regarded as a mere suture zone, and finally my success in dissociating all the constituent platelets of the ventral area of some species, have led me to conclude that it is a distinct platelet, presumably of recent origin.

A Review of Freshwater Species

There have been reported many freshwater species having two anterior ntercalary plates, either separated or contiguous. In them the plate pattern of the epitheca and the structural relations of the ventral area are known to vary widely not only in different species but also in varieties of the same species, and the specific diagnoses are still in a state of confusion. Though this may be partly due to misinterpretation, it is still probable that the freshwater forms present more variations in skeletal morphology

than marine species.

In *Peridinium marchicum* v. *keyense* NYGAAD the two intercalary plates are contiguous to cach other as in the marine species, while in *P. marchicum* v. *javanicum* WOLOSZYNSKA they are separated. The dorsal pattern of *P. marchicum* LEMM. is intermediate between the two just mentioned, while in *P. marchicum* v. *simplex* WOL. there are no intercalary plates at all. The figures of PLAYFAIR suggest that *P. caudatum* v. *guildfordense* PLAYF. and *P. geminum* PLAYF. have a small, compact ventral area, while in *P. caudatum* v. *Planctonicum* PLAYF. and *P. Geminum* v. *excavatum* PLAYF. the area expands posteriorly and intrudes into the hypotheca.

WOLOSZYNSKA has illustrated some freshwater species whose ventral areas are only partially analyzed, and it is nearly impossible to arrange these freshwater species systematically on the basis of the structure of the ventral area as known at present, but an inspection of WOLOSZYNSKA's figures has convinced me that the ventral area of these species also consists of four plates grouped in contact with the flagellar pore and a minute transitional plate at the proximal end of the girdle.

Reviewing the published figures available for me at Present, I have found 12 species, 2 subspecies, 11 varieties and 1 forma provided with the contiguous dorsal intercalaries while 9 species and 13 varieties with the separated intercalaries. And to these may be added *P. quinquecorne* ABÉ, characterized by two separated dorsal intercalary plates and the peculiar organization of the ventral area; and these characters together with its extreme scarcity in the sea suggest its possible freshwater origin. I purpose to return to this question in a later paper.

I. GROUP AVELLANA

Section Avellana PAULSEN 1931.

The body is globular, rounded polyhedral or elongated biconical, with circular or oval girdle section and no antapical horn or spine. The deeply concave descending girdle has a corrugated wall. In most cases there is at the apex of the epitheca a peculiar elongated, dorso-ventral furrow, sometimes extending dorsally and indenting the dorsal apical plate 3′. This furrow is covered, as in *Gonyaulax*, by a closing platelet which can be isolated by a slight pressure on the cover glass. The apical pore lies in its median part or close to its ventral end. No description of this peculiar elongated apical furrow is found in literature except that of

LEBOUR for *P. thorianum*. The ventral area is a deeply excavated, narrow, straight or slightly curved furrow. It expands towards the left in most cases, opposite the distal end of the girdle, and consequently the anterior median corner of the postcingular plate 1‴ is sharply pointed or elongated and truncate at the end. It is not guarded by prominent lists and its anterior end turns into the proximal part of the girdle with smooth curvature. The ventral apical plate is characterized by the anteriorly displaced shoulders and asymmetrically convex posterior part obliquely truncated at the hind by the anterior margin of the ventral area. The anterior intercalary plates are two in number and equal or subequal in size in the majority of cases, three in a few species and one in rare cases of extreme variation. The ventral postcingulars 1‴ and 5‴ are prolonged backwards along the ventral furrow to near its posterior end.

The plate pattern of the ventral area is characterized by the symmetrical arrangement of the two middle plates, which are subequal and lie directly on either side of its middle part. The posterior plate is small and symmetrical in from, but very rarely asymmetrical. The transitional plate is comparatively large in some species. Both the right and the left plates extend anteriorly to the middle of either the distal or the proximal end of the girdle, and terminate posteriorly at the same level or the right a little further backwards than the other. The flagellar pore is an elongated, straight or slightly curved opening, and has an indistinct flagellar fin on its rights edge; it is not uniform in width, the widest part lying in the anterior half, and its anterior end is truncated obliquely. The flagellar trough is conspicuous and may be long and narrow or short and wide, and its cavity is prolonged backwards for a short distance beyond the trough itself into the posterior plate. The small, pentagonal posterior plate is wedged in slightly or deeply between the two antapical plates.

The surface of the theca is smooth with sparsely scattered pores, or covered with minute, roughly rounded or polygonal poroids, sometimes large enough to give a corrugated or spiny appearance to the shell. No other of surface markings are present. The girdle plates are marked by grooves and ridges alternating at regular or irregular intervals.

Peridinium pietschmanni BÖHM has a descending girdle, a straight ventral furrow extending to the antapex and a rippled thecal surface similar to that of *P. thorianum*, characters which make it appropriate to include it in the group Avallana. *P. robustum* MEUNIER has many characters very closely similar to those of *P. thorianum*. In the possession of a straight ventral furrow with characteristic anterior end, spheroidal body flared at the girdle, the posterior extension of the two ventral median plates of the postcingular series, corrugated girdle-plates and the rippled thecal surface, *P. robustum* is nearest to *P. thorianum* or *P. avellana*, but differs in having three, symmetrically arranged intercalry plates.

The following seven presumably valid apecies and one variety found in literature are to be included in the Avellana group:

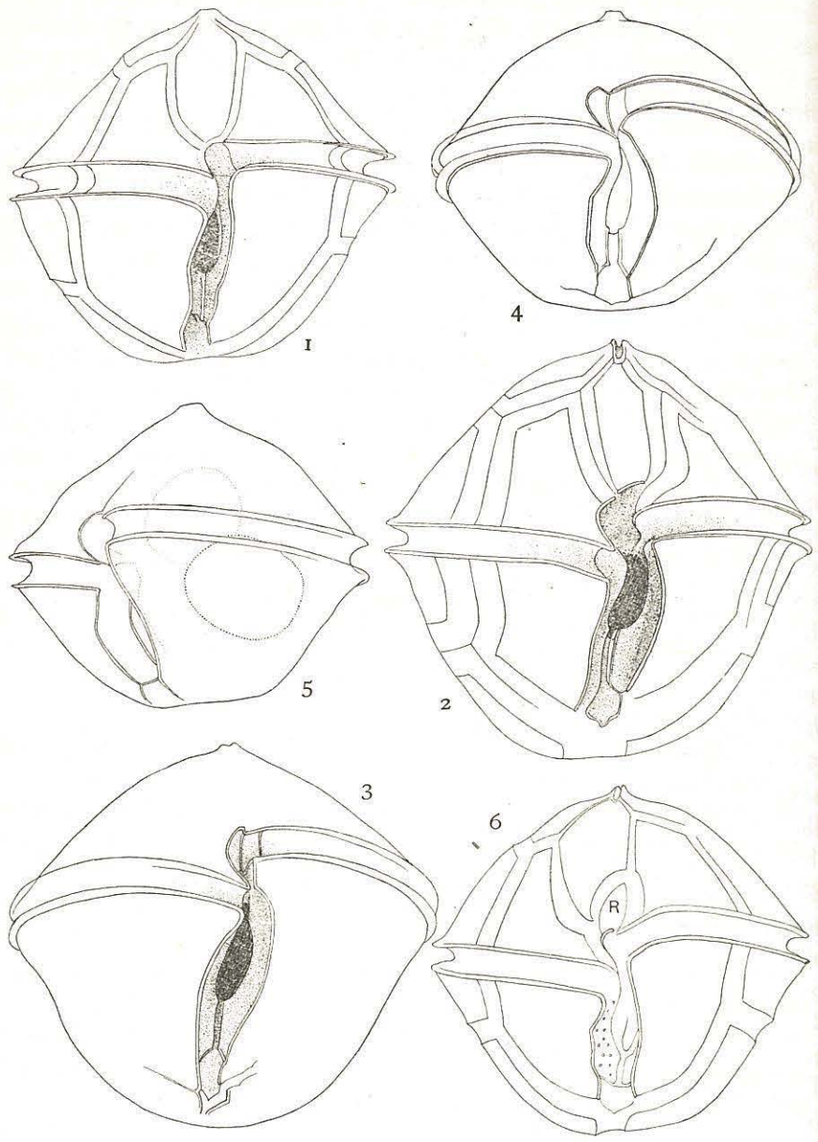
P. abei (ABÉ) PAULSEN
P. abei v. *a-elegans* (BÖHM) (*P. biconicum* v. *a-elegans* BÖHM)
P. avellana MEUNIER
P. levanderi ABÉ
P. pietschmanni BÖHM
P. robustum MEUNIER
P. thorianum PAULSEN
P. ventricum ABÉ

1. Peridinium thorianum PAULSEN 1905

PAULSEN 1908.
LEBOUR 1922, 1925.
DANGEARD 1927.

This is a well established species with rounded body destitute of distinct apical horn, antapical appendages and protrusions. The areolation of the thecal surface and the flaring of the body at the girdle are other characteristics.

The ratio of body length to diameter is variable. In the specimen illustrated in Fig. 2 the body is elongated longitudinally, while in that shown in Fig. 4 it is flattened and has a slight protrusion at the apex which is indistinct in side view (Fig. 5). The intermediate, presumably normal forms are illustrated in Figs. 1 and 6; in them the apex is displaced a little ventrad, while the posterior extremity of the rounded hypotheca lies slightly dorsal to the centre (Fig. 9). As seen in Figs. 1, 2 and 5, a slight depression or flattening is noticeable at the posterior end of the body in some specimens, when viewed from the ventral side. There is also a flattening or slight depression, in most cases, in the ventral surface of the body, extending from the apex to the antapex, and the posterior flattening or depression mentioned just before is caused by the posterior prolongation of this ventral depression, whose posterior median region is occupied by the ventral furrow.



The epitheca is conical or dome-shaped and the hypotheca is rounded. It is worth noting that there is a faint furrow on either side of the girdle, associated with the flaring of the body already mentioned. This is plainly illustrated in all my figures, and is also recognizable in the three species to be described later.

The girdle is median, but displaced distally 1–1.3 girdle width. It is deep and guarded by low, hyaline lists. Its proximal end is bent backwards at a right angle to form the anterior part of the ventral furrow, and the outer margin of this bend is smooth in normal specimens, as illustrated in Fig. 1. This elegant curvature at the anterior end of the ventral furrow is a most prominent and characteristic feature of the Avellana group and is of practical use in recoguiring it, though interfered with in some cases by intrusion of the ventral furrow into the epitheca in the manner illustrated in Figs. 2–4.

The plate pattern is also characteristic of the group. The three dorsal apical plates are small, while the characteristically elongated ventral apical is shield-shaped, with shoulders of unequal heights, and reaches as far as the girdle. The ventral apical as a whole may be symmetrical or asymmetrical, as in Fig. 12 and Figs. 6 and 10, which show two extreme examples. Its posterior end is obliquely truncated by the anterior margin of the ventral area, and in most cases its subterminal region expands towards the right, as shown in Figs. 1 and 10. The intercalaries are two in number and equal or subequal. The precingulars are mostly seven, but in the specimen illustrated in Figs. 6 and 10, there is at the proximal end a minute supernumerary plate presumably cleft out of the ventral apical, as judged from its position and relations to the anterior plate of the ventral area. The precingulars are lowest dorsally and gradually become higher ventrad. The ventral two postcingulars are the longest of the series, corresponding exactly to the terminal precingulars in basal length, as also with the ventral girdle plates. These relations are most

P. thorianum PAULSEN (1)

Fig. 1. Ventral view of a specimen with narrow ventral furrow and slight antapical indentation.

Fig. 2. Somewhat elongated specimen with wider ventral furrow, broad intercalary zones and anterior indentation of the ventral area.

Fig. 3. A larger specimen with slight anterior indentation and left flaring of the ventral furrow.

