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318. AUSTRALIAN PALEOCENE *LAMARCKINA* AND *CERATOBULIMINA*, WITH A DISCUSSION OF *CEROBERTINA*, *PSEUDOBULIMINA*, AND THE FAMILY ROBERTINIDAE

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ABSTRACT

The genera **Cerobertina**, **Pseudobulimina**, and **Robertinoides** have the same basic form and orientation of toothplate as **Ceratobulimina** and **Lamarckina**, but they are more advanced structurally and phyletically in possessing some or all of: chamberlets, double aperture, enrolled toothplate, primary septal foramen. **Cerobertina** evolved from **Ceratobulimina (Ceratolamarckina)**, acquiring its advanced characters quite independently of **Robertinoides** and in parallel; it seems that **Pseudobulimina** and **Alliatina** did this also. All these genera are placed in the family Robertinidae, for which three subfamilies are recommended: Ceratobulimininae, Robertininae, and Alliatininae, subfam. nov.

Lamarckina is a relatively conservative group, low in variability and distinct from **Ceratobulimina s.l. Ceratobulimina** is more diverse and variable; the three subgenera proposed by Troelsen, **Ceratolamarckina**, **Ceratocancris** and **Ceratobulimina s.s.**, are acceptable and useful on morphological, stratigraphical and phylogenetic bases. Five species of **Lamarckina** and **Ceratobulimina**, including **Ceratobulimina (Ceratocancris) praecursoria** sp. nov., are known from the Paleocene of southern Australia.

INTRODUCTION

The genera grouped around *Ceratobulimina* have been the subject of several special studies during the past three decades. Earlier confusion, exemplified by Cushman's first classification (Cushman 1928) where *Ceratobulimina, Lamarckina* and *Robertina* were referred to the Cassidulinidae, Rotaliidae and Buliminidae respectively, was resolved in large part by detailed structural studies during the mid-thirties. Following lucid descriptions of *Epistominoides* and *Ceratobulimina* by Plummer (1934, 1936), Glaessner (1937) recognized the evolutionary coherence of these and several other genera on the basis of their internal structures; the genera thus were combined as the family Ceratobuliminidae. Subsequent studies by Höglund (1947), Brotzen (1942, 1948), Troelsen (1954) and several others have added considerably to our knowledge of these genera. And yet there is some justification for Pokorný's assertion that "a comparison of all these works shows how chaotic and tortuous the path of palaeontological research can become" (Pokorný 1958; English translation by K. A. Allen, 1963). Certainly the family group systematics have been somewhat "chaotic and tortuous"; presumably the recent classification by Loeblich and Tappan (1964) and the present contribution sustain this tendency. Apparent reasons for this include the fact that the tests themselves are more involved structurally than in most smaller foraminifera; the approaches of different workers differ greatly; and while these forms are non-planktonic and therefore slightly unfashionable at the present time, sufficient new data has been acquired to bring about some rather drastic reappraisals.

Attention lately has been focused more on the early *Epistomina*-like forms (reference in Espitalié and Sigal, 1963, Loeblich and Tappan, 1964). In the Tertiary and Recent in the southern Indo-Pacific faunal province there are quite a few *Ceratobulimina*-like species, but they have been neglected somewhat, apart from studies by Finlay (1939) and Troelsen (1956). The Paleocene of Australia includes both the oldest true *Ceratocancris* and the structurally most advanced *Ceratolamarckina*. In the later Tertiary and Recent, *Cerobertina, Pseudobulimina* and *Robertinoides* are well represented. Apertures and toothplates have been emphasized in the study of these genera; observations on wall structure in oriented sections are not relevant to family group systematics and will be the subject of a separate paper.

It is worth emphasizing that the classification arrived at in Part Two of this paper is likely to be extended, rather than drastically modified, when more genera are considered. The present classification is introduced because the emphasis is placed on the phyletic unity of the group, as reflected in their toothplate structures. The Robertinacea, and particularly the Ceratobuliminidae, recently have acquired several new members (Loeblich and Tappan 1964), though these authors make it clear that some of these genera are included only tentatively. The next steps will be to investigate the structure of these forms further and to reconsider the advisability of using the aragonite wall as the single, exclusive key character to define the superfamily. Perhaps there is a "chaotic and tortuous" stretch still to be traversed before we can regard the systematics, up to and including superfamily rank, as resting on a secure basis.

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PART ONE: *LAMARCKINA* AND *CERATOBULIMINA*

Occurrence

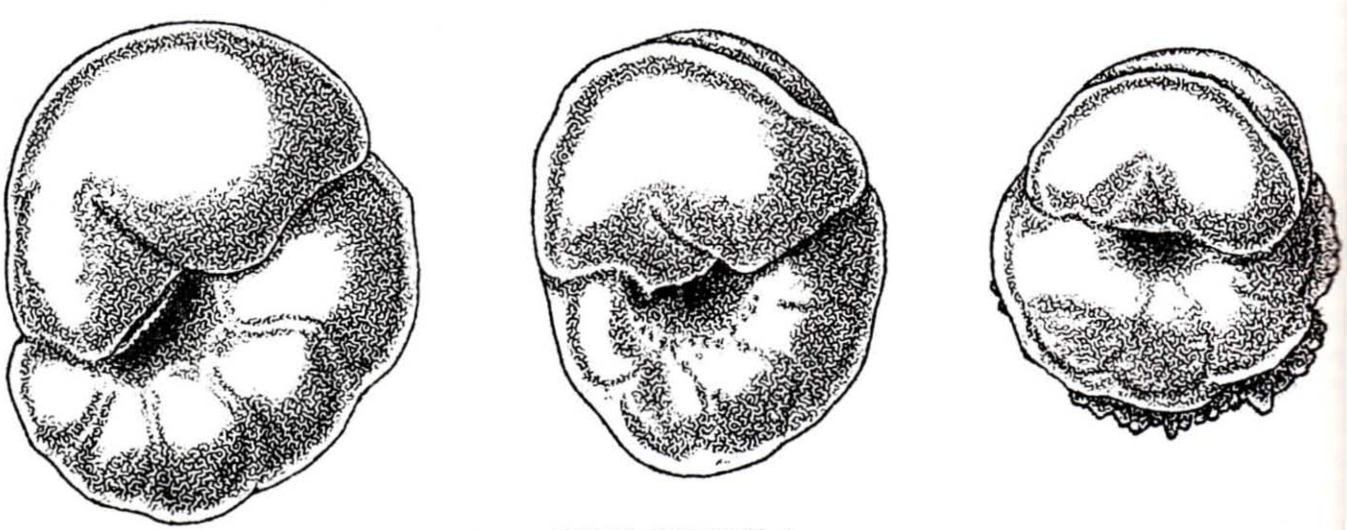
The species studied come from two widely separated Paleocene sequences in southern Australia. In the Wangerrip Group in the Otway Basin, Western Victoria, foraminiferal faunas have been found in the Pebble Point Formation at the base of the sequence, and in the Rivernook Member of the overlying Dilwyn Clay. These assemblages have been dated as Middle Paleocene and Upper Paleocene respectively (McGowran, 1965). From the Perth Basin in Western Australia, Parr (1938) described a fauna which he regarded as Upper Eocene. This fauna, in what is known now as the King's Park Shale, has been re-dated as Paleocene (McGowran 1964). Table 1 summarizes the occurrence of *Lamarckina* and *Ceratobulimina* in these formations. Further data are given under the species concerned at the end of the paper.

Aperture and Toothplate

(1) *Lamarckina* (text fig. 1, 2). The aperture of *Lamarckina* varies from semicircular to distinctly crescentic. As noted by Glaessner (1937), *Lamarckina* has much the same sort of toothplate structure as *Ceratobulimina*. The major difference from all *Ceratobulimina*, except perhaps the earliest species, such as *C. woodi* Khan, is that the attachment line of the toothplate to the septal face bends sharply.

TABLE 1

	Pebble Point Formation	Rivernook Mem., Dilwyn Clay	King's Park Shale
Lamarckina rugulosa Plummer		+	+
Lamarckina naheolensis Cushman and Todd		+	?
Ceratobulimina (*Ceratolamarckina*) *jutlandica* Troelsen	+	+	
Ceratobulimina (*Ceratolamarckina*) *westraliensis* Parr	+	+	+
Ceratobulimina (*Ceratocancris*) *praecursoria* sp. nov.			+



TEXT FIGURE 1

Left, *Lamarckina erinacea* (Karrer), Miocene, Kostej, Rumania. Centre, *Lamarckina wilcoxensis* Cushman, Bashi Marl Member, Hatchetigbee Formation, Lower Eocene, Alabama. Right, *Lamarckina rugulosa Plummer,* Wills Point Formation, Paleocene, Texas. All 106 ×. Note toothplate suture in apertural face.

Thus the toothplate is folded crosswise into two triangular components. One of these is fixed to the septal wall below the foramen and also to the apertural face where it is marked by a distinct line or groove (text fig. 1, 2). This is particularly clear in topotypes of *L. erinacea* (Karrer), though it is not shown in the specimen figured by Loeblich and Tappan (1964). The other component of the toothplate is fixed to the septum on a line running from just below the marginal end of the foramen to the contact of the septum with the previous whorl at the boundary of the umbilical depression. It may cross this contact to be anchored on the previous whorl. The free edge of the toothplate, curved or rippled slightly and serrate, runs from this point to the outer (marginal) end of the groove or line in the apertural face.

These results, derived primarily from *Lamarckina rugulosa* and *L. naheolensis,* have been confirmed in *L. wilcoxensis* Cushman and Ponton, *L. airensis* A. N. Carter, *L. glencoensis* Chapman and Crespin, *L. ovula* Le Calvez, and the type species, *L. erinacea* (Karrer). They agree with Glaessner's results (Glaessner 1937). Brotzen (1942) figured the same structure, though later (1948) he described it obscurely (Troelsen 1954). Troelsen (*l.c.*) on the other hand described the toothplate as "rather small"; his figured *L. wilcoxensis* (Pl. 10, fig. 2) suggests the structure described above, but *L. rugulosa* (Pl. 10, fig. 1) is misleading, in that the lower component of the toothplate is not shown.