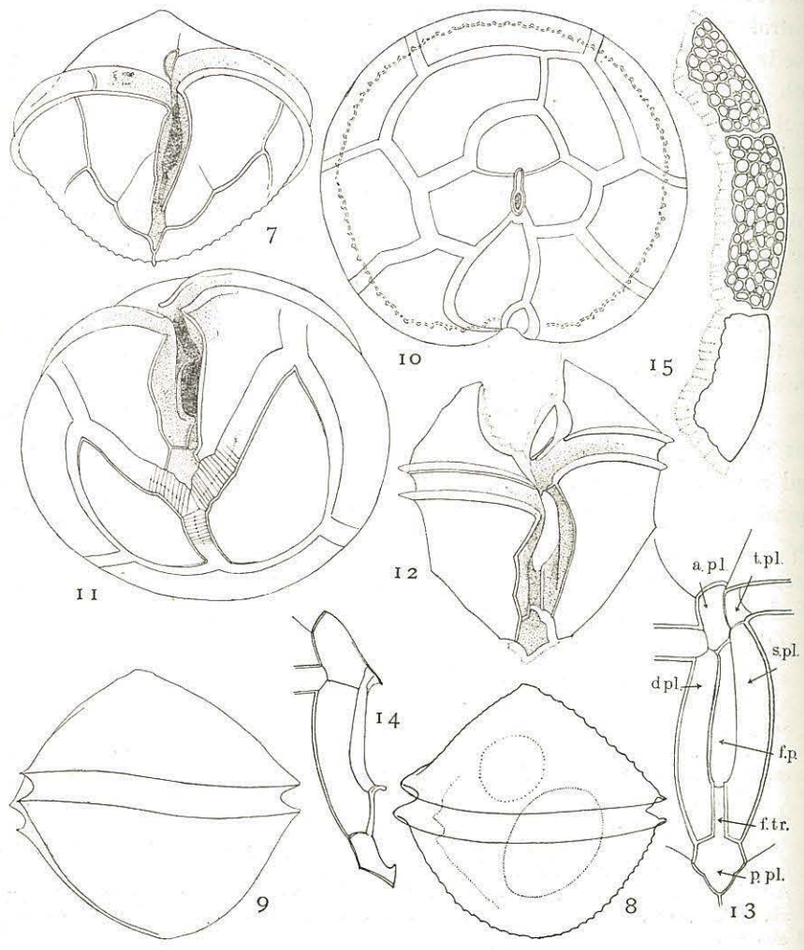
Fig. 4–5. A smaller, flattened specimen with slightly differentiated apical horn.

Fig. 6. Another specimen with an accessory precingular (r).

All the figures in this paper, except schematized ones, were drawn with a camera lucida under magnification of 600 (Zeiss 40×15). Fig. 59 is magnified about 500, and Fig. 83 about 1500.

clearly shown in Fig. 12. The posterior end of these terminal postcingulars may be symmetrical or the right one may extend farther backwards than the left. Fig. 2 is an example of marked variation. The antapical plates may be equal or subequal.

The apical pore lies at the ventral end of the apical furrow, which has no ventral prolongation corresponding to the ventral slit of the apical pore of most species of this genus nor does the apical furrow deeply indent the dorsal apical plate, while its ventral end expands slightly to receive the apical pore.



The median margins of the ventral postcingulars are sometimes straight, but in most cases they are curved inward, so that the middle region of the ventral furrow expands laterally, correspondingly increasing its width here. But there is a another kind of increase in furrow width due to growth of the thecal plates. In Fig. 2 the ventral furrow is wider than in Fig. 1 showing another specimen. In most cases the furrow is very narrow directly behind the proximal end of the girdle, but in well grown specimens it is equally wide through its whole length (Fig. 2). The furrow shows an anterior, a middle and a posterior division, separated by more or less distinct constrictions. The anterior division is occupied by the anterior plate, the middle by the two middle plates and the posterior by the posterior plate, as clearly shown in Figs. 4 and 13. Fig. 3 is an exceptional but interesting example showing the affinity of this group to the Monovela group in sometimes having the median corner of the postcingular plate truncated. The plate pattern of the furrow is shown schematically in Fig. 13. The small anterior plate lies somewhat obliquely between the ventral apical plate and the truncated anterior edge of the flagellar pore; its obliquity may be surmised also from Figs. 3 and 4. This plate sometimes indents the epitheca in the manner illustrated in Figs. 3, 4 and 2; in the last case extending anteriorly along the inner margin of the postcingular 1″. The two median plates lie face to face in the middle division forming its lateral walls; the left plate extending posteriorly from the proximal posterior end of the girdle and the right from midway between the anterior and posterior margins of the distal end of the girdle to the posterior constriction of the furrow. The posterior plate is small and pentagonal or hexagonal. A typical hexagonal example

P. thorianum PAULSEN (2)

Fig. 7–9. A small specimen with narrow ventral furrow. 7—Ventral view. 8—Dorsal view. 9—Side view showing ventral displacement of the apex and dorsal retraction of the antapex.

Fig. 10. Apical view of the specimen of fig. 6 showing elongated apical furrow, asymmetrical dorsal plate pattern and corrugated girdle wall.

Fig. 11. Ventro-antapical view of the same specimen.

Fig. 12. Isolated ventral region of the same specimen.

Fig. 13. Schematized plate pattern of the ventral area. a. pl.—anterior plate, d. pl.—right plate, s. pl.—left plate, p. pl.—posterior plate, t. pl.—transitional plate, f. p.—flagellar pore, f. tr.—flagellar trough.

Fig. 14. Right half of the ventral furrow plates showing interrelations between flagellar pore, flagellar trough, primary part of the flagellar pore sunk into the body and three of the four plates.

Fig. 15. Three dorsal precingular plates (Fig. 6) showing surface areolae and pores, wavy periphery of thecal plates and marginal extensions overlapped by adjacent plates.

is shown in Fig. 13, in which the posterior one-fourth of the plate is constricted from the rest and wedged in between the two antapicals. The flagellar pore is elongated either straight (Figs. 1 and 11) or reniform (Figs. 2 and 12), and occupies the median part of the middle division from the level of the proximal end of the posterior girdle list to the center of the division or a little further backwards. The flagellar trough is long and narrow in the specimens shown in Figs. 2 and 3, but short and wide in those shown in Figs. 1 and 4. The structure of the ventral furrow is neither simple nor in accordance with the plate pattern described above. The antero-dextral part of the ventral pore is obscured by a ridge extending from the distal end of the anterior girdle margin to the posterior end of the flagellar pore, and decreasing in height posteriorly and finally fading away after traversing the right plate obliquely. This ridge marks off from the ventral furrow proper containing the flagellar pore and extending anteriorly along the sinistro-dorsal side of the ridge to from the anterior region of the primary ventral furrow, a shallow groove on its dextro-ventral side, deepening anteriorly into the distal end of the girdle and occupying the ventral major part of the right plate. The proximal end of the girdle, in most cases, deepens directly into the anterior region of the ventral furrow, but in some cases (Figs. 2, 3 and 4) there can be observed along the left margin of the anterior plate, another short ridge extending from the postero-median corner of the precingular plate 1″ to the anterior end of the flagellar pore thus dividing the girdle furrow from the anterior region of the ventral furrow and leading the former into the flagellar pore. A similar structure can be observed in the corresponding part of the ventral furrow of *P. depressum* and its allies. From the above account, it appears that the food current from the proximal part of the girdle passes over the flagellar pore and is not interfered with by a current from the distal part of the girdle, both blending together behind the flagellar pore.

The surface of the thecal plate is covered by small rounded poroids of subequal size and has minute pores which are more numerous at the intersections of the ridges demarcating the pits than between the intersections. The anterior and left plates of the ventral area have no surface markings, while the other two are areolated faintly and have minute pores (Fig. 6).

The outer margins of the thecal plates are not always straight but may be jagged owing to the presence of marginal poroids, and in specimens with narrow suture zones the adjacent margins of two plates correspond in jaggedness (Fig. 15). In some cases there are no suture zones but instead stout jagged lines threading through a pitted surface. The suture zone seems homogeneous in narrow-sutured specimens and faintly atriated in broad-sutured ones, but even in the former, the overlapping peripheral zones of adjacent plates appear plainly striated when separated (Fig. 15).

Dimensions: Body length 56–85 μ, transverse diameter 53–85 μ, dorso-ventral diameter 58 μ—, width of ventral furrow 7–13 μ, width of girdle 5.5–6 μ.

This is a northern species and has been reported in Orient from the Okhotsk Sea and the east coast of Hokkaido.

2. P. rotundata, n. sp.

This is a small globular species, closely resembling the preceding in general features, but differing mainly in its wider ventral area, in the surface markings of the theca and in more extended development of the apical furrow.

The plate pattern and the plate formula are those typical for the group Avellana. The ventral apical is smaller and the other three larger than *P. thorianum*. The two contiguous dorsal intercalaries may be equal or subequal. Of the two halves of the ventral margin of the dorsal apical plate, with the apical furrow between, the left or the right one may be displaced more ventrad. In the hypotheca the right antapical plate is larger than the left.

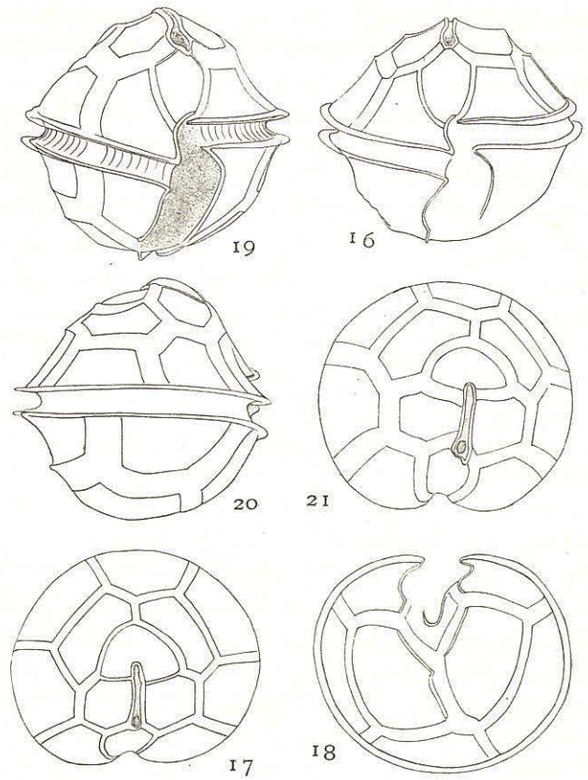
The apical furrow is broad and prolonged dorsally into the dorsal apical plate for a short distance, and is guarded laterally by low hyaline lists, with its ventral end expanded a little for the apical pore and sometimes truncated obliquely (Fig. 21).

The girdle is relatively wide, with characteristic curvature of its proximal end and its displacement typical of the group. The girdle plates are also typically corrugated (Fig. 19). The ventral area is a deep excavation with the left margin flared immediately behind the proximal part of the girdle (Figs. 16, 19); but the excavation is restricted mainly to its anterior major part, while its posterior and postero-sinistral marginal region corresponding to the posterior plate is shallow or even flush with the surrounding plates. Indistinct narrow lists are present on the inner margins of the four plates surrounding the hypothecal part of the ventral area; in narrow-sutured specimens, they are continuous along the furrow

but separate in broader-sutured ones (Figs. 18, 19). Though owing to insufficient material I have failed to analyse the ventral area of this species, Fig. 18 is suggestive of the presence of an asymmetrical posterior plate similar to that of *P. hemisphericum* to be described next.

The surface of the theca is smooth and the somewhat large pores are sparingly distributed.

Dimensions: Body length 42–52 μ, transverse diameter 50 μ, dorso-



P. rotundata, n. sp.

Fig. 16. Ventral view of a presumably normal specimen.

Fig. 17. Apical view.

Fig. 18. Antapical view showing elevated posterior plate of ventral area and furrow fin along the median margin of the antapical plates.

Fig. 19–21. Another specimen with asymmetrical ventral expansion of apical furrow. 19—Oblique ventral view. 20—Side view showing the fin of apical furrow. 21—Apical view showing asymmetry at anterior end of ventral spical plate.

ventral diameter 44–47 μ, girdle width 5.5 μ, width of ventral furrow 10–12 μ.

This species is distinguished at once from the preceding by its broader ventral furrow and associated development of the bordering lists, swollen epitheca and larger size of the three apical plates. In general body form it resembles the freshwater *P. gatuense* NYGAAD (1926) and allies, but differs in structural details, such as plate pattern, ventral area and surface markings. It seems to me probable that the two following peculiarly modified species have been derived from this species.