A further structure was noted by Troelsen and confirmed in part, but not completely, by the present study. According to Troelsen, the gap by which the main volume of the final chamber has access to the "umbilical vestibule," or the "sekundärer Kammerraum" of Brotzen (1942), is closed at the next instar but one (*i.e.* the third-last chamber) by a very delicate, pustulose plate, the vestibule thus being sealed. Study of several species has shown that this plate exists (text fig. 2.6), but it appears in the second-last chamber in *L. glencoensis,* for which dissecting material was relatively abundant. Moreover, it does not seal off a cavity, but together with the toothplate forms the new floor of the chamber. Troelsen's diagrammatic section (1954, fig. 2a) can be corrected for *Lamarckina* by removing the earlier septa below (adaxial to) the toothplates. Thus, when the final chamber is removed, the "umbilicus" is seen to be a hemispherical bowl lined in part by toothplates and pustulose secondary plates. Strictly speaking, this is not an umbilicus in the rigorous sense of Reiss (1960, 1963) but analogous rather to the "false umbilicus" of *Globorotalites* or *Eponides.* The pustulose plate in the second-last chamber only is shown in text figs. 2.3 and 2.5.

(2) *Ceratobulimina* (*Ceratolamarckina*) (text figs. 3, 4). While Troelsen (1954) showed that there is some variation in structure in *Ceratolamarckina,* this variation is somewhat greater in the subgenus as it is understood here.

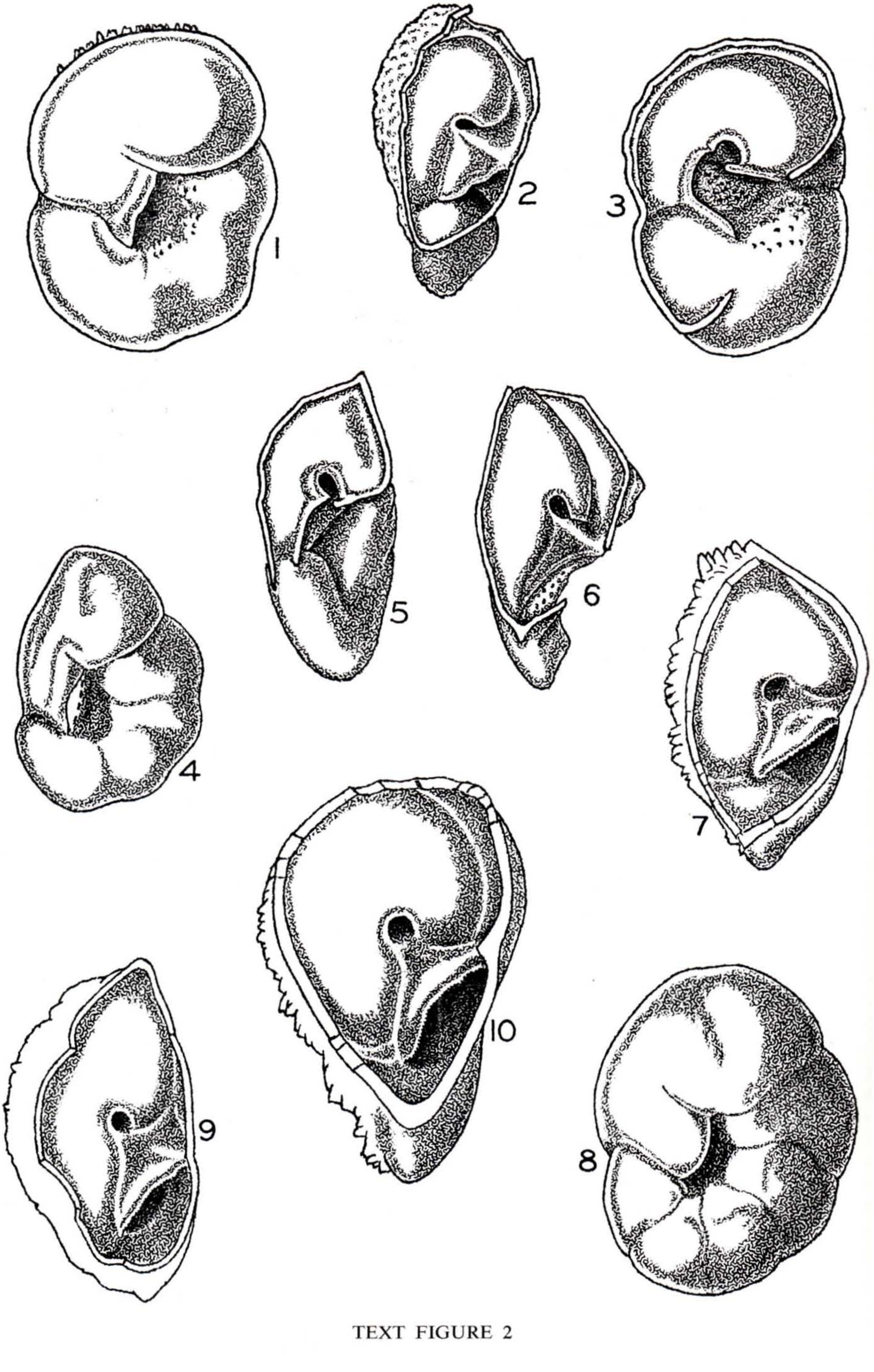
Troelsen's description of the structure in *C. woodi* Khan has been confirmed in paratypes and other specimens. The apertural lip is curved; the toothplate attachment groove in the apertural face is distinct; the toothplate is curved, like *Lamarckina* but not so sharply, so as to extend down to the base of the septal face.

In the Paleocene species *C. jutlandica* Troelsen, the hollow of the aperture and umbilicus is rather open and the groove is distinct. The toothplate is restricted. It is a simple, more or less triangular plate with the slightly thickened free edge extending from the marginal side of the foramen to the marginal end of the groove. Thus it is equivalent to half of the folded toothplate in *Lamarckina* and *C. woodi.* But the thickened rim bordering the secondarily replaced umbilical area also is present, though not as a line of attachment.

The groove or line in the apertural face occurs in *C. perplexa* (see also Plummer, 1936) and *C. tuberculata* (Brotzen, 1948, pl. 19). In *C. tuberculata* the septal attachment of the toothplate extends beyond the foramen without reaching the spiral wall (Brotzen, 1948, Troelsen, 1954). In *C. perplexa* it reaches the spiral wall without becoming attached to it (Plummer, 1936). That is, in both species the toothplate is more extensive than in *C. jutlandica,* as well as being curved "downwards."

C. westraliensis represents a still more advanced stage. The apertural lip may be straight but usually is curved strongly. More than in the previous species, the aperture-umbilicus has a distinctly crescentic appearance because the aperture, as defined by its free lip, extends further into the apertural face. Correlated with this, the groove in the apertural face is absent or insignificant. Thus the free edge of the toothplate joins the apertural face at a point very near the apex of the apertural notch. The other end of the toothplate's free edge usually is joined to the spiral wall, again in contrast to other known species of *Ceratolamarckina.* One specimen figured is irregular (but not unique) in that the septal attachment does not extend beyond the foramen. These specimens were broken; it is possible that the effect was caused by lamellar exfoliation. There is no other evidence for this, however, and it is thought to represent toothplate variation.

(3) *Ceratobulimina* (*Ceratobulimina*). The disappearance of the groove and the attachment of the toothplate to the spiral wall in *C. westraliensis* clearly foreshadow the structure of *Ceratobulimina s.s.* Troelsen (*l.c.*) has shown how the toothplate in this subgenus is curved strongly, being wrapped around the deep apertural cleft at one side and fixed for a considerable length to the spiral wall at the

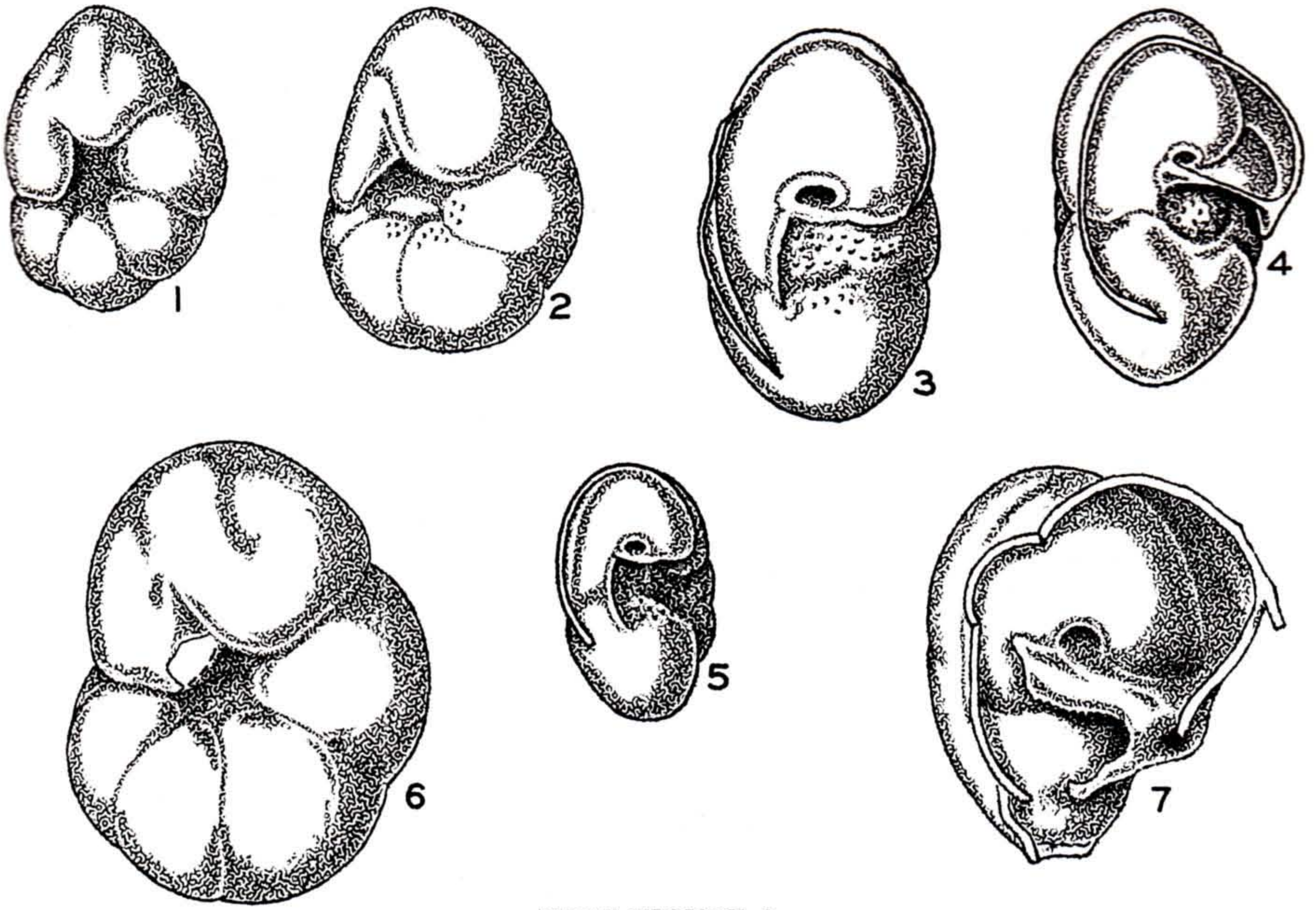


TEXT FIGURE 2

other. These characters were observed in *C. contraria* (Reuss) and in *C. pacifica* Cushman and Harris.