3. P. hemisphaericum, n. sp.

The body is peculiarly flattened, flared at the girdle and show remarkable variations in plate pattern of both epitheca and hypotheca and in the structural relations of the apex.

The apex is flattened like a table top and there is a laterally compressed apical horn at its ventral end. The hypotheca is low and dome-shaped. The girdle is descending and the ventral furrow extends to the centre of the hypotheca without indenting the antapex.

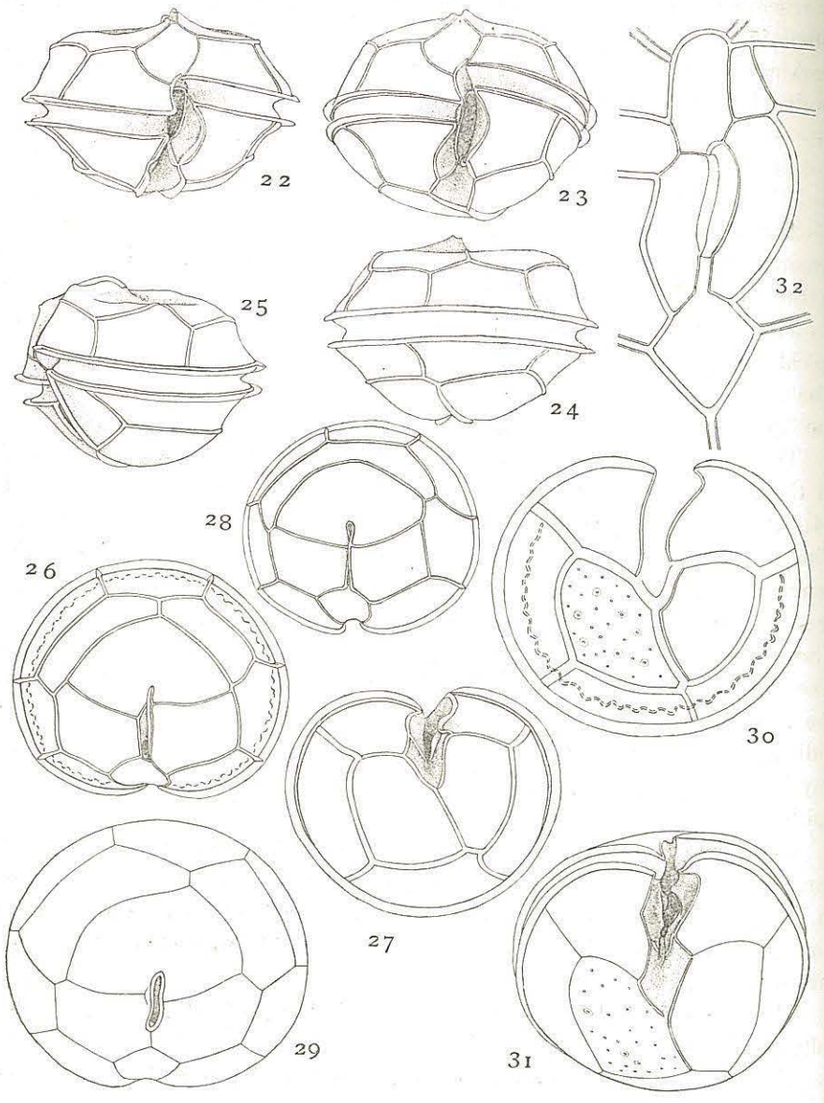
The apical horn is a low dorso-ventrally running ridge slightly inclined to the right and with the apical furrow at its distal margin (Figs. 22, 24), and the dorsal half of the flat apex is slightly concave (Fig. 25). The structural relation of the girdle to the proximal curvature of the ventral furrow is typical of the group, and the two ends of the former are displaced by 1.5 girdle widths. The girdle lists are low and hyaline. The cingular section is broad oval with or without ventral depression. The ventral area is deeply excavated anteriorly and extends backwards in the form of ƨ to the center of the hypotheca; its lists are low and indistinct like those of the preceding species. The hypotheca is devoid of any antapical appendage or protrusion, and is nearly as high as the epitheca including the apical horn.

I have bad only three complete and one broken specimens, each with some differences in plate pattern and apical trough from the others, but in view of the more extended variations in skeletal morphology to be directly described it does not seem to me justifiable to divide this species into varieties.

The plate formula of this species is 4′, 1–2_a, 7″, 5‴, 2⁗, with the following variations.

The three dorsal apical plates are exceedingly large and occupies the

major part of the flat top, while the ventral plate is very small and appears only on the ventral side. The shape of this ventral plate is typical of the group in having asymmetrical shoulders and an oblique posterior margin apposed to the anterior plate of the ventral area. The largest of the apicals is the middorsal 3′, and the size difference between



it and the smallest ventral is greater than in the preceding species. In one specimen the ventral I′ is not in contact with the apical trough, while in the remaining two it is in direct contact, as normally. In two specimens there are two anterior intercalaries, while in the other smallest one there is a single large laterally elongated plate instead. In the former specimens, the left plate is slightly smaller than the right. It may be worth noting that the two plates in question of the specimen shown in Fig. 29 are respectively in contact with the apical 2′ and 4′ in a similar manner, while in the one show in Fig. 26, the left intercalary is separated from the apical 2′ by the anterior extension of the second precingular to the dorsal apical. The latter condition of the intercalary also occurs in the third smallest specimen shown in Fig. 28, showing a tendency of the intercalary row to move on towards the right. In all cases the precingulars form the periphery of the flat apex. The antapical series is another source of variation. Antapical I′′′′ (left) is always smaller than 2′′′′ (right). In two of the three specimens the right antapical and the second postcingular (2′′′′) are separated by a shorter or longer suture (Figs. 27, 31), as in most species of this genus, but the third case is peculiar in that these two plates lie in direct contact.

The apical pore lies at the ventral end of the apical trough, which may be straight or irregularly curved. In two specimens it is notably elongated so as to separate the two apicals 2′ and 4′ from each other, and in these cases the left edge of the trough stands out more prominently than the right, so that with the inclination of the apical horn, the trough is displaced towards the right margin of the blunt apex (Fig. 22). In the

P. hemispherium, n. sp.

Fig. 22. Ventral view showing fins of ventral furrow and proximally ascending but distally descending girdle.

Fig. 23. Postero-ventral view of the same individual showing general features of ventral furrow.

Fig. 24. Dorsal view.

Fig. 25. Side view showing concavity of apical plateau.

Fig. 26. Apical view showing plate pattern, peculiar development of apical furrow and corrugation of girdle wall.

Fig. 27. Anterior view.

Fig. 28. Apical view of the smallest specimen with a single intercalary.

Fig. 29. Apical view of a different specimen with shortened apical furrow.

Fig. 30. Antapical view of another specimen with abnormal antapical plate pattern, showing surface marking and position, length, and corrugation of dorsal girdle plate.

Fig. 31. Postero-ventral view of the specimen of Fig. 29 showing ventral area, especially asymmetry of posterior plate.

Fig. 32. Schematized plate pattern of ventral area.

other specimen the apical trough is shorter and separated from the apical 1′ by a short suture between the apicals 2′ and 4′ (Fig. 29). The ridge of the trough are equally hign.

The deep girdle is bordered by low hyaline lists, and consists of three plates and a small transitional one. Each of the two ventral girdle plates is as long as the terminal precingular or postcingular is broad, and the other dorsal plate occupies the whole remainder of the cingulum (Fig. 30). The pentagonal transitional plate lies at the proximal end of the girdle, with its median part extending into the ventral furrow. The corrugation of the girdle plates is prominent but somewhat irregular (Figs. 26, 30).

The ventral furrow, whose plate pattern is shown schematically in Fig. 32, is deep and irregularly ƨ shaped (Fig. 23). It may be divided into three parts as described before. In two specimens, the anterior plate does not indent the epitheca, but in the third it indents the epitheca in like manner as in *P. thorianu.* The two middle plates lie face to face, forming the side walls of the deepest middle part of the furrow. The posterior plate lies in the posterior expanded part of the furrow, immediately behind the posterior constriction at the asymmetrical posterior ends of the middle plates, and is irregularly pentagonal, being more expanded on the left side. This asymmetry of the posterior plate, coupled with the obliquity of the posterior enbs of the middle plates brings the posterior plate into line with the oblique intra-antapical suture. The two middle plates are separated anteriorly by the flagellar pore, and posteriorly by the flagellar trough, which is shorter than in *P. thorianum* and whose cavity is prolonged for a short distance into the posterior plate (Fig. 31). The flagellar pore is elongated longitudinally with its anterior part slightly curved to the right, and bears on its right edge a rudimentary fin.

The ventral furrow is guarded along the inner margins of the four surrounding plates by low hyaline lists of four components; of these the two anterior are respectively continuous with the median end of the posterior girdle list bordering the median and anterior margin of the terminal postcingulars, while the two, unequal in size, posterior border the ventro-median margins of the posterior plates and extend dorsad beyond the antapex along the intra-antapical suture (Figs. 27, 31). A similar but more inconspicuous list is borne by the suture connecting the posterior end of the flagellar trough with the posterior constriction of the ventral furrow (Figs. 22, 23, 27 and 31).

The otherwise smooth surface of the thecal plates have fairly small,

sparsely distributed pores of two kinds, one with thickened border and the other without. (Figs 30, 31).

Dimensions: Body length 37–40 μ, transverse diameter 45–60 μ, dorso-ventral diameter 41–54 μ, girdle width 5–5.5 μ.

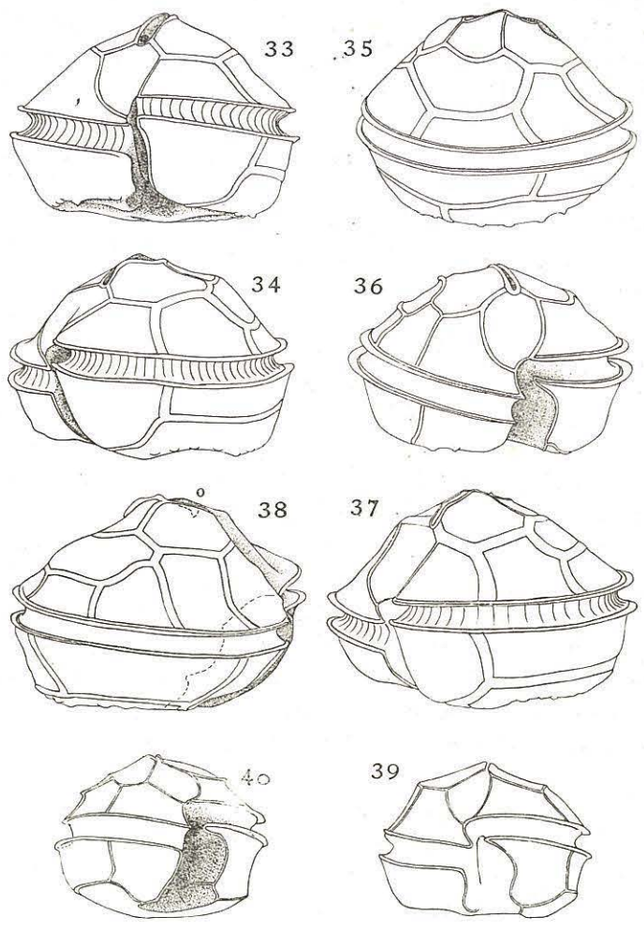
This species resembles *P. excentricum* in having ventrally displaced apical horn and flattened epitheca, but differs in the discending girdle, plate pattern and structural relations of the ventral area. The hypotheca of this species corresponds plate for plate and list for list with those of the preceding species but not with those of *P. thorianum.* The plate pattern also prove a closer relationship between this and the preceding one. The peculiar flattening of the epitheca and the ventral displacement of the laterally compressed apex have no parallel in the subgenus *Archaeperidinium* nor in the genus *Peridinium.*

4. P. clavus, n. sp.

This is a small species with peculiarly flattened hypotheca and highly variable plate pattern of both epitheca and hypotheca. The body is broadly pentagonal in ventral or side view, with low conical epitheca and flattened hypotheca, a reverse condition to that of the preceding species. The deep girdle is postmedian and descending, being displaced distally by 1.5 girdle widths, and bordered by low hyaline lists. The cingular section is circular or oval with or without ventral flattening, and the transverse diameter of the epitheca at the girdle is smaller than that of the hypotheca.