(4) *Ceratobulimina* (*Ceratocancris*) (text fig. 5). The new Paleocene species *C. praecursoria* has the basal aperture, between an axial notch and a marginal notch, characteristic of *Ceratocancris* (Finlay, 1939, Troelsen, 1954). The long groove extending into the apertural face from the axial notch is distinct but variable in its angle to the aperture. The apertural face is rather flattened, the "covering plate" (Finlay, *l.c.*) being less distinct than in *C. australis* Cushman and Harris and *C. stellata* Bandy especially. Unfortunately, the preservation of the new species rendered further detailed examination impossible, apart from the toothplate and some minor points.

The structural features of *Ceratocancris* were studied in most detail in *C. australis*. Troelsen (*l.c.*)



TEXT FIGURE 3

Aperture, toothplates in *Ceratobulimina* (*Ceratolamarckina*). All 158 X.

1, *C.* (*Cl.*) *woodi* Khan, Gault, Albian, Folkestone, England.

2-5, *C.* (*Cl.*) *jutlandica* Troelsen. 2, 4, Paleocene, LaTrobe bore No. 1, western Victoria; 3, Paleocene, Rivernook Member, Dilwyn Clay, western Victoria; 5, Paleocene, Rugaard, Denmark. *Note*: toothplate suture in apertural face; restricted toothplate; sharply defined edge of pustulose recessed area.

6, *C.* (*Cl.*) *perplexa* (Plummer), Wills Point Formation, Paleocene, Texas. Apertural lip broken: original position shown by broken line.

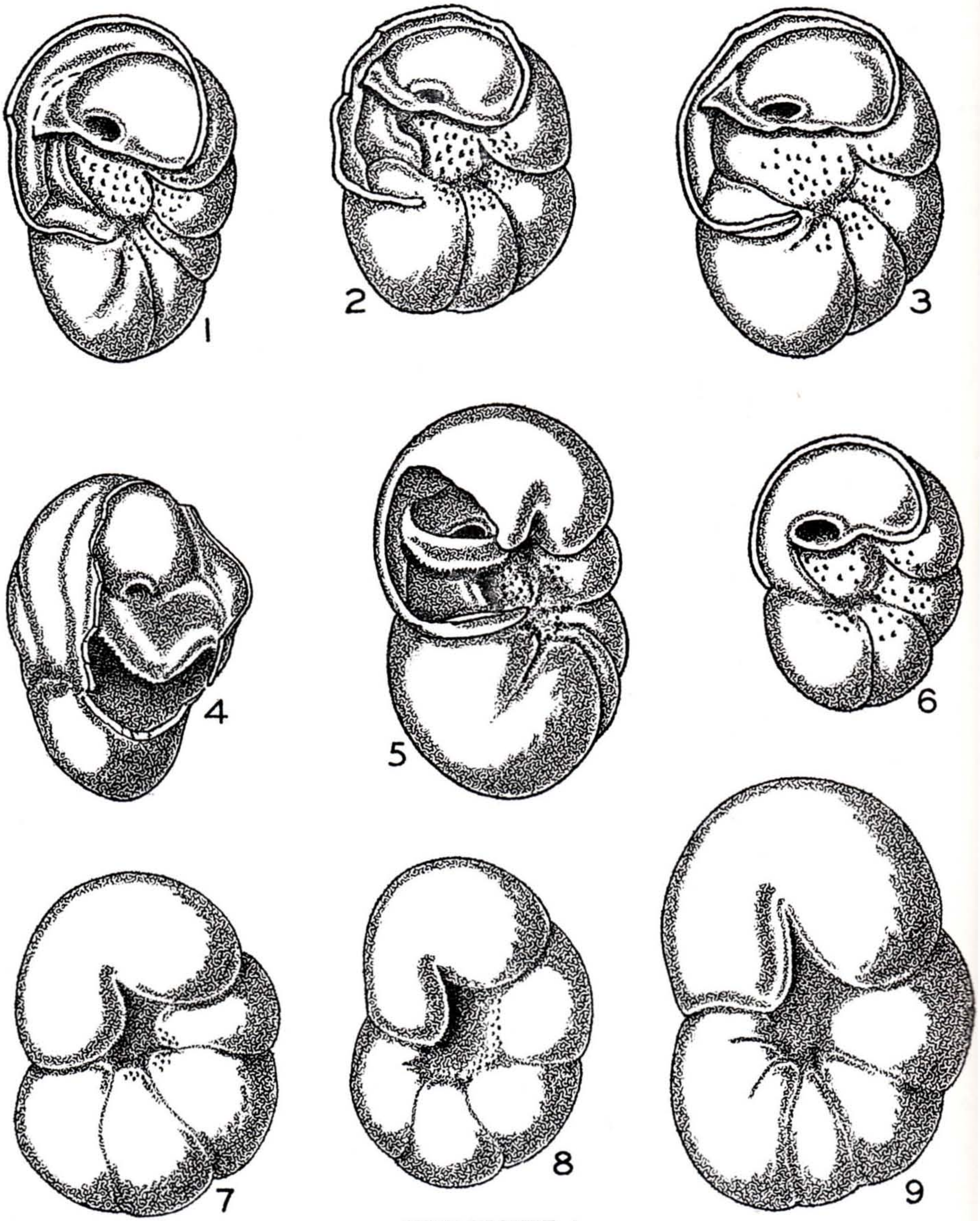
7, *C.* (*Cl.*) *tuberculata* Brotzen, Paleocene, Denmark. Second last chamber opened; position of ultimate septal foramen shown as deep shadow below broken end of ultimate septum; folded toothplate larger than in *C. jutlandica* but not reaching spiral wall.

EXPLANATION OF TEXT FIGURE 2

Apertures, toothplates in *Lamarckina*.

1-3, *Lamarckina rugulosa* Plummer; 4-6, *L. naheolensis* Cushman and Todd; both from Rivernook Member, Dilwyn Clay, Paleocene, western Victoria. 7, 8, *L. airensis* Carter, Brown's Creek Clays, Upper Eocene, western Victoria. 10, *L. glencoensis* Chapman and Crespin, Jan Juc Formation, Oligocene, western Victoria. 9, *L. erinacea* (Karrer), Miocene, Kostej, Rumania. 1-6, 158 X; 7-10, 106 X.

Note: Similarity of apertures and toothplate sutures in 1, 4, 8 (apertural lip broken in 4: original position shown by broken line). Similarity of toothplate form and orientation in 2, 6, 7, 9, 10. Delicate membrane, pustulose on under-side, attached to previous free edge of toothplate in 6; toothplate of third-last chamber is figured. Recessed secondary wall below toothplate attachment in 3, 5.



TEXT FIGURE 4

Aperture, toothplate in *Ceratobulimina* (*Ceratolamarckina*) *westraliensis* Parr. 1-8, Paleocene, Rivernook Member, Dilwyn Clay, western Victoria; 9, Paleocene, King's Park Shale, Western Australia. All 158 X.

Note: toothplate attached to spiral wall in 1-5 but not 6; position of old aperture in relation to septal foramen in 1-3, 6; distinct flange at edge of pustulose area in 1, 2, 5, 6 but not 3; lack of toothplate suture in 7-9 because toothplate wrapped around aperture (apex of aperture is behind axial end of free edge of toothplate in 4).

has described clearly the structure of *C.* aff. *C. haueri* (d'Orbigny). The diagnostic "accessory internal partition" has the same relationship to the marginal notch as the main toothplate has to the axial notch (or cleft) in *Ceratobulimina* (*sensu lato*) and all closely related genera. That is, the marginal notch marks a true infold of the apertural face, which tapers away as a low ridge over the shoulder of the previous whorl toward the axial hollow, without leaving the previous whorl (text fig. 5). Loeblich and Tappan (1964) have not figured the accessory partition, as they claim, but apparently the remains of the main toothplate and the edge of the resorbed area in the septal face.

The apertural lip may remain partly as a free structure after the next instar (Troelsen, *l.c.*) or it may be covered completely. Three specimens figured here (text fig. 5) show it remaining, but in others of the same species there is no trace on the penultimate chamber.

The toothplate is very similar to the toothplate of *Ceratolamarckina*. In *C. praecursoria* and *C. australis* it has about the same shape and extent as in *C. westraliensis*. Also, it is attached for a short distance to the spiral wall, a minor difference from the findings by Troelsen (*l.c.*). Loeblich and Tappan (*l.c.*) repeat Troelsen's opinion that the toothplate is not attached to the spiral wall, but this seems to be contradicted clearly by their figured specimen of *C. clifdenensis*. In *Ceratocancris* the free edge of the toothplate has a relationship to the axial groove different from that in *Ceratolamarckina*. In the latter the free edge terminates close to the outer end of the groove, where there is a tight fold. But in *Ceratocancris* the free edge extends down well below this, almost to the axial notch in the aperture, though the tight fold at the outer end still is present.

Evolution and Classification

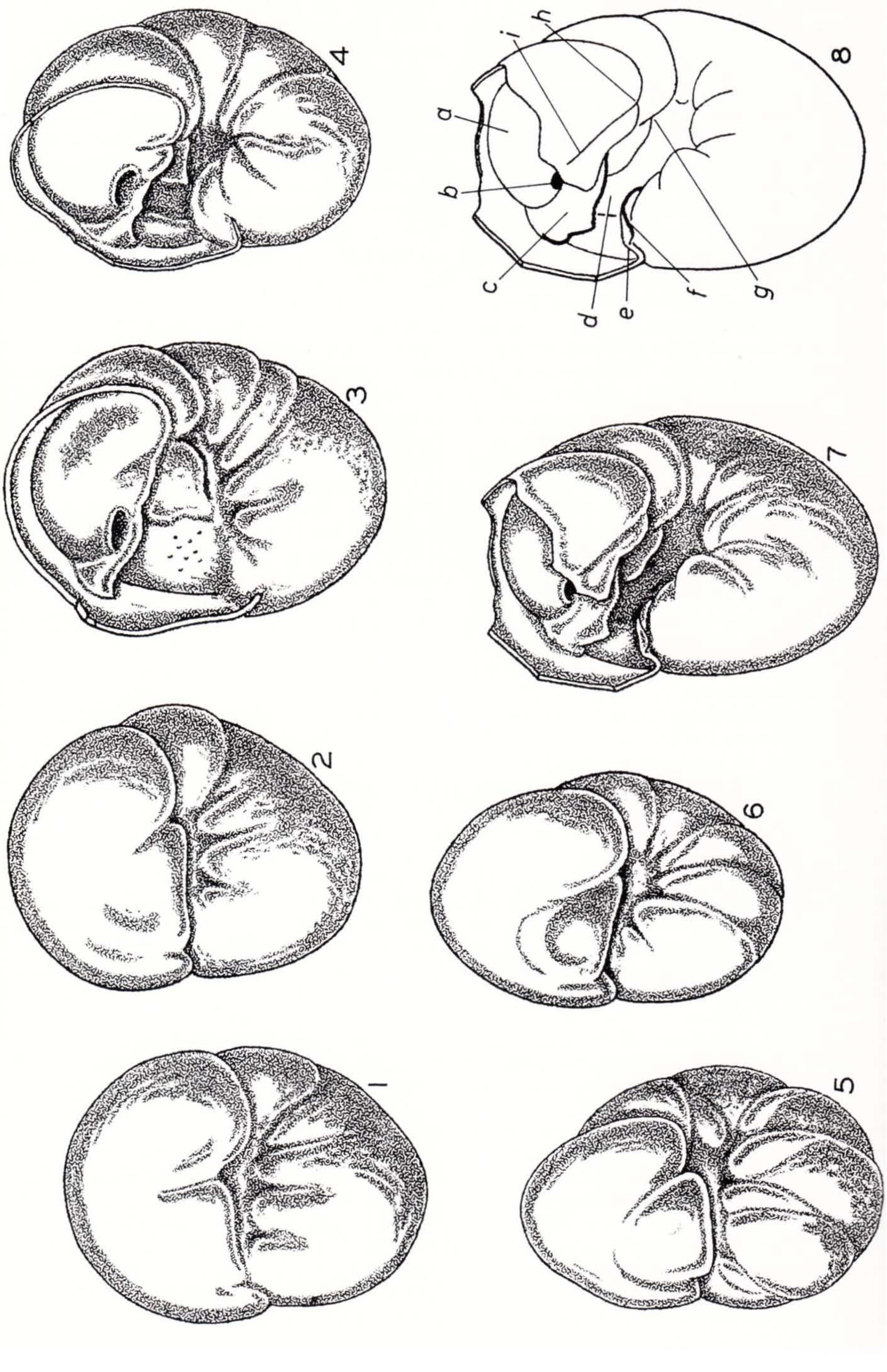
Loeblich and Tappan (1964) distinguish *Lamarckina* from *Ceratobulimina* (*sensu stricto*) on external characters only, especially the carinate periphery of *Lamarckina*. They dismiss the toothplate of *Lamarckina* as being similar to *Ceratobulimina s.s.*, which is quite incorrect. Certainly *Lamarckina* forms a consistent morphologic facies distinguishable from *Ceratobulimina* (*sensu lato*). *Lamarckina* is very low in variability because its species show a remarkable uniformity in structure; hence it is also conservative, because evolution has brought about neither any great diversity nor any advance in basic structure. *Ceratobulimina s.l.*, on the other hand, clearly has undergone more phyletic development and more structural diversification. On the basis of their external characters alone, the two groups have rarely, if ever, been confused in actual practice. To this extent the diagnoses given by Loeblich and Tappan are justified. But it is reassuring to find that both the distinctness of the two groups and their contrast in overall variability is supported by studies of the toothplates.

Glaessner (1937) and Brotzen (1942, 1948) were aware of these similarities and contrasts. But Glaessner (1945) did not separate the genera clearly by their toothplates; nor did Brotzen (1948), as noted already, express the distinction clearly. These workers recognized also a closer structural similarity among the older species. Troelsen's (1954) study of the Albian species *Ceratobulimina woodi* Khan clearly supports the idea of two diverging groups (the divergence being due almost entirely to evolution in *Ceratobulimina s.l.*); though Troelsen did not stress this. The toothplate in *C. woodi* is closer to *Lamarckina* than are the toothplates in younger *Ceratobulimina s.l.* It is not folded so definitely into two parts; and this with the gross form of the test supports retention of *C. woodi* in *Ceratobulimina s.l.* in spite of its acknowledged intermediate position. Certainly there is no question as to the distinctness of the two genera in the late Cretaceous, Tertiary or Recent. The toothplates alone make this clear, apart from the divergent case of *C.* (*Cl.*) *jutlandica*. The conservative *Lamarckina* tends to have thicker and more opaque walls; and there is no trace of the old aperture on the septal face as in *Ceratobulimina s.l.* because this part of the apertural face is resorbed entirely. Nor is a pustulose plate attached to the toothplate in *Ceratobulimina s.l.*

Whether *Ceratobulimina s.l.* arose from *Lamarckina* or vice versa is not clear. Loeblich and Tappan (*l.c.*) acknowledge no *Lamarckina* older than Upper Cretaceous; but the Albian species *L. elongata* Hofker (1956) seems to belong here. Older forms all seem to be nonumbilicate, thus belonging to *Praelamarckina* Myatlyuk, etc. The toothplate of *Garantella* Kaptarenko-Chernousova figured by Espitalié and Sigal (1963) appears to have basically the same form and orientation as the toothplate of *Lamarckina*.

Recognition of structural diversity in *Ceratobulimina* by Finlay (1939) and Troelsen (1954) led to the erection of the subgenera *Ceratobulimina s.s.*, *Ceratocancris*, and *Ceratolamarckina*. Almost all subsequent authors have rejected some part of Troelsen's arrangement. The present study, on the other hand, has confirmed both the desirability and the rank of these taxa.

Ceratolamarckina has rather more internal diversity than Troelsen implied. Three distinguishable types are known from the Paleocene. *C.* (*Cl.*) *jutlandica,* with its restricted toothplate and open umbilicus, diverged from the main branch. It is closest to *C. woodi,* among known species, but no intermediate species are known from the stratigraphic interval between Albian and Paleocene.



TEXT FIGURE 5

The main branch of *Ceratolamarckina* is represented in the Upper Cretaceous by *Ceratobulimina kremnoides* Taylor (Santonian, Victoria; Taylor, 1964) and *C.* (*Cl.*) *cretacea* Cushman and Harris (see Plummer, 1936); and in the Paleocene by *C.* (*Cl.*) *perplexa* and *C.* (*Cl.*) *tuberculata*. Finally, the Paleocene species *C.* (*Cl.*) *westraliensis* is transitional to *Ceratobulimina s.s.* though closer to *Ceratolamarckina;* the discovery of transitional species is only to be expected. Troelsen (1954) also has noted that *C.* (*Cl.*) *tuberculata*—the type species!—shows transitional tendencies in the same direction. Accordingly we refer *westraliensis* to *Ceratolamarckina*. The known range of *Ceratolamarckina* is Lower Cretaceous to Paleocene. A younger species which may be transitional also is *Ceratobulimina lornensis* Finlay (Upper Eocene, New Zealand; see Finlay, 1939, Dorreen, 1948, Hornibrook,1961). The figures given and the general similarity to *C. westraliensis* suggest that it is a *Ceratolamarckina,* but the toothplate remains to be studied.

In general terms the evolution of *Ceratobulimina s.s.* from *Ceratolamarckina* is quite clear. The oldest species known of *Ceratobulimina s.s.* are Eocene in age, *e.g. C. alazanensis* Cushman and Harris (Finlay, 1939) and *C. evoluta* Cushman and Jarvis (Kiesel and Lotsch, 1963). Loeblich and Tappan (*l.c.*) give the range of *Ceratobulimina* as Upper Cretaceous to Recent. The Upper Cretaceous record may refer to *C. aegyptiaca* Said and Kenawy (Contr. Cushman Foundation Foram. Research, 1957, p. 83), from the lower Turonian of Egypt. This is an enigmatic species whose toothplate was not mentioned. It cannot be accepted as a *Ceratobulimina* without further study, because it may equally well, from the description and figures, belong elsewhere, for instance in the group of *Epistominella* or even *Baggatella*.

Loeblich and Tappan (*l.c.*) have submerged *Ceratobuliminoides* Parr in *Ceratobulimina s.l.* Examination of the holotype and only specimen of the type species, *Ceratobuliminoides bassensis* Parr, suggests that there are no toothplates and that the wall probably is granulate in texture. These impressions are supported by two specimens of a new *Ceratobuliminoides* from the Miocene of South Australia, lent by Dr. Mary Wade. Until more material is available, Parr's (1950) comparison of *Ceratobuliminoides* with *Heronallenia* is supported.