The epitheca is flat and conical, with convex side and well developed, dorso-ventrally elongated apical furrow. The antapical flattening is not even but seems to have a slightly raised marginal ring. one low protuberance on the right side and one more on the sinistro-dorsal margin of the ventral furrow (Fig. 33). The sides of the hypotheca is stronger dorsally than ventrally, and the left border of the ventral furrow is much longer than the right, in consequence of the displacement of the girdle (Figs. 34, 36 and 37).

The plate pattern and plate formula of both epitheca and hypotheca are highly variable. The plate formula is 4–5′, 1–2_a, 7–8″, 5‴, 2–3⁗. The plate pattern is in the main that characteristic of the group Avellana. The apical series is relatively smaller, but the ventral shield plate larger than in the preceding species. The apicals are different in number and arrangement for each individual so far observed by me; four is presum-



P. clavus, n. sp. (1)

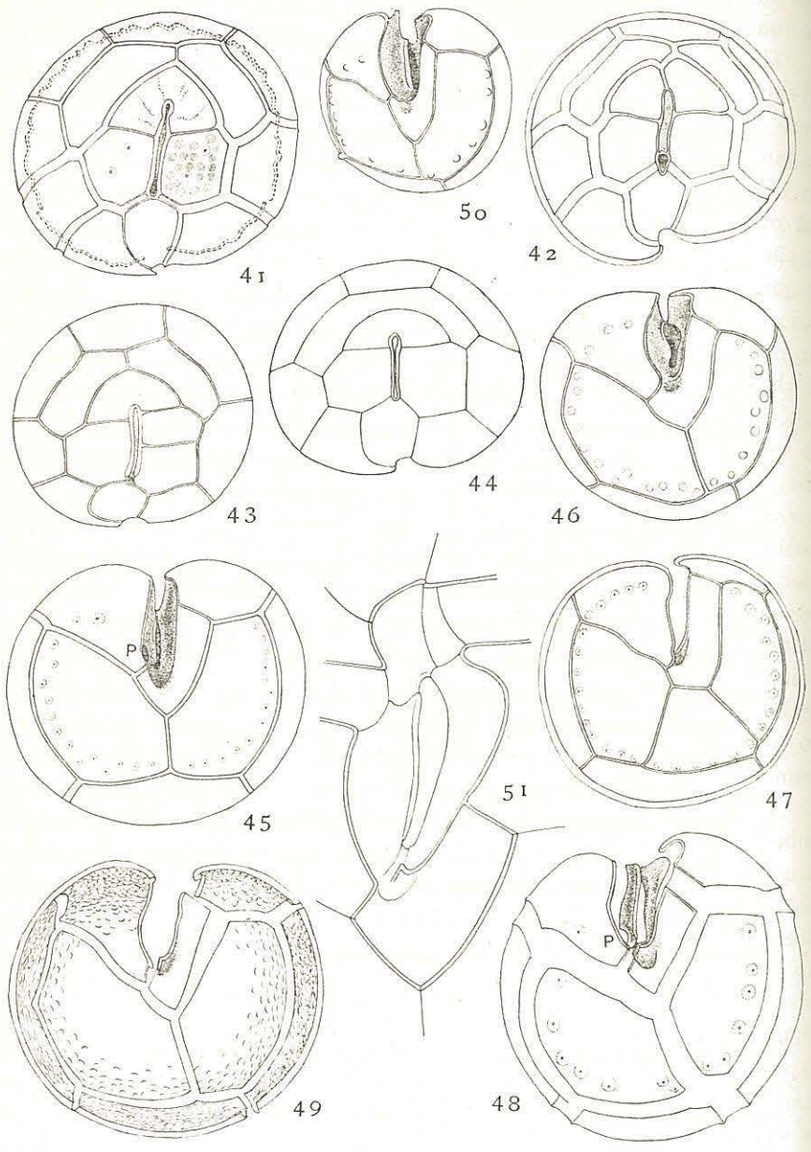
Fig. 33. Ventral view of a specimen with narrow ventral furrow.
Fig. 34. Sinistro-ventral view.
Fig. 35. Dextro-dorsal view.
Fig. 36. Oblique ventral view of another specimen with wider ventral furrow.
Fig. 37. Sinistro-ventral view of a specimen with eight precingulars.
Fig. 38. Side view showing excavation of ventral furrow and position of apical pore.
Fig. 39. Ventral view of one of the smallest individuals with wider ventral furrow.
Fig. 40. Olique ventral view.

ably the normal number (Figs. 41, 44), but sometimes an accesory plate is present, apparently claft out of either apical 2′ or 3′ (Figs. 42, 43). I have also found a specimen with eight instead of seven precingulars and another with seven precingulars and a large intercalary but with otherwise normal plate pattern.

The apical furrow is also variable; it may be straight or curved irregularly and may reach to the center of the dorsal apical. The apical pore may be small and circular or elongated and lies at the slightly expanded ventral end of the apical furrow. In the specimen illustrated in Fig. 42, this pore is demarcated from the dosal major part of the furrow by a transverse ridge and has a short ventral furrow which is apparently homologous with the ventral slit of the apical pore of the majority of *Peridinium*-species. In the specimen shown in Fig. 41, the apical furrow is notably extended dorsally and has a subterminal constriction, beyond which is a pore-like depression. The furrow is bordered laterally by low hyaline lists in most cases but in the specimen illustrated in Fig. 43, the lists are absent from its ventral end. Once I was lucky enough to come across a specimen in which the entire epitheca lay detached from the coagulated contents and an examination of the epitheca revealed the presence of an elongated slit at the apex just corresponding in size and position to the apical furrow, while on the surface of the contents an elongated, narrow plate was found sticking closely but which I succeeded by careful manipulation in isolating under the microscope. Another time, after loss of the left apical plate, the apical furrow was found adhering complete to the other three apicals, with the apical pore at its ventral end and left edge adjacent to the lost plate. I am therefore constrained to think that this is due to the existence of an apical furrow plate homologous with the "apical closing platelet" of the genus *Gonyaulax*.

The anterior intercalaries are normally two and may be equal or subequal. In the specimen illustrated in Fig. 44, however, there is a single large plate dorsal to the semicircular apical 3′. In all cases, the anterior intercalary does not reach to the terminal precingulars, as in the preceding species. The precingulars are mostly seven, but may be eight as in Fig. 41, in which the supernumerary one is judged from the relations of the plates, the sixth of the series. The girdle wall consists of two shorter ventral plates and a larger dorsal. The postcingular series is typical for the genus. The two laterals and the dorsal are narrow and limited, in the main, to the sides of the hypotheca. The left ventral (1‴) is small and extends only half-way between the girdle and antapex, while

the right ventral (5‴) is large plate and extends much further backwards. The antero-median beak-like extension of the postcingular I‴ is very remarkable (Figs. 36, 39, 40, 46 and 50). The equal or subequal ant-



apicals are normally two, but in the specimen shown in Fig. 47 they are three and subequal.

The ventral area of this species is peculiar and seems to differ from that of the two preceding species in extent and shape. It extends posteriorly to the center of the hypotheca and the ventral furrow is restricted to its anterior part occupied by the three anterior plates of the ventral area. The posterior plate is of considerable size and confined to the bottom of the hypotheca. The ventral furrow is mostly narrow and deep, and its component plates are prone to fall asunder and be lost under the microscope, so that I have not succeeded in completely analyzing the ventral furrow of an individual. By patching together observations made on different specimens, I have however reached the conclusion which is schematically shown in Fig. 51. The three anterior plates and the transitional plate are in the same relations as in the preceding species, except that they are laterally compressed and form a very narrow and deep groove. The narrow, elongated flagellar pore extends backwards to near the posterior margin of the left or right plate, and is connected with the posterior plate by the short flagellar trough lying at right angles to the former; so that, viewed from the antapex, the posterior end of the flagellar pore seems to lie at the posterior end of the ventral furrow s. str. The posterior plate is elongated rectangular and extends sinistro-ventrally on the outer side of the left plate. The shape and extent of this plate varies in different individuals, and when the ventral furrow is as wide or narrow as in Figs. 40 or 46, the median marginal excavated

P. clavus, n. sp. (2)

Fig. 41–44. Apical view of four individuals with different plate patterns of epitheca.
Fig. 41. Presumably a normal plate pattern of apicals and intercalaries of the specimen illustrated in Fig. 37–38, showing posterior constriction of apical furrow, weak areolation and sparsely distributed pores and extent of the three girdle plates. There are eight precingulars.
Fig. 42. Epitheca of the specimen illustrated in Fig. 33–35 with five apicals.
Fig. 43. Another plate pattern of epitheca with five apicals.
Fig. 44. A different plate pattern of epitheca with a single intercalary.
Fig. 45. Hypotheca of a specimen with narrow ventral furrow and pore-like depression at the right margin of the furrow.
Fig. 46 Hypotheca of another individual with wider ventral furrow.
Fig. 47. Hypotheca of a different specimen with narrow ventral furrow and three antapicals.
Fig. 48. Hypotheca of a larger specimen having narrow ventral furrow with partly isolated plates.
Fig. 49. Hypotheca of the specimen illustrated in Fig. 37–38; furrow plates lost, posterior plate partly isolated, areolae unevenly distributed.
Fig. 50. Antapical view of the smallest specimen with wider ventral furrow and ventrally expanded posterior plate.
Fig. 51. Schematized pattern of ventral area.

part of this plate forms the posterior end of the ventral furrow. A most interesting peculiarity of this species is the presence, apparently only in specimens with narrow ventral furrow (Figs. 45, 48), of a slit-like oval pore on the right edge of the ventral furrow at some distance from its posterior end. In the specimen illustrated in Fig. 48, with partially separated furrow plates, there was a minute oval pore on the suture between the right plate and the postcingular 5‴.

The thecal plates are thin and bear on the surface circular thickenings penetrated by minute pores. The antapical plates have along their outer margins an irregular row of minute poriferous tubercles (Figs. 33–36, 45–48 and 50) of variable size and number; these are undoubtedly modifications of the ordinary pores present on other thecal plates. Further, in large, grown up specimens, the thecal surface may be irregularly areolated, somewhat as in *P. thorianum*, and these areolations are especially prominent on the sides of the hypotheca and the marginal part of the bottom plane (Figs. 41, 49). The girdle plates are corrugated as in other species.

Dimensions: Body length 31–55 μ, transverse diameter 43–63 μ, dorso-ventral diameter 32.5–60 μ, width of girdle 4.5–5.5 μ, width of ventral furrow 3–9.5 μ.

This species occurred sparsely in the plankton collected on March 13, 1927, but in numbers in that collected on 30, April 1926, in both cases together with the two preceding species. *Gonyaulax catenata* (LEV.) KOFOID, with pentagonal body and asymmetrical ventral hypotheca, is most closely related to this species, but differs profoundly in the details of the skeletal morphology of the ventral area as well as of the remaining parts of the body.

The peculiar flattening of the epitheca of the preceding species and the hypotheca of this, and the variability of plate pattern and plate formula in both epitheca and hypotheca are unique not only in the subgenus *Archaeperdinium* but in the whole genus *Peridinium*. This species combines an epitheca closely similar to that of *P. rotundata* with a flattened hypotheca, and the preceding species combines the hypotheca of *rotundata* with a flattened epitheca. In the globular *rotundata* and the two flattened species before us, the epitheca seems to be constructed on the same general plan, but the plate pattern and plate formula are very variable in the two species under consideration, especially in the flattened half. The hypotheca is generally admitted as being more conservative than the epitheca and the least subject to variation in the

genus *Peridinium*. The presence of three antapical plates is so far unknown in any other species of *Peridinium*, and the variation of antapical plate pattern is something unusual in the genus.