That *Ceratocancris* arose from *Ceratolamarckina* is shown by the similarity of their toothplates. Perhaps the groove in *Ceratocancris* is homologous with the groove in most *Ceratolamarckina;* on the other hand it may represent closure of the aperture of *C.* (*Cl.*) *westraliensis*. The second alternative is supported by the toothplate being attached to the spiral wall and also extending below the groove in *C.* (*Cc.*) *australis*. Thus *C.* (*Cl.*) *westraliensis* may be the ancestor of both *Ceratobulimina s.s.* and *Ceratocancris,* to say nothing of *Cerobertina* (see Part Two). The relationship of *Ceratocancris* to *Ceratolamarckina* is confirmed further by the primitive aspect of *C.* (*Cc.*) *praecursoria* sp. nov., which has a less pronounced "tongue" or "plate" between the notches than the later species. *C. praecursoria* is the oldest *Ceratocancris known*. N. K. Bykova et al. (in Rauser-Chernoussova and Fursenko 1959) extend the range as far back as Jurassic, but then they do not recognize *Ceratolamarckina*. At the other extreme, Loeblich and Tappan (*l.c.*) restrict *Ceratocancris* to the Miocene. The reason for this, in view of the structure of the Eocene species *C. eximia* (Rzehak), *C. stellata* Bandy, etc., is not known.

The three groups of species, accordingly, can be recognized as evolutionary units on the basis of morphologic and stratigraphic evidence. *Ceratolamarckina* is both the oldest and the closest, in its aperture and toothplate, to *Lamarckina*. Internal phyletic divergence in *Ceratolamarckina* is visible, yet there is no particular need to designate the blind offshoot of *C.* (*Cl.*) *jutlandica* taxonomically. Younger *Ceratolamarckina,* particularly *C. westraliensis,* point clearly toward *Ceratobulimina ss.* and *Ceratocancris,* which arose by further divergence in the Lower Tertiary. Thus the three taxa recognized by Troelsen are confirmed; they rest on a firm evolutionary basis. That is, we reject the conclusions of later authors (Bykova *et al., l.c.;* Reiss, 1963)

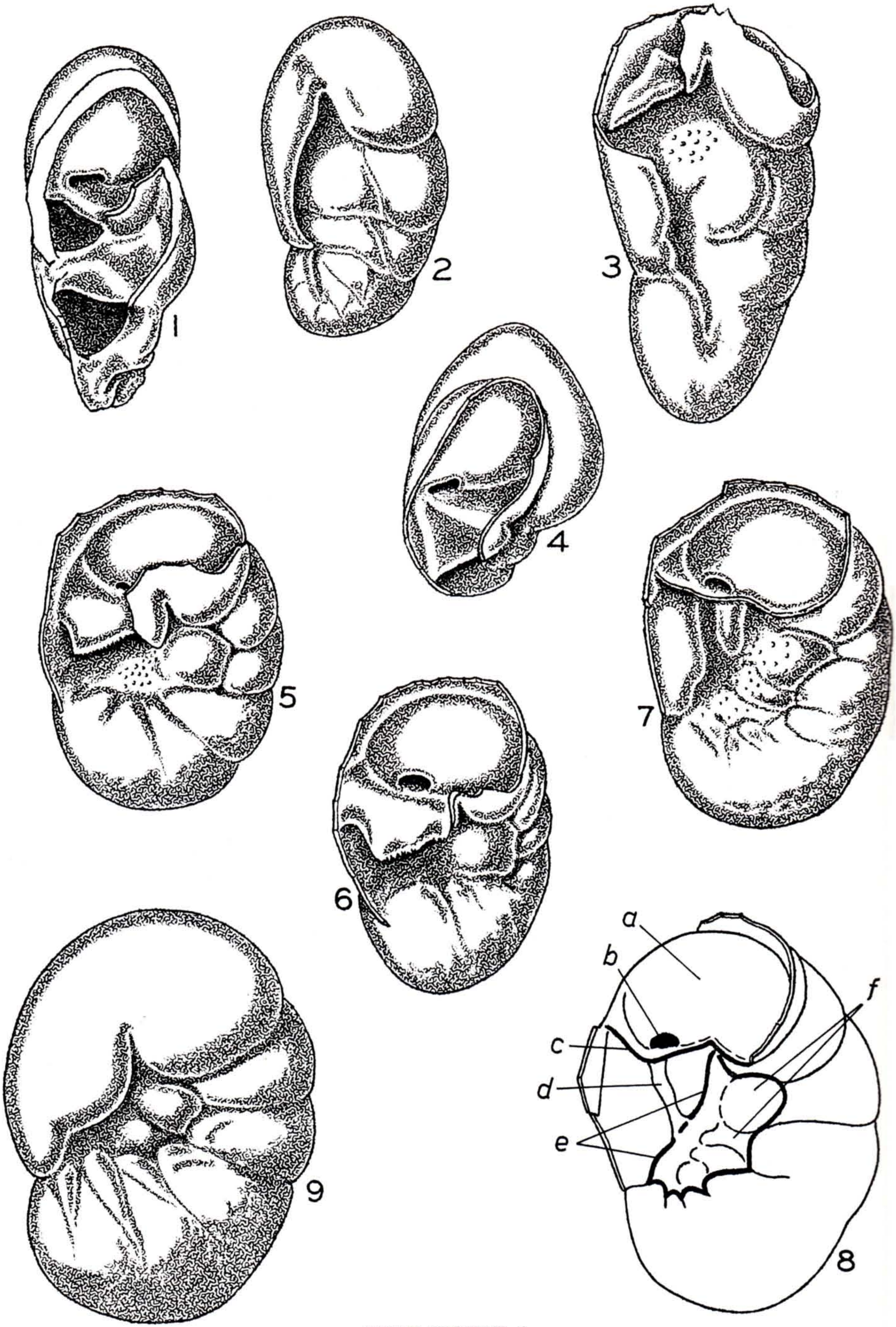
EXPLANATION OF TEXT FIGURE 5

Aperture, toothplate in *Ceratobulimina* (*Ceratocancris*).

1-3, *C.* (*Cc.*) *praecursoria* sp. nov., Paleocene, King's Park Shale, Western Australia. 144 ×. 5, *C.* (*Cc.*) *stellata* Bandy, Upper Eocene, Lisbon Formation, Alabama. 144 ×. 4, 6-8, *C.* (*Cc.*) *australis* Cushman and Harris, Lower Miocene, Batesford, western Victoria. 96 ×.

Note: flattened face and rudimentary marginal notch in 1, 2 in contrast to 5, 6; toothplate suture crossing groove in previous apertural face and attaching to spiral wall in 3, 4; remnants of old apertural lip still present as free edge in 3, 4.

7, 8, same specimen, final chamber opened, viewed obliquely from umbilical side. a, ultimate septal face; b, ultimate septal foramen, partly hidden; c, toothplate, free edge shown by heavy line; d, resorbed and secondarily covered area in old apertural face; e, position of marginal apertural notch in intact specimen; f, subsidiary toothplate, free edge shown by heavy line; g, penultimate axial notch, with groove and remnants of apertural lip; h, ultimate axial notch; i, groove in apertural face.



TEXT FIGURE 6

who do not acknowledge *Ceratolamarckina*. These groups are recognizable as such, while of course being not entirely clear-cut.

The final point concerns the rank of these taxa. Pokorný (1958) and Reiss (*l.c.*) retained them as subgenera, but Bykova *et al.* (*l.c.*) and Loeblich and Tappan (*l.c.*) upgraded them to generic rank. There are good reasons for returning to Troelsen's classification. The contrast of *Lamarckina* with *Ceratobulimina s.l.*, already discussed, is expressed best as two opposing genera, with the greater divergence and internal phyletic diversity of the latter reflected by the interpolation of three subgenera. The toothplates of *Lamarckina* and *Ceratobulimina* obviously are similar, but the similarity is greater among the three groups within *Ceratobulimina*. To a large extent this is true also for the gross form of the test. And the somewhat transitional nature of these taxa must be admitted. Thus the evolutionary perspective derived from comparative morphology and stratigraphic distribution leads us to recognize three subgenera in *Ceratobulimina*.

The main conclusions arising from this study are listed after Part Two; the phyletic relationships are summarized in text fig. 9.

PART TWO:

CEROBERTINA, PSEUDOBULIMINA, AND THE FAMILY ROBERTINIDAE

Cerobertina Finlay

Finlay compared his new genus to *Ceratobulimina*, from which it was distinguished by ". . . a series of supplementary chambers along the umbilical edge of the main chambers, more or less distinctly marked off by a groove or internal line" (1939, p. 118). Troelsen (1956) emphasized the similarity of *Cerobertina* to *Ceratobulimina* in the mutual relationship of aperture, toothplate, and septal foramen; he recognized that each chamberlet closed the aperture of the previous instar; and he stated explicitly that *Cerobertina* resembles *Robertina* in a superficial way only. Loeblich and Tappan (1964), on the contrary, place *Cerobertina* in the family Robertinidae, implying that the septal foramen is "homologous" with part of the primary aperture. Further, they note diagnostically a "secondary internal partition" which appears to form supplementary chamberlets. Doubt about the meaning of "secondary" aside, it is clear that Loeblich and Tappan regard the chamberlet and the main chamber as together forming a single cavity, or lumen, with a single aperture. Thus *Cerobertina* is compared with *Pseudobulimina*, for which this is stated explicitly.

The oldest *Cerobertina* described by Finlay is *C. kakahoica*, which appears first in the Bortonian (Finlay 1939, Hornibrook 1961). No further species have been described from the Eocene or older levels. *C. kakahoica* is common in some layers of the Brown's Creek Clays (U. Eocene, Western Victoria) and their equivalents. There seem to be no records of *C. kakahoica* identified as such in the Eocene of Australia. Parr (1947) listed *Ceratobulimina*, and Crespin (1954; in Raggatt and Crespin, 1955) listed *Pseudobulimina glaessneri* Howe and Roberts. These records probably refer to *Cerobertina kakahoica*, whose identification has been confirmed by Dr. N. de B. Hornibrook. Mr. D. J. Taylor has supplied some excellent specimens from the subsurface Upper Eocene of western Victoria. *C. kakahoica* is a rather large, robust, thick-walled species. The external form and internal structure are shown in text fig. 6.

The toothplate does not differ significantly from the toothplate of *Ceratobulimina* (*Ceratolamarckina*) *westraliensis*. It is downcurved more sharply, being closer in orientation to the plane of the septum. In the axial region it is wrapped around the aperture in the same way, and it is attached to the spiral wall for a somewhat greater distance. But both the form of the test and the anatomy of the toothplate suggest a close relationship.

Removal of the main chamber and the included toothplate reveals two crucial characters. First, it is clear that the septal foramen has nothing to do with the aperture of the previous instar. Text fig. 6

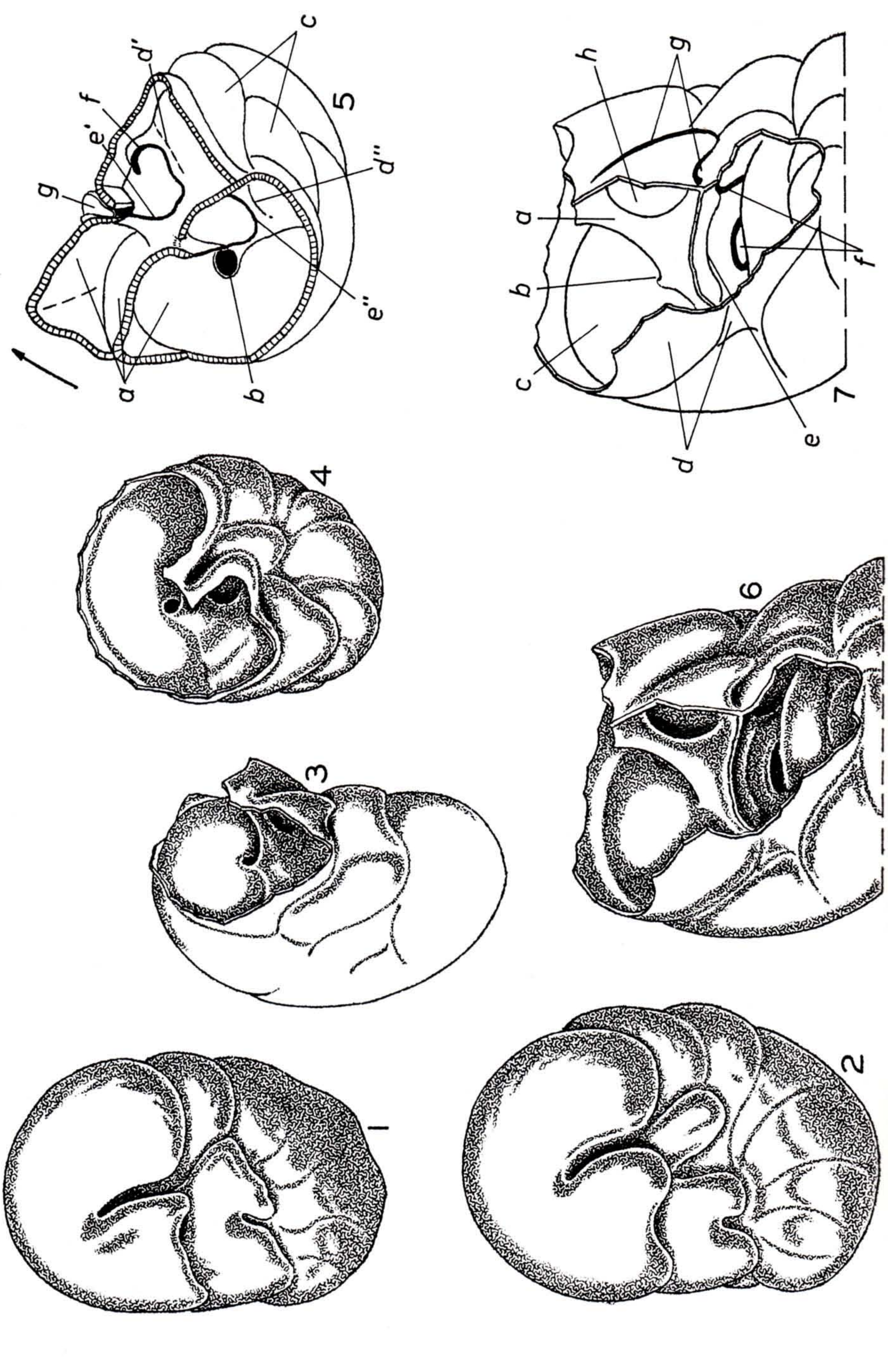
EXPLANATION OF TEXT FIGURE 6

Aperture, toothplate in *Cerobertina*.

1-4, *C. dehiscens* (Heron-Allen and Earland), Lower Miocene, Fyansford Clay, western Victoria. 5-9, *C. kakahoica* Finlay, Upper Eocene, Brown's Creek Clays, western Victoria. 1, 3, 4, 158 ×; 2, 5-9, 106 X.

1, view in coiling plane of 3rd-and 4th-last chamber, 2nd-and 3rd-last septa broken to show axial side of foramina, 4th-last septum and foramen intact. *Note*: position of free edge of partly resorbed toothplates: compare with 3, 4. 2, view of elongate aperture and chamberlets. 3, 4, same specimen, final chamber opened; showing toothplate folded into two parts, attached to spiral wall and wrapped around aperture.

5, 6, large toothplates intact, attached to spiral wall and wrapped around aperture. 7, 8, different specimens, toothplate removed. a, ultimate septal face; b, ultimate septal foramen; c, broken edge of toothplate; d, resorbed "trench" in old apertural face, covered by lamella during subsequent instar; e, edge of previous aperture, visible as "trench" in septal face, also covered by lamella; f, ultimate and penultimate chamberlets, with no direct connection to ultimate main chamber, outer edge of chamberlet zone shown by heavy line. 9, apertural view, showing chamberlets and curved aperture.



TEXT FIGURE 7

shows how there are "trenches" in the septal face, one at the base reflecting the old aperture and the other extending from this up to the toothplate immediately below the septal foramen. The distinctness of the foramen from the old aperture emphasizes the similarity of *Cerobertina kakahoica* to *Ceratobulimina s.l.* (compare with text fig. 4). These results support the observations by Troelsen (1956) on younger species.

Secondly, the umbilical, "secondary" chamberlets have no direct access to the main chamber. In *C. kakahoica* the chamberlet is a small but usually prominent globular structure; previous chamberlets are overshadowed by test growth and lamellar accretion. However, chamberlets are present in minute individuals with only three or four chambers. As noted by Troelsen (1956), the chamberlet is merely a bulge in the lamella which covers the old apertural opening. The broken line outlining the chamberlet axially in text fig. 6.8 indicates the break in slope at the base of the bulge, not a partition. The ultimate chamberlet encloses a space which is continuous with the cavity under the toothplate of the penultimate chamber. There are no partitions, primary or secondary, apart from the toothplate already noted; nor is there access from the ultimate chamberlet to the ultimate main chamber other than *via* the penultimate chamber and through the septal foramen.

Most of these structural features have been confirmed in the Miocene species *Cerobertina dehiscens* (Heron-Allen and Earland). Both this species and the type species, *C. bartrumi* Finlay, occur in the Lower Miocene of Victoria (Carter, 1964).

C. dehiscens is a more elongate, less tightly coiled species than *C. kakahoica* (text fig. 6). Thus the free edge of the aperture is more elongate. And the toothplate, while similar in essentials, differs in being folded distinctly, recalling *Lamarckina* in its division into two triangular components. The hinge of this fold extends from under the foramen to the apex of the aperture, around which the toothplate is wrapped. The line of attachment on the spiral side curves below the foramen before reaching the spiral wall very close to the junction with the septal face.

The septal foramen is situated "diagonally" in the septal face at the apex of the old aperture. It seems clear that the foramen is derived from the old aperture but extended by resorption. However, a specimen showing definitely the outline of the old aperture in relation to the foramen was not available for illustration. Troelsen (1956) found that the septal foramen had nothing to do with the old aperture in *C. bartrumi* Finlay and *C. mahoenuica* Finlay.

In forms in which the toothplate is wrapped around the aperture but the foramen is derived from the latter, passage from chamber to chamber is much more tortuous than in cases where the foramen is entirely secondary and always above the toothplate. Troelsen (1954, text fig. 2 and discussion; and also Troelsen 1956) has stressed this contrast (but see discussion in fourth paragraph under "Classification"). In *Robertinoides, Alliatina* and *Cerobertina bartrumi* (not *mahoenuica*) Troelsen (1954, 1956) has noted that the toothplate is resorbed partially. The path of protoplasm thus is simplified considerably. This is found also in *Cerobertina dehiscens*. In these species most of the lower triangular component is resorbed, the marginal end of the free edge regressing to a position not far below the foramen and the axial end retreating to the opposite side of the old aperture. Significantly, the toothplate is not resorbed partially in the penultimate chamber in *C. kakahoica,* where the foramen is quite distinct from the old aperture. Ultimately the relative positions of toothplate and septal foramen are the same, whether the latter derives from the old aperture or not [compare this relationship in *Cerobertina dehiscens* and *Ceratolamarckina tuberculata* (text fig. 3), where the toothplate is not partly resorbed].

EXPLANATION OF TEXT FIGURE 7

Apertures, toothplate in *Pseudobulimina chapmani* (Heron-Allen and Earland). Recent, Antarctica. 1, 6, 7, BANZARE Station 30; 2, 5, Sta. 100; 3, 4, Sta. 39. All X 106.

1, 2, apertural view, showing sutural and bulimine apertures and irregular lobes of chamberlets. 3, 4, specimens with chamberlets intact, showing enrolled toothplates from different angles.

5, view from above of 2nd-last and 3rd-last chambers; broken edges hatched; arrow shows coiling direction. a, three successive septa; b, 3rd-last septal foramen; c, 2nd-and 3rd-last chamberlets; d^{1}, d^{11}, line at which toothplate apparently joins top of chamberlet; e^{1}, e^{11}, positions of toothplate free edges after secondary resorption; f, earlier sutural aperture, now chamberlet foramen, with toothplate arching over it; g, plug in earlier bulimine aperture forming base of main septal foramen, with chamberlet foramen below (note "pillar" at either side).