The ventrally displaced and laterally compressed apical horn of *hemisphaericum* would correspond exactly in position to the posterior part of the narrow ventral furrow of *clavus* if similar-sized individuals of the two species were catenated apex to antapex, and the pore above mentioned as being present in *clavus* on the marginal edge of the ventral furrow appears to be homologous (?) with the posterior catenal pore of *G. catenata* (LEV.) KOFOID, while the apical ridge of *hemisphaericum* is highest behind its middle (Fig. 25) and the apical opening lies near its ventral end. The minute surface tubercles of this species are limited to the outer margins of the bottom plates of the hypotheca, while its central major is perfectly smooth.

The peculiar structures and intimate correlations above pointed out for the three species appear to me to suggest that one of the flattened species is either an upper or lower member of a series of species whose primitive form is to be looked for in a globular species like *P. rotundata*. The great variations shown by the two flattened species may possibly be due to their catenation or some internal disturbances happening at the time the new theca is formed; but this is merely a surmise.

Under these circumstances, it seems to me best to keep these three species distinct, at least provisionally, until further evidences are forthcoming.

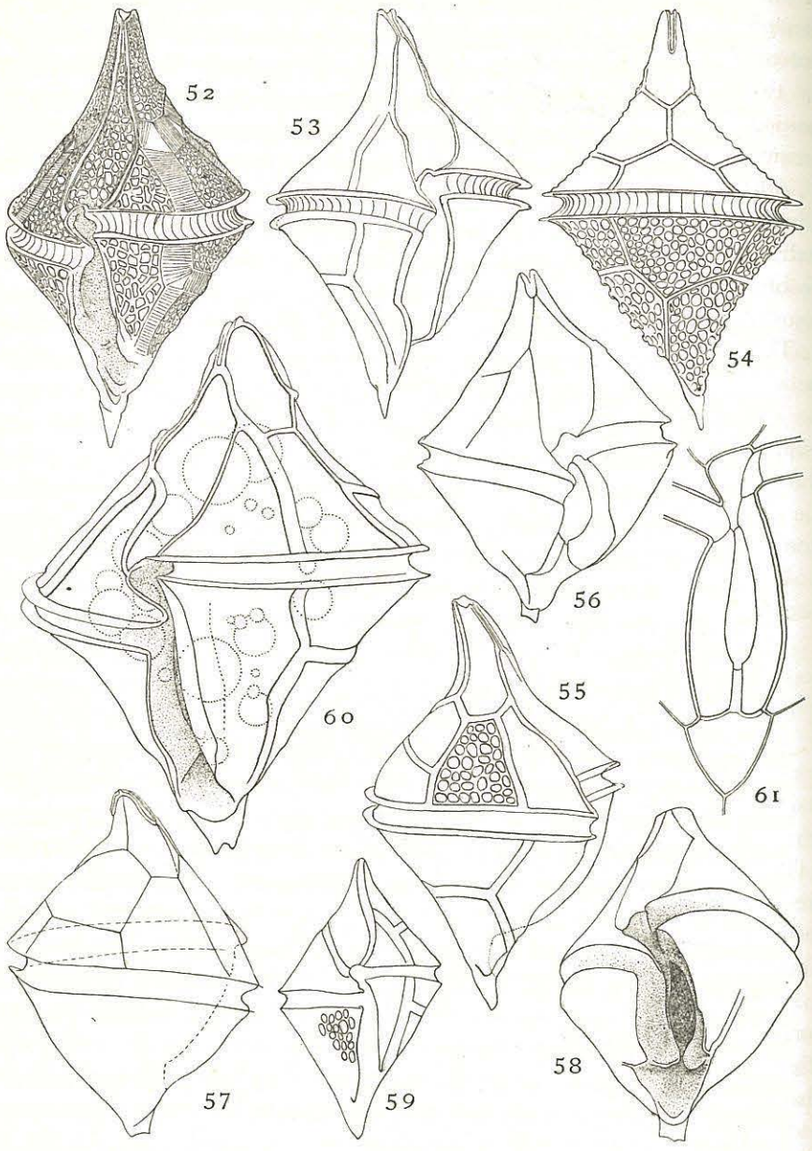
5. P. abei (ABÉ) PAULSEN.

PAULSEN 1931, p. 53.
Peridinium biconicum ABÉ 1927.
P. biconicum f. *elegans* BÖHM 1931.

As DANGEARD's *P. biconicum* (April 1927) has priority to my own, PAULSEN has proposed the name *abei* for my species (June 1927).

The form and diameter of the body as well as the surface markings are subject to some variation. Typically the body appears to be biconical as illustrated in my former paper, and this form I shall call *typica*. There are however many others, e. g. the epitheca may be concave, with a dorsally curved, more or less well differentiated apical horn and a narrow ventral furrow (Fig. 53–55), probably corresponding to *P. abei* f. *elegans* (*P. biconicum* f. *elegans* BÖHM) from the Persian Gulf. I have also come across some short, broad examples with a wide ventral furrow and no apical horn; these I will call f. *rotunda* (Figs. 56–58).

Individuals found in the summer plankton of Asamushi are mostly medium-sized and delicate, while the specimen obtained by me in summer plankton from off the shore of Imabari on the Inland Sea, is a huge one



measuring 105 μ in length and 70 μ in transverse diameter (Fig. 60). Again, among Mr. AKATSUKA's sketches of *Peridinium* obtained from the east coast of Hokkaido and the Tohoku district, which I have examined through his kindness, I have found one of a biconical species reproduced in Fig. 59, which he called a *Gonyaulax*-species, but which is in reality *P. abei*, as may be seen from its size and body form, the wide ventral apical, elongated postcingular I‴, straight ventral furrow and characteristic anterior and asymmetrical posterior ends, together with the round reticulations of the thecal surface suggested in his figure. In think that the specimen sketched by him belong to my f. *typica* from Asamushi.

The plate pattern of the ventral area, as shown in Fig. 61, is nearly the same as in *P. thorianum*. The asymmetrical form of the posterior plate is also pronounced in some specimens. The surface areolation of the theca is similar to that of *P. thorianum*, but is subject to individual variation, being faint in some and rough but typically rounded in others (Fig. 54), while in extreme and rare cases it may be angular (Fig. 52).

The body is brown, with many ink-red oil droplets of various sizes around the nucleus (Fig. 60).

Dimensions: Body length 105–70 μ, transverse-diameter 80–47 μ, dorso-ventral diameter –49 μ–, width of girdle 5 μ.

This is probably a southern form and occurs only in the summer plankton of Mutsu Bay and off the coast of Miyako in the Tôhoku district as well as in the Inland Sea. It has also been reported by BÖHM from the Persian Gulf.

II. GROUP MONOVELA

In the winter plankton of Asamushi, there were several species with globular body, ventral area of peculiar structure wholly different from that of any other groups of the genus, and two or three intercalary plates. A careful examination of their ventral area has induced me to separate

P. abei (ABÉ) PAULSEN

Fig. 52. Ventral view of a typical specimen with surface reticulations of angular meshes.

Fig. 53–55. Ventral, dorsal and side views of another specimen with dorsal inclination of apical horn and rough areolation.

Fig. 56–58. Ventral, side and oblique posterior views of a *rotunda* specimen with wider ventral furrow and no apical differentiation.

Fig. 59. Miyako specimen drawn by AKATSUKA.

Fig. 60. Oblique ventral view of a huge specimen from the Inland Sea, Aug. 27, 1930.

Fig. 61. Schematized plate pattern of ventral area.

them from the preceding group.

The group Monovela is characterized by flat ventral area, by having the flagellar fin as sole extension of the thecal surface and its development in the reversed direction from the side-fin of the ventral area of *Diplopsalis*, by the circular girdle and the marked asymmetry of the posterior three plates of the ventral area.

The apical horn may be present or absent. The circular girdle is not deep nor is it flared at the margin. The anterior plate of the ventral area indents the epitheca deeply. The plate formula is 4′, 2–3$_a$, 7″, 5‴, 2⁗. When there are two intercalary plates they may be equal or subequal, and when there are three they are asymmetrical and lie more on the left side of the body. The midventral apical plate (1′) is asymmetrical in shape and somewhat oblique in position. The apical pore is prolonged ventrally or dorsally into the apical furrow or slit. The major part of the ventral area is flush with the surrounding body surface, and the ventral furrow s. str. is limited to the part occupied by the anterior plate and medin part of the left plate covered by the flagellar fin. The ventral area is narrow at the cingulum but expanded laterally at the middle. The flagellar pore has the form of a curved sausage or comma, with pointed anterior and rounded posterior ends, and lies obliquely in the middle of the ventral area, with its posterior end deflected toward the right in consequence of the posterior curvature of the left plate. The flagellar trough, deeper at the left, is short and obscured by the asymmetrical elevation of its two sides. The posterior plate expands asymmetrically along the postero-sinister margin of the left plate and its lateral ends are in contact with the posterior ends of the median postcingulars. These relations in the posterior half of the ventral area are nearly the same as in *P. clavus;* hence I look upon this group as most closely related genetically to the Avellana group.

We find in literature only two species, *P. minutum* KOFOID and *P. monospinum* PAULSEN, to be referred to this group, and the latter is regarded by PAULSEN himself as a synonym of the former.

P. monospinum PAULSEN 1907.

PAULSEN 1908, p. 41, fig. 49.
LEBOUR 1925, pl. 16, fig. 3.

PAULSEN's figures plainly show the characteristic posterior plate of the ventral area indenting the antapical plates, which are bounded from the left plate by a stout ridge (1908, fig. 41 *c*). The ventral area is correctly

described by him as follows: "Längsfurche nach unten zu schwach erweitert, nur die rechte Kante mit von einem Stachel gestützen Flügel." This description and the presence of a spine-like structure in his figure *c* springing from the postero-dextral corner of the middle region are strong reasons for including *monospinum* in this group. In his figure *a* is shown a structure referable to the direct contact of the left intercalary with the first precingular, while his figure *b* shows a symmetrical arrangement of the intercalaries; the former suggests the presence of three intercalaries, as in my Fig. 72, whereas the latter suggests only two. LEBOUR (1925, fig. 3 *a*, *b*, *d*) also shows two intercalary plates. The occurrence of two or three intercalaries and of symmetrical and asymmetrical patterns in one and the same species, is not improbable in the subgenus *Archaeperidinium*, but its actual occurrence in this species has not been noted. The circular girdle of this species is another characteristic of group monovela.

P. minutum KOFOID 1907.

KOFOID 1907, p. 310, pl. 31, figs. 42–45.

KOFOID's original description and figures of this species are incomplete in regard to the detailed structure of its ventral area, but the narrow posterior part of the midventral rhombic plate, the sparse porulation of the thecal plate, the circular girdle and its flat wall indicate that this species should be referred to this group. His figure 43 suggests the oblique elongation of the ventral slit of the apical pore, which is a general characteristic of this group. Owing to lack of detailed analized figures of their ventral area, I can not be certain of the identity of KOFOID's *minutum* and *monospinum* of PAULSEN and LEBOUR. FAURÉ-FREMIET (1908) has also described a similar species under the name *P. minutum* var. *tahihousensis* (p. 227, fig. 13, pl. 16, fig. 15).

6. **P. asymmetrica,** n. nom.

Sphaerodinium asymmetrica ABÉ 1927.

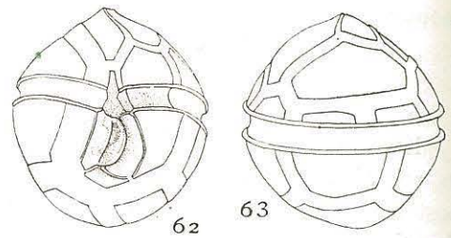
The plate pattern of the ventral area of this species, as illustrated in Fig. 11 *a* and Fig. 13 of my former paper, the obliquity of both the apical slit and the ventral apical from their usual directions, the asymmetrical plate pattern of the intercalaries and the circular girdle with flat wall and low lists, all show that its correct taxonomic position is in this group.

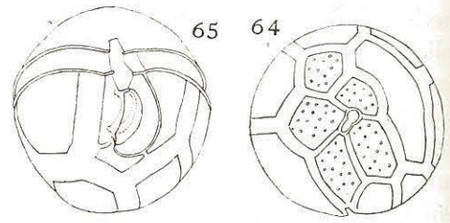
The elevation of the right and posterior plates and the depression of the anterior plate are illustrated in Fig. 13. The large, rectangular transitional plate lies at the proximal end of the girdle (Fig. 11 *a* and Fig. 13, p. 393). The plate formula is 4′, 3_a, 7″, 5‴, 2⁗.

7. P. mutsuensis, n. sp.

The body is globular or slightly elongated longitudinally, has a faintly pointed apex and is circular at the girdle without ventral flattening. The girdle is slightly premedian, faintly excavated and bordered by narrow lists.

The plate formula is 4′, 2_a, 7″, 5‴, 2⁗. The diagonal elongation of the ventral apical (1′) and the ventral prolongation of the apical pore to form the short, wide apical furrow are distinct (Figs. 62, 64). The intercalaries are two, an extremely large, elongated left occupying one-third of the circumambient length at this level, and a smaller pentagonal right. In consequence of this pronounced asymmetry of the intercalaries and the diagonal elongation of the ventral apical mentioned above, both the apical and the precingular series have undergone a clockwise twist. The proximal four plates of the precingular series are all small in consequence of the elongated left intercalary, while the remaining three are large, the distal one (7″) being the largest of the series (Fig. 64). The postcingular row is wide, and the lateral 2‴ and 4‴ extend halfway towards the antapex. The proximal 1‴ is smaller than the distal 5‴ corresponding to the small precingulars, and its median





P. mutsuensis, n. sp.

Fig. 62. Ventral view.
Fig. 63. Oblique side view showing large intercalary.
Fig. 64. Apical view showing plate pattern and pores.
Fig. 65. Ventral area of another specimen.

margin is indented widely by the left plate of the ventral area, while that of the distal 5‴ is straight. The antapical are relatively small.

The ventral area is wide and short and does not extend to the center of the antapex. The anterior plate is constricted at the middle and with its truncate anterior extension lies partly in the epitheca. The right plate lies wholly in the hypotheca and extends straight posteriorly. The sausage-shaped left plate indents the postcingular 1‴. The posterior plate is irregularly hexagonal with pointed anterior and posterior ends, the former deflected to the right in connection with the oblique elongation of the flagellar pore. The flagellar fin is relatively small but covers the pore and the inner margin of the left plate. The flagellar pore is slightly curved and somewhat sunk in the body (Fig. 62), so that the flagellar trough lies for the most part inside it on its posterior wall. The left plate has a low list on its outer margin, which connects the flagellar trough with the proximal end of the posterior girdle list. The minute, slender transitional plate lies half in the girdle and half in the ventral area.

The thecal plates are smooth and bear sparsely distributed minute pores; in the ventral area only the three posterior plate have pores.

Dimensions: Body length 40–47 μ, transverse diameter 36–43 μ, dorso-ventral diameter 36–43 μ, width of girdle 5 μ.

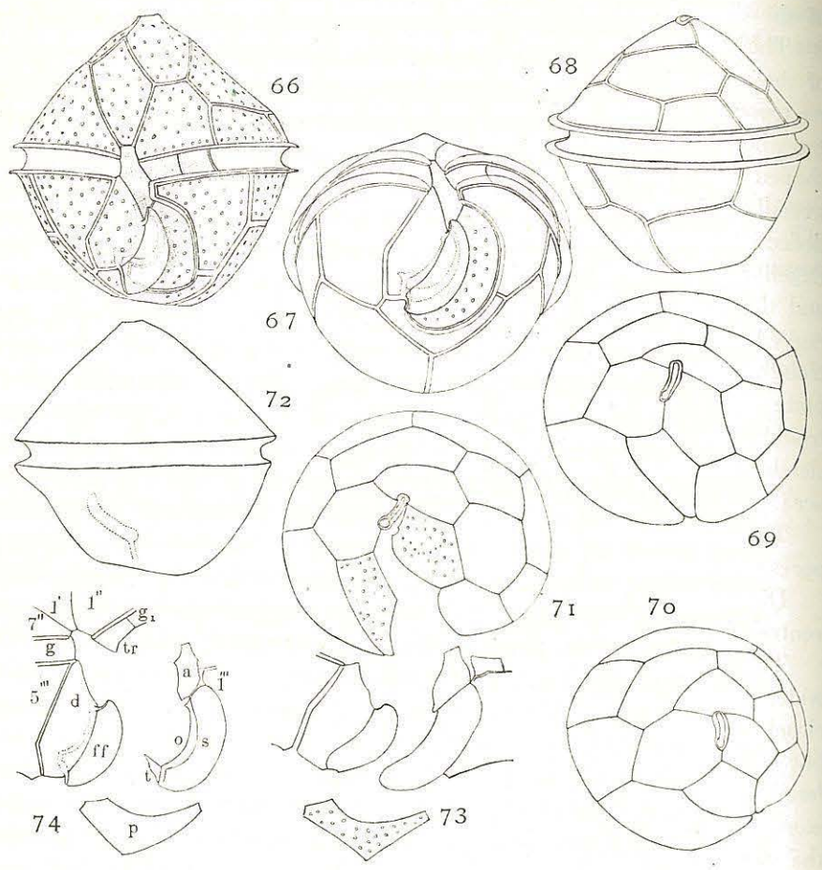
This species is distinguished from *P. minutum* by its slender body, wider ventral area and the absence of apical differentiation. It is most closely related to *P. asymmetrica* in body form and stractural relations, but is distinguished by its wider ventral area, pointed apex and the different relations of the intercalaries to the surrounding plates. From *P. monovelum* and *P. constricta* it is distinguished not only by the shape of the ventral area and the plate pattern of the epitheca but also by body form and size.

In PAULSEN's system this species is to be referred to the Excentrica group, but the characteristic plate pattern of the ventral area and of the epitheca removes it from *P. excentricum*.

8. P. monovelum, n. sp.

The body is medium-sized and rounded pentagonal in side view.

The epitheca is conical with a bluntly pointed apex. The deep, circular or slightly ascending deep girdle is bordered by low hyaline lists. The cingular section is broadly oval. The hypotheca is rounded and slightly flattened at the antapex.



P. monovelum, n. sp.

Fig. 66. Ventral view.
Fig. 67. Oblique antapical view of ventral area.
Fig. 68. Oblique dorsal view.
Fig. 69. Apical view.
Fig. 70. Oblique apical view of another specimen.
Fig. 71. Flattened epitheca of the specimen of Fig. 66–69, showing pores and separated apical furrow plates.
Fig. 72. Oblique dorsal view of a smaller specimen with posterior flattening.
Fig. 73. Isolated plates of ventral area.
Fig. 74. Same from another specimen. a—anterior plate, d—right plate, s—left plate, p—posterior plate, ff—flagellar fin, o—tube wall of flagellar pore, t—dorsal wall of flagellar trough, tr—transitional plate, g—girdle plate.

The plate formula is 4′, 3_a, 7″, 5‴, 2⁗. The sausage-shaped apical furrow, with the apical pore at its ventral end, is oblique and connected with the ventral apical by a short suture between apical 2′ and 4′. The apical furrow plate can be isolated from the surrounding plates by applying pressure on them (Fig. 71). The ventral apical (1′) is elongated obliquely and not in contact with the apical furrow. The dorsal apical (3′) is irregularly pentagonal (Figs. 69–71). There are three intercalaries of subequal size, displaced as a whole to the left side of the epitheca, so that the left terminal one (1_a) is in contact with the proximal precingular (1″). The middle intercalary (2_a) is pentagonal and slightly wedged in between precingular 3″ and 4″, as in the Pyriformia group. Of the precingulars, the dorsal 4″ and the right 7″ are the largest (Figs. 69–71), and the sinistrally displaced intercalaries reduce the size of the left 2′, 1″ and 2″. The two ventral postcingulars, different in shape from the others, are large and extend a good way backwards, while the other three are low. The left 1‴ has at its antero-median corner an elongated neck with abruptly truncated distal end. The large antapicals occupy one half of the hypotheca.

The girdle wall consists of one transitional and three girdle plates. The first girdle plate is small and subequal to the transitional. The third plate is exceedingly long and conterminous with the two distal precingulars as with the corresponding postcingulars (Fig. 68).

The ventral area is nearly one-third as large as the whole ventral surface of the hypotheca, and asymmetrically expanded at the middle. The flagellar pore lies obliquely in the middle of the ventral area, and bears a broad flagellar fin with a minute rib on its postmargin, springing from the postero-median corner of the left plate. The small anterior plate lies in the inter-cingular region, and indents the epitheca with its broad, truncated anterior extension. The right plate is lens-shaped, confined to the hypotheca and bears a broad flagellar fin upon its median margin. The curved, sausage-shaped left plate is subequal to the right and broadly indents the postcingular 1‴. These two median plates differ especially in their outer contour, which is rounded in the left but pointed in the other, and bring about the asymmetry of the middle part of the ventral area (Figs. 66, 67). The posterior plate is broadly V-shaped and extends laterally beyond the two middle plates, the left half being more slender. The flagellar trough is short and lies at the posterior end of the flagellar pore which has a posterior prolongation. The anterior border of the posterior plate is pointed at the flagellar trough and the

plate has a greater extension to the left than to the right (Figs. 73–74). The right and posterior plates are flat and bear no marginal lists, but the left plate is bordered on the outer side by a low hyaline list connecting the flagellar trough with the proximal end of the posterior girdle list (Figs. 66, 67). The flagellar fin is expanded distally (Figs. 66–67, 73–74), and its anterior part spreads towards the left over the flagellar pore while the distal part of its posterior end spreads ventrally and posteriorly, away from the pore. The longitudinal furrow s. str. is limited to the part occupied by the flagellar pore, the anterior and left plates. The large, quadrangular transitional plate lies in the proximal part of the girdle and extends distally about half the basal length of the precingular 1″; its proximal half expands slightly in its posterior part (Figs. 73, 74) The median marginal part of the left plate composing the left side wall of the inner extension of the ventral pore is illustrated in Fig. 74, while the corresponding part of the right plate forming the opposite wall of the pore is seen folded under the plate along its median margin. The truncated postero-median margin of the left plate delimiting flagellar trough on the left side, bears a minute appendage (Fig. 74 *t*) forming the dorsal wall of the flagellar trough.

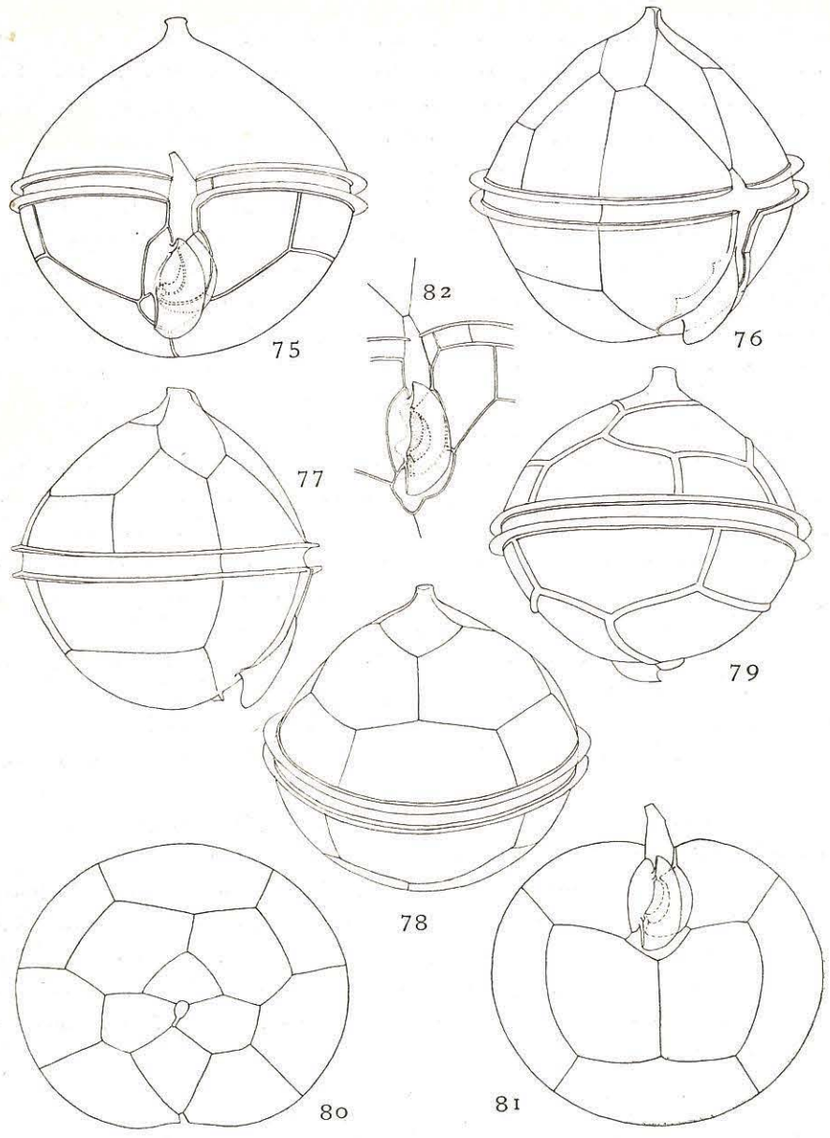
The thecal surface is smooth but sparsely beset with comparatively large pores. A regular line of pores is present in both the pre- and postcingular plates just outside the girdle lists. In the ventral area, only the three posterior plates bear pores (Fig. 66). The cell content is light brown.