6, 7, same specimen, oblique spiral view; ultimate main chamber and chamberlet opened. a, enrolled part of toothplate; b, septal foramen hidden behind toothplate; c, ultimate septal face; d, remnants of spiral walls of main chamber and chamberlet of current instar; e, junction of ultimate septal face with roof of ultimate chamberlet; f, penultimate sutural and bulimine apertures, now chamberlet foramina; g, sutural and bulimine apertures, neither being connected to chamberlet but opening into vestibule; h, vestibule, partly enclosed by enrolled toothplate.

Pseudobulimina EARLAND

When erecting *Pseudobulimina,* Earland (1934) described the aperture as "an inconspicuous arch" on the inner edge of the apertural face. The long and prominent slit in the latter was stated to be merely a cleft whose walls extended back to the septal face but which afforded no exit from the chamber. Earland compared *Pseudobulimina* with *Ceratobulimina,* but emphasized the double series of chambers. The smaller chamber opened allegedly into the larger *via* a tube joined to the cleft.

Glaessner (1937) recognized the relationship of *Pseudobulimina* to *Ceratobulimina* on the one hand and *Robertina* on the other. So did Hofker (1951), who described *Pseudobulimina convoluta* (Williamson). Loeblich and Tappan (1964) refigured the type species, *Pseudobulimina chapmani* (Heron-Allen and Earland). They compared the internal subdivision with *Robertina,* the subsidiary suture on the spiral side being derived from a "partial division." They note the "aperture with 2 diverging slits as in *Robertinoides*" but follow Earland (*l.c.*) in stating that the large cleft is not an opening, and that the smaller chamber connects internally and directly with the larger.

Pseudobulimina chapmani was identified at several stations of the B.A.N.Z. Antarctic Research Expedition (1929-31) by Parr (1950). These specimens have been studied. The structural aspects discussed here are illustrated in text fig. 7.

The aperture is a true double structure because the large, bulimine cleft is a real opening. Both the bulimine and the sutural apertures open into a vestibule enclosed by the toothplate. The toothplate is a very delicate and rather extensive structure, but the free folded component is not large. As in all members of this group, the toothplate is continuous with the chamber wall on the right-hand side of the aperture (in a dextrally coiled specimen in apertural view). It is folded sharply, again like several discussed above, about a hinge from the apex of the large aperture to the peripheral side of the foramen. The free folded part on the spiral side of the hinge is enrolled somewhat, with the free edge extending in a broad curve from near the apex of the larger aperture to a point near its base. It is continuous with the infolded "pillar" at the free edge of the bulimine aperture. (The free edge is seen only with difficulty; the figures show instead the profile of the enrolled part of the toothplate.) The chamber has access to the sutural smaller aperture below the toothplate. We can agree with Earland to the extent that the "cleft" is bordered on one side at least by a wall extending back to the septal face, and also that the structure called a "tube" is present. But both this tube and the cleft have a free edge. Toward the spiral side the toothplate flattens. Its contact with the septal face usually is clear, but it appears to become plastered on top of the chamberlet (text fig. 7). Oriented sections are needed to check this. However, it seems that Glaessner (1937) was partly correct in suggesting that the suture between each pair of chambers on the spiral side had something to do with the toothplate (compared with *Ceratobulimina*).

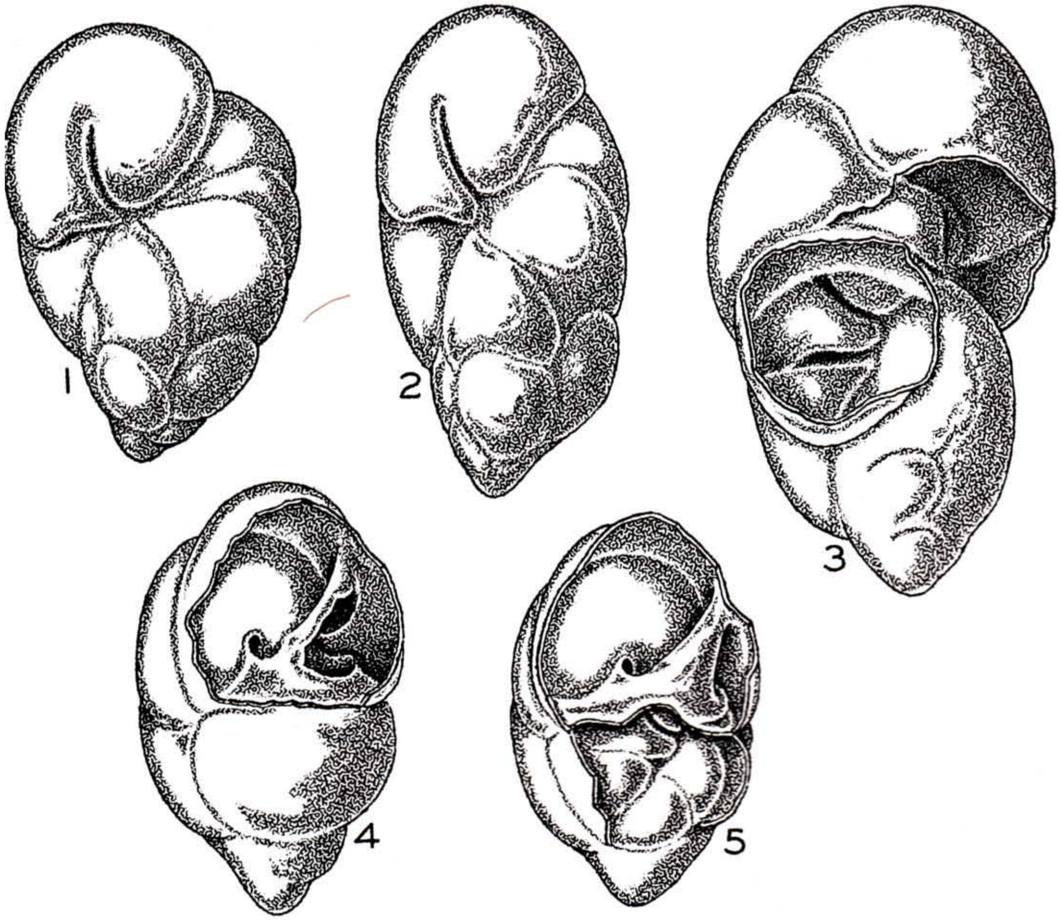
The septal foramen derives from the aperture, as implied by Loeblich and Tappan in their classification. But it is also enlarged distinctly by resorption. As discussed above for *Cerobertina* it is to be expected that the toothplate becomes resorbed partially at the next instar. This was found to be so. The free folded part between the hinge-line, the line of attachment to the chamberlet and the top of the sutural aperture is resorbed almost completely.

The chamberlets, or second series of chambers, are flattened, strongly lobate, and vary greatly in size, form, and position. They have no external aperture. Nor, indeed, does the chamberlet connect directly with the main chamber of the same instar, as stated by Earland, Hofker and Loeblich and Tappan. Like the chamberlet in *Cerobertina,* it is a *cul-de-sac* connected only with the main chamber of the previous instar. It covers the previous basal aperture and lower part of the previous bulimine aperture. The toothplate and the sutural aperture both sit on top of the chamberlet.

Robertinoides Höglund

The discovery that the final chamberlet has no direct connection with the final chamber in *Cerobertina* and *Pseudobulimina* raised the question of the mutual relationship of these cavities in *Robertinoides,* for Höglund, in his famous study of *Robertina* and *Robertinoides* (Höglund 1947), stressed the opinion that the two cavities in fact were parts of a single chamber, divided by a "diaphragm" in which there was, at the base, a "saddle-shaped opening." Glaessner (1937), in the first significant structural study of *Robertina,* had noted the "partition" (Höglund's "diaphragm") which divides the chamber into two (implicitly complete) parts. Troelsen (1954) found that Höglund's "saddle-shaped opening" is represented in *Robertinoides declivis* (Reuss) by a thin plate bridging the distal branch of the previous main aperture. Troelsen thereby seems to imply, but does not state, that the proximal chamber half is not connected directly with the distal half. His illustrations support this, as do Glaessner's. However, Troelsen was of the view also that the entire internal structure was a single infold of the test wall (see also Hofker, 1956). Loeblich and Tappan (1964) repeated this in their diagnoses of *Robertina* and *Robertinoides.*

Study of *Robertinoides* sp. from the Brown's Creek Clays (Upper Eocene, western Victoria) showed that the "proximal" or lower compartment



TEXT FIGURE 8

Apertures, toothplate in *Robertinoides* sp., Brown's Creek Clays, Upper Eocene, western Victoria; all × 158.

1, 2, intact specimens, showing sutural and bulimine apertures and variation in gross form. 3, oblique view from below, last two chamberlets opened, main chambers intact; showing previous apertures connecting chamberlets with main chambers of respective previous instars, and no connection with main chambers of respective current instar. 4, main chamber opened, toothplate broken, exposing bulimine aperture from inside, and arching above sutural aperture. 5, another specimen, same orientation as 4, main chamber and chamberlet opened; showing tightly enrolled toothplate intact.

has no direct access to the other (text fig. 8). As in *Cerobertina* and *Pseudobulimina,* the only access is via the penultimate upper chamber.

In general terms, the toothplate seems to agree with the structure described by Höglund. Perhaps the "lip tube" is less complete, with the "window" broader and more open (see Höglund, *l.c.,* for explanation and illustration of these terms). The presence of a lip tube is shown by a circular remnant on broken specimens (see also Troelsen, 1954, fig. 4, 5), but the exact details of this structure could not be checked on the material available. It was noted that the toothplate passes over the smaller sutural part of the paired aperture. In this respect, in the way in which the toothplate sits on top of the chamberlet, and in the actual shape of the toothplate, the resemblance to *Pseudobulimina* is remarkable. The main differences are the apparent absence of a lip tube in *Pseudobulimina* and the narrow space under the toothplate extending further toward the back of the chamber in *Robertinoides* sp. (There is a small pit at the posterior sutural junction, but it seems to be closed. Thus there are some differences from the species described by Höglund.)

Evolution

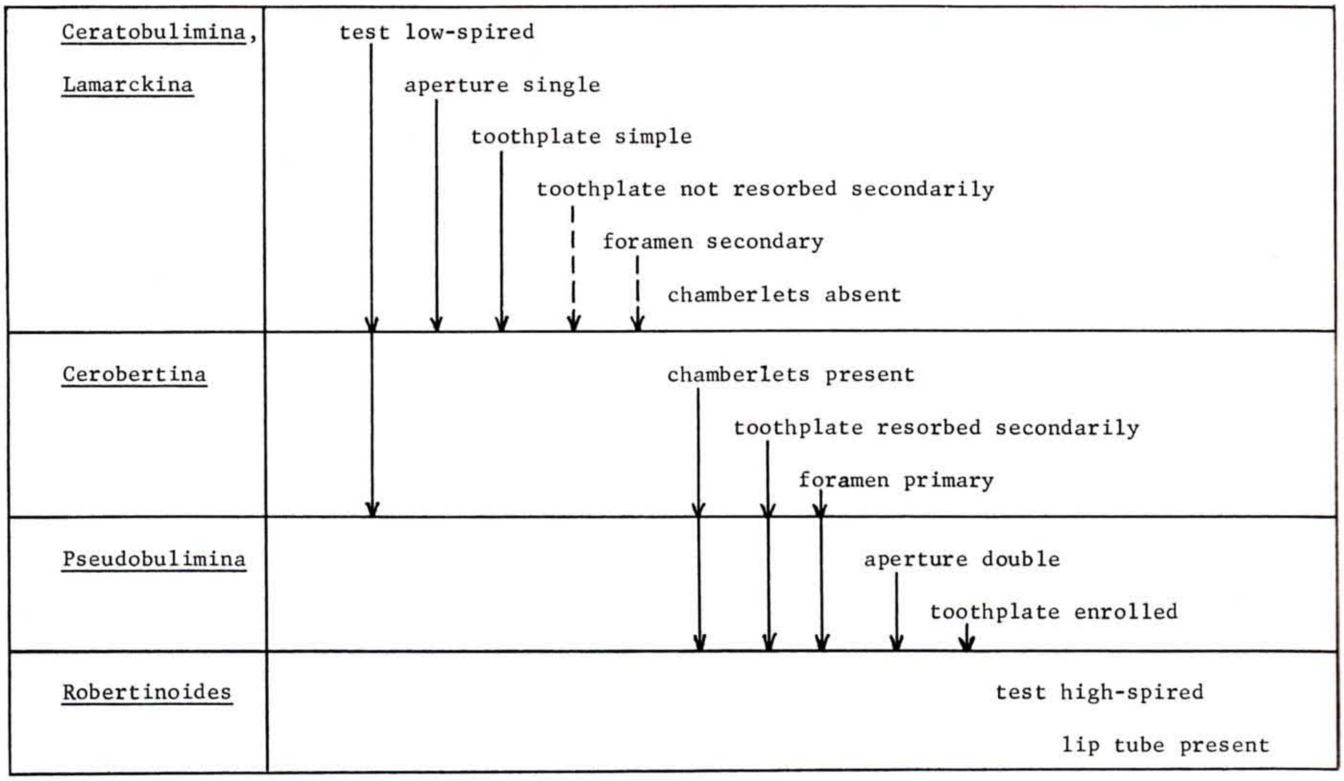
The first point concerns the significance of the chamberlet. These structural studies should have made it clear that the chamberlet, where present, is not homologous with the space under the toothplate in *Ceratobulimina.* The chamberlet is homologous with the lamellar membrane covering the old aperture and umbilical area in *Ceratobulimina* and *Lamarckina,* being a swollen outgrowth of this structure.

The genera under consideration can be arranged in a descending morphological series from the simplest to the most "advanced" (Table 2). Table 3 summarizes the more important characters of these genera, to which *Robertina* has been added.

This series has been observed in more general terms by previous authors (*e.g.* Glaessner, 1945). There is sufficient structural and stratigraphic evidence available to demonstrate (a) that the morphological series is not a linear phylogenetic sequence, and (b) that some at least of the important characters in common have been acquired independently. A summary of phylogeny is given in text fig. 9.

We can say positively, in support of Troelsen (1956), that *Cerobertina* evolved from *Ceratobulimina s.l.* in the Lower Tertiary. More specifically, the oldest known *Cerobertina, C. kakahoica,* is transitional morphologically and intermediate temporally between *Ceratolamarckina* (*C. westraliensis*) and younger *Cerobertina.* This lineage acquired first the chamberlets and then the primary (more or less) septal foramen and the secondarily resorbed

TABLE 2

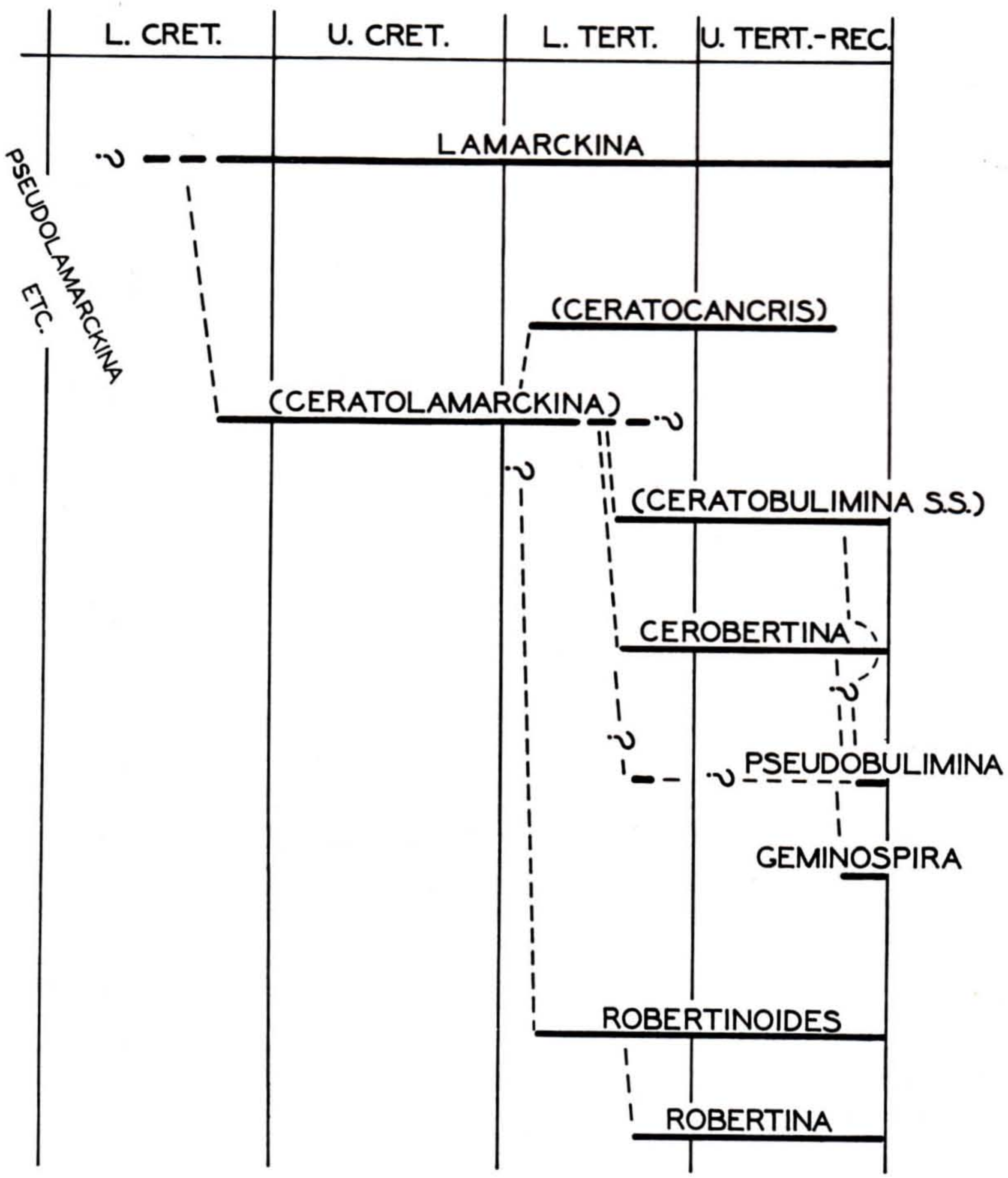


Morphological series. Arrows represent retention of character in next taxon listed; broken arrows represent retention in part only of next taxon.

TABLE 3

	APERTURE		FORAMEN		TOOTHPLATE		CHAMBERLETS		COILING	
	Single	Double	Part Primary	Secondary	Simple	Complex	Absent	Present	Low	High
Lamarckina	+			+	+		+		+	
(*Ceratolamarckina*)	+			+	+		+		+	
(*Ceratocancris*)	+			+	+		+		+	
(*Ceratobulimina s.s.*)	+			+	+		+		+	
Cerobertina	+		+	+	+			+	+	
Pseudobulimina		+	+			+		+	+	
Robertina	+		+			+		+		+
Robertinoides		+	+			+		+		+

Summary of characters in selected taxa in the family Robertinidae



TEXT FIGURE 9
Phylogenetic relationships of selected taxa in the family Robertinidae.

toothplate, although the present observations, together with those by Troelsen (1956), show that the species group is quite variable in these respects.

The chamberlets and the primary septal foramina which *Cerobertina* has in common with *Robertinoides* and *Robertina* must have been acquired independently in the latter group. Loeblich and Tappan (*l.c.*) range *Robertina* from Lower Eocene to Recent, and *Robertinoides* as Recent only. Yet *Robertinoides* is found in the Eocene, complete with double aperture and lip tube, and it is present in the Paleocene of Australia, in the King's Park Shale (*Robertina* sp. of Parr, 1938). Only a few not particularly good specimens of this species are known, but the circular outline of the lip tube attachment has been seen. The species is close to *Robertina wilcoxensis