Dimensions: Body length 50–58 μ, transverse diameter 51–54 μ, dorso-ventral diameter 42–46 μ, width of girdle 5–5.5 μ.

This species is distinguished at once from all others of the Avellana group by its pentagonal form, circular girdle, flat girdle plates and expanded ventral area; from *P. verrucosum* MANGIN by its larger size and the asymmetrical extension of the intercalaries; and from *P. minutum* KOFOID and *P. monospinum* PAULSEN by its larger ventral area, and the absence of apical differentiation.

9. **P. constricta,** n. sp.

The body is spherical with a small but abruptly elevated apical horn lying ventrally at a short distance from the center of the epitheca. The cingular section is oval with or without ventral flattening. The epitheca is slightly larger than the hypotheca. The fact that "the hypotheca plus



P. constricta, n. sp.

Fig. 75. Ventral view.
Fig. 76. Dextro-ventral view.
Fig. 77. Side view showing posterior extension of flagellar fin and low lists of ventral area.
Fig. 78. Antero-dorsal view.
Fig. 79. Oblique dorsal view showing posterior extension of flagellar fin.
Fig. 80. Schematized plate pattern of epitheca.
Fig. 81. Plate pattern of hypotheca and ventral area.
Fig. 82. Ventral area of a specimen with small postcingular 1‴ and larger 5‴.

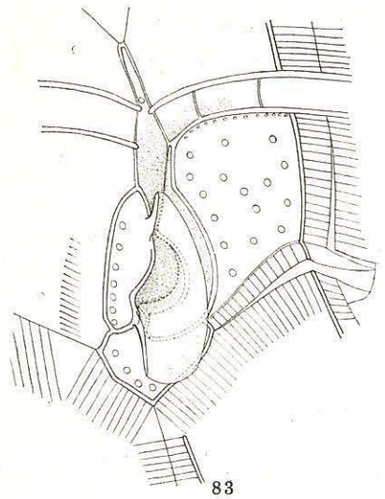
the girdle is about equal to the epitheca" in *P. minutum* is also true in this species. The girdle is circular, but its ventral ends curve backwards in a similar manner (Figs. 75, 83). The girdle wall is flat or slightly concave and bordered by low hyaline lists.

The plate formula is 4′, 2_a, 7″, 5‴, 2⁗. The ventral plate pattern of the epitheca is "ortho" and two intercalaries may be equal or subequal, but symmetrical. The three dorsal apicals are small while the diamond-shaped midventral (1′) extends obliquely from the ventral slit of the apical pore to the anterior end of the ventral area. The two terminal postcingulars may be equal or the left (1‴) may be slightly smaller than the right (5‴). The ventral slit of apical pore is narrow and deflected to the right of the apical horn in connection with the obliquity of the apical 1′.

The small, short ventral area does not extend to the center of the epitheca; it is spoon-shaped and consists of an anterior narrow and a posterior expanded parts, and bordered by low hyaline lists continued forwards to the ventral ends of the posterior girdle lists. The longitudinally elongated anterior plate lies between the girdle ends and the anterior parts of the terminal postcingulars, the median margins of which are parallel for a short distance; its narrow anterior extension indents the epitheca deeply and obliquely between the two terminal precingulars and comes in contact with the posterior end of the apical 1′.

The abruptly expanded middle part of the ventral area is clearly marked off from the narrow anterior part. The right plate is small and straight. The more or less curved, sausage-shaped left plate with its narrow anterior extension reaches to the proximal end of the girdle, beyond the middle expanded part of the ventral area, but the right plate terminates further backwards, not reaching the girdle. The relatively large flagellar pore lies at the centre of the middle part, and is pointed anteriorly but rounded posteriorly. The short flagellar trough lies half outside and half inside the pore (Fig. 83). The posterior plate is set off from the middle part of the ventral area by a slight constriction, and is asymmetrical in shape, the right half being short and wide and the left elongated and narrow, but both coming into contact with the posterior ends of the terminal postcingulars. This asymmetry of the posterior plate is related to the asymmetrical posterior extension of the terminal postcingulars (Figs. 82, 83). The exceedingly broad, distally expanded right flagellar fin nearly covers the left half of the posterior broader part of the ventral area, and bears two ribs on its anterior and posterior

margins. The anterior rib springs from the median border of the right plate at the anterior end of the flagellar pore and is abruptly curved forwards, while the much longer posterior rib springs similarly at the posterior end of the pore, and abruptly curves backwards, and is subject to individual variation sometimes reaching beyond the posterior end of the hypotheca. A much smaller fin can be observed in a few cases on the left edge of the pore. If we except the flagellar fin on the right plate, the left anterior fin connecting the flagellar trough with the proximal end of the posterior girdle list is most prominent among the marginal lists.



P. constricta, n. sp. (2)

Fig. 83. Ventral area of another specimen, drawn with a camera lucida. (ca. ×1500).

The small transitional plate lies exclusively to the proximal part of the girdle, which slightly expands here mediad and posteriad. The first girdle plate is a little larger than the transitional, while the distal plate is elongated and conterminous with the precingular 7″; the remaining part of the girdle is covered by the elongated second plate.

The smooth thecal surface have sparsely distributed somewhat large pores, and a regular line of small pores is present on the precingulars just outside the girdle lists. In the ventral area, a line of several larger pores can be observed along the outer margin of the right and the posterior plates, while the other two plates have no pores or porulated very sparingly. In the specimen shown in Fig. 83, there is a pore in the basal part of the anterior extension of the anterior plate.

Dimensions: Body length (excluding the apical horn) 55–64 μ, transverse diameter 60–67 μ, dorso-ventral diameter 56 μ, width of girdle 4–5 μ.

This species is closely related to *P. minutum* KOFOID in body form but differs in size and has a smaller ventral area. From *P. monospinum* LEBOUR it is distinguished by its shorter ventral area and ventrally displaced apex. It is distinguished from the most closely related *P.*

monospinum PAULSEN by its larger size and different epithecal plate pattern. These minor differences from *P. minutum* and *P. monospinum* are not of taxonomic importance and the available descriptions and figures of the ventral area of these species are far from complete, while as described above, there are many types of plate pattern for the ventral area of this group. I will however provisionally regard my species as new. From the ether species of this group the new one is distinguished at once by its larger body, differentiated apical horn and relatively small ventral area of peculiar structure.

III. GROUP EXCENTRICA

Section Excentrica PAULSEN 1931.

PAULSEN was the first to distinguish *P. excentricum* and *P. groenlandicum* from other members of *Archaeperidinium* and establish the section Excentrica on the basis of irregularity of the two intercalary plates. *P. mutsuensis* would have to be included in this group if we disregard the profound differences in the skeletal morphology of the ventral area. The number and relative size of the epithecal plates are subject to variation and not sufficient for such taxonomic distinction as PAULSEN has made.

P. excentricum seems to be quite unrelated to the two groups already described, from which it differs not only in the dorsal intercalaries but also in surface marking, well developed spinous girdle lists and the structure of the ventral area.

But a close relationship between this and some of the Avellana group is suggested by the corrugated girdle plates and the ventrally displaced apical horn. Except for these resemblances, the plate pattern of the ventral area and of the epitheca as well as the well ribbed girdle lists of *P. excentricum* plainly show that there are greater differences between this and the preceding two groups than between the two groups themselves. In the peculiar flattening of the body and the ventral displacement of the apical horn, *P. excentricum* seems to be most closely related to *P. hemisphaericum*, but an examination of the ventral area brings out some fundamental differences from the other two groups in its structural relations and plate pattern.

This group is characterized by the irregular flattening of both epitheca and hppotheca, the remarkable ventral displacement of the apical horn, the spinose thecal plates, the presence of a large transitional plate in the ventral area and the longitudinal elongation of the ventral furrow.

P. excenticum PAULSEN is the sole representative of this group.

10. P. excentricum PAULSEN.

PAULSEN 1908.
LEBOUR 1925.
P. perrieri FAURÉ-FREMIET 1909.

The body is irregularly flattened, the apical horn stands near the ventral end and the ventral furrow is considerably elongated.

The dorsal region of the epitheca and the ventral part of the hypotheca are very flattened, though in different degrees in different individuals. There seems to be a tendency for larger individuals to be relatively more flattened, as may be seen by comparing the three specimens illustrated in this paper. In consequence of the dorsal flattening of the epitheca, the apical differentiation is conspicuous in a side view of any specimen, but in a ventral view of small apecimens (Fig. 91), the epitheca is simply triangular in contrast to larger specimens (Fig. 84) with conspicuous apical horn. In small specimens, the apical end is flattened dorso-ventrally and there is a prominent ridge running dorsad (Fig. 98), but in larger specimens this ridge is indistinct.

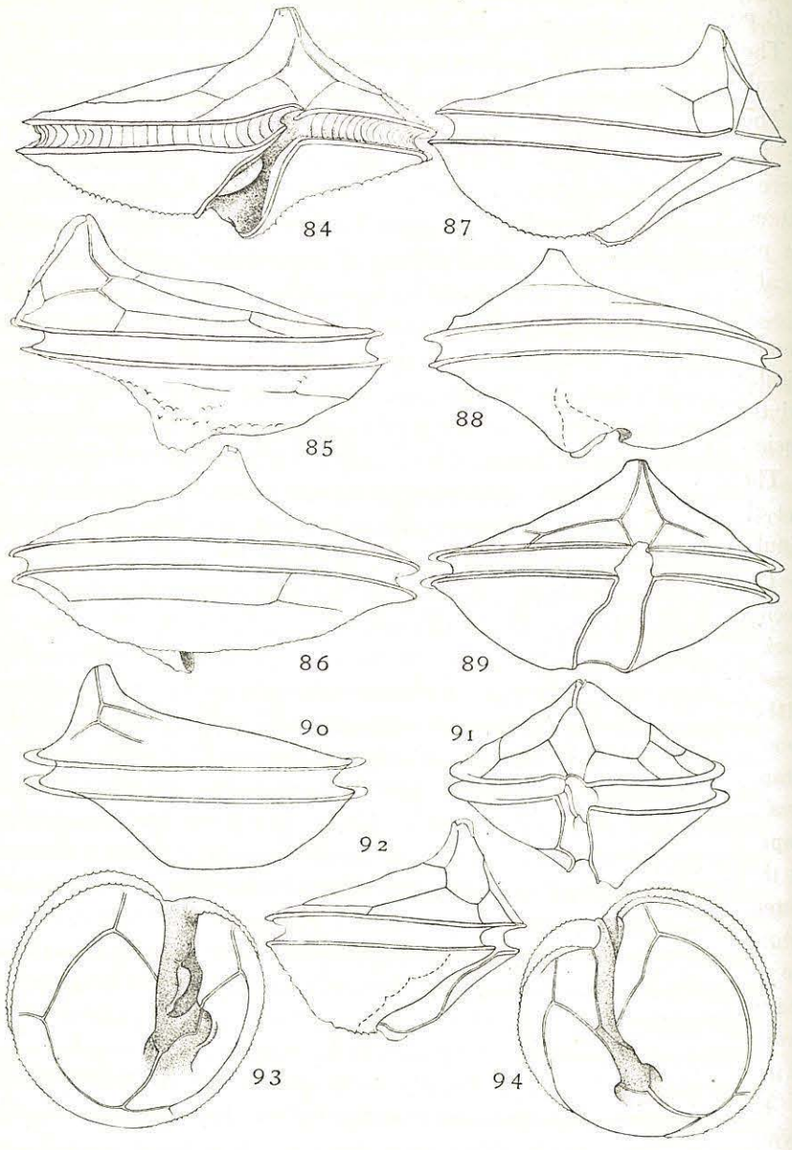
The girdle is circular or slightly ascending, especially in its distal part (Figs. 84, 87, 91.); it is deep and bordered by narrow, minutely spinulated lists.

The hypotheca is strongly flattened in its ventral half, but in smaller specimens it is relatively higher than in larger ones. In the smallest specimen here shown, the height of the hypotheca is 0.42 times the transverse diameter, but only 0.17 times in the largest specimen and 0.21 in the intermediate one. I have observed two main forms of hypotheca, one with a horn-like process at the antero-median corner of the left antapical plate (Fig. 84) and the other without (Fig. 89), but intermediate ones are numerous (e. g. Figs. 87, 88). With regard to its position and shape, it is in most cases on the left margin of the ventral furrow, formed by the left antapical plate and the left plate of the ventral area and is flattened laterally by the excavation of the ventral furrow (Figs. 84, 85, 86); but more rarely, it lies on the antapical plate slightly removed from the margin of the ventral area and is also excavated on its median side by the posterior prolongation of the ventral furrow (Figs. 92-94).

The cingular section is roundish, with the largest transverse diameter in its ventral half, and has a midventral indentation.

The plate pattern is characteristic, with irregular dorsal apical and asymmetrical intercalaries. The apicals are small and the smallest apical

(1′) is connected with the apical pore by its pretty long ventral slit (Figs. 84, 91). The smaller left intercalary is mostly elongated, as in Fig. 95 or 98, but often much shorter (Fig. 97). Of the precingulars, there are



two types. In the specimen illustrated in Fig. 95 or 98, the precingulars 4″ and 5″ are subequal and divided by the middorsal suture, while in others, precingular 4″ is notably smaller than 5″ and the intervening suture is displaced to the left (Fig. 97). The left antapical is a little smaller than the right.

The apical pore has a narrow, elongated ventral groove or "slit" with thin, hyaline lists, which may sometimes be prolonged beyond the groove around the ventral apical plate (Fig. 85).

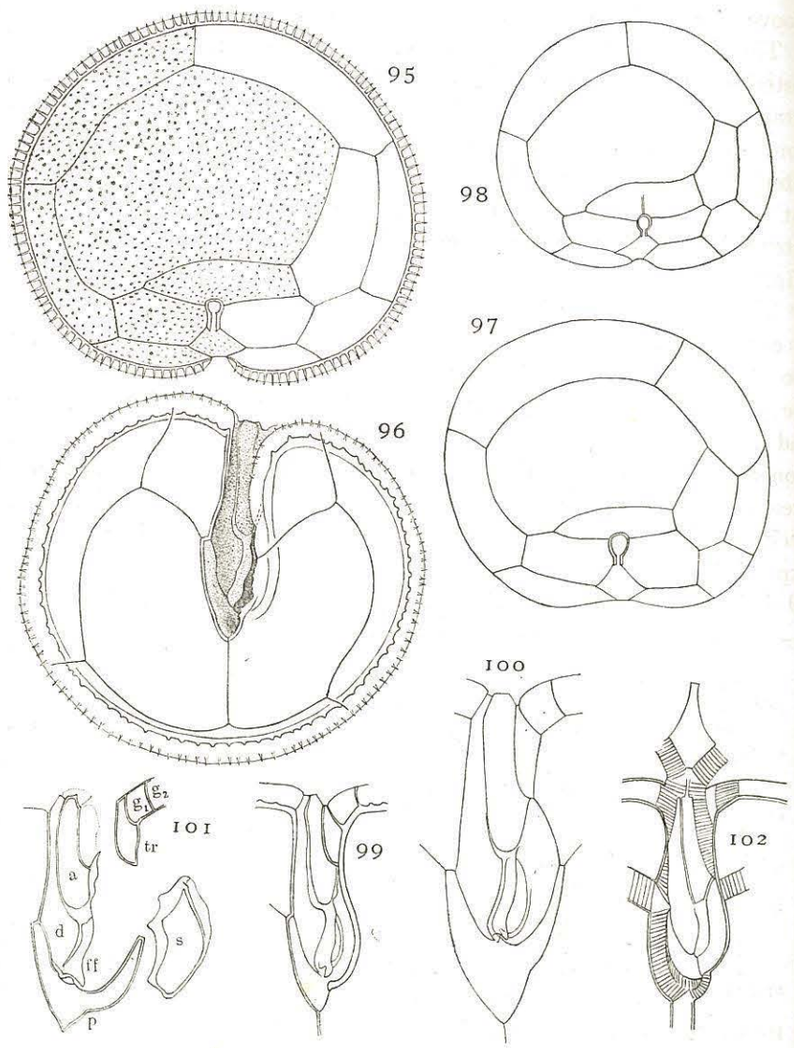
The deeply excavated ventral area is relatively wide, slightly expanded posteriorly and reaches beyond the center of the hypotheca between the antapicals. The two ends of the posterior girdle list extend backwards along the median margins of the ventral postcingulars and border the anterior half of the ventral furrow. The right list is mostly indistinct, but the left is broad and ribbed like the girdle list; very rarely both extend backward around the posterior margin of the ventral furrow (Fig. 88).

The plate pattern of the ventral area is also characteristic. The girdle is covered for the most part by the much elongated second plate, and the other two distal plates are very small and lie at the ventral ends of the girdle. The large transitional plate is confined to the ventral furrow and is symmetricall with the anterior part of the right plate. The elongated anterior plate lies in the median part of the anterior ventral area and slightly indents the epitheca (Figs. 89, 91). The slender anterior neck of the right plate extends to the epitheca, and its posterior expanded part bears the stout flagellar fin on its median edge (Figs. 96, 99–101). The irregularly sharped and very concave left plate occupies

P. excentricum PAULSEN (1)

Fig. 84. Oblique ventral view of a large specimen showing corrugated girdle and flagellar fin of ventral furrow.
Fig. 85. Side view showing irregular flattening of body and posterior protuberance.
Fig. 86. Dorsal view.
Fig. 87. Oblique side view of another specimen with inconspicuous posterior protuberance.
Fig. 88. Oblique dorsal view of a different specimen.
Fig. 89–90. Ventral and side view of a smaller specimen without posterior protuberance.
Fig. 91–94. A small specimen with higher body and unusual posterior extension of ventral furrow.
Fig. 91. Ventral view.
Fig. 92. Side view.
Fig. 93. Oblique antapical view showing left half of ventral furrow, flagellar fin and posterior plate.
Fig. 94. Oblique antapical view showing right half of ventral furrow and of posterior plate.

the left excavation of the ventral furrow. The posterior plate is slender and V-shaped, with the left arm longer than the right, and both abitting on the postero-lateral margin of the two median plates; the arms are truncated at the ends. The ventral furrow is deeper in its left posterior half than elsewhere, and accordingly its left posterior part is obscured by the overhanging body wall (Fig. 96) lined by the left plate and the left



arm of the posterior plate. The relatively small flagellar pore lies in the left posterior region of the furrow between the concave left and the elevated right plates. The flagellar trough is pretty long and lies in the posterior inner wall of the ventral furrow; its antero-posterior extension can not be observed from outside the furrow but can be surmised from the broadly truncated posterior margin of the left plate (Fig. 101). The ventral furrow may sometimes extend backwards beyond the ventral area into the median anterior region of the antapicals (Figs. 93–94).

The surface of the theca is closely covered with fine spines, better developed in the hypotheca than in the epitheca. The girdle plates are corrugated tranversely, apparently as in the Avellana group (Fig. 84), but the corrugation is superficial in this species (Fig. 96), whereas in the Avellana group it affects the plates themselves. Again, the width of the tranversely striated sutural zones of the ventral area are variable according to individuals; when they are wide, the four plates of the ventral area are as a whole surrounded by them, but there are no similar zones between the component plates. There is also a wide zone between the anterior and the transitional plate (Fig. 102). These facts seem to suggest that the four plates of the ventral area are more closely connected with one another than is the transitional plate with them, and that this intimate connection of the four plates is not disturbed by the subsequent growth of the thecal plates, or in other words, the hydro-dynamical relations within the ventral furrow are retained throughout life, least subject to disturbances. But this matter is reserved for full treatment in later contributions.

Dimensions: Body length 43–48 μ, transverse diameter 58–84 μ, dorso-ventral diameter 50–75 μ, width of girdle 5–6 μ.

P. excentricum PAULSEN (2)

Fig. 95. Apical view of a large specimen, showing surface spines and ribbed girdle list.

Fig. 96. Antapical view showing superficial corrugation of girdle wall, right half of ventral furrow, flagellar fin, right plate, right halves of anterior and posterior plates and deeply concave median part of left plate. The left list bordering the anterior half of the furrow is distinct but the right one is indistinct.

Fig. 97. Plate pattern of a smaller specimen with smaller left intercalary.

Fig. 98. Plate pattern of another smaller specimen with longer left intercalary.

Fig. 99. Plate pattern of ventral area with left ventral half removed.

Fig. 100. Schematized plate pattern of ventral area.

Fig. 101. Component parts of ventral area and proximal part of girdle, of a specimen with pretty wide sutures, spread out in a plane. Thin structureless marginal membranes lining the median and posterior marginal parts of the transitional and the midventral apicals, are present on anterior and left margins of anterior plate.

Fig. 102. Transversely striated zones around the ventral area.

LITERATURE

127) Böhm, Anton 1931. Peridineen aus dem Perrischen Golf und dem Golf von Oman. —Archiv f. Protistk. Bd. 74.

128) Dangeard, P. 1927. Peridiniens nouveaux ou peu connus de la croisière du "Sylvana". —Bull. de l'inst. océanographique. No. 491. Monaco.

129) Dangeard, P. 1927. Notes sur la variation dans le genere *Peridinium*.—Bull. de l'inst. océanographique. No. 507. Monaco.

130) Entz, Géza 1927. Über Peridineen des Balaton-Sees.—Archivum Baltonicum. No. 1.

131) Lebour, M. V. 1925. The dinoflagellates of northern sea.—Marine Biological Association of the United Kingdom. Plymouth.

132) Meunier, A. 1910. Microplankton des mers de Barents et de Kara.—Duc d'Oriléans. Campagne artique de 1907. Bruxelles.

133) Nygaad, G. 1926. Plankton from two lakes of the Malayan region.—Videnskabelige Meddeleker fro Dansk Naturhistorisk Forening i Kφbenhavn. Bd. 82. Kφbenhavn.

134) Ostenfeld, C. H. and Nygaad, G. 1925. On the phytoplankton of the Gatun Lake, Panam Canal.—Dansk Botanisk Arkiv. IV. No. 10. Kφbenhavn.

135) Paulsen, O. 1913. Peridinailes ceterae.—Bull. trimestriel des résultats acquis. Copenhague.

136) Paulsen, O. 1931. Études sur le Microplancton de mer d'Alboran.—Trabajos. No. 4. Madrid.

137) Pavillard, J. 1923. Apropose de la systematique des Peridiniens.—Bull. de la soc. bot. de France. Tome 70. Paris.

138) Peters, N. 1928. Die Peridinien Bevölkerung der Weddelsee mit besonderer Berücksichtung der Wachstums- und Variationsformen.—Internationale Revue der gesammten Hydrobiologie und Hydrographie. 21. Leipzig.

139) Schilling, A. J. 1913. Dinoflagellatae (Peridineae).—Die Süswasserflora Deutschelands. Heft III. Jena.

140) Woloszynska, E. 1912. Das Phytoplankton einiger javanischer Seen, mit Berücksichtung des Sawa-planktons.—Bull. Acad. Sci. Cracovie, Cl. math. Sci. Nat. Ser. B.

For further literature on this subject, see my former paper (1927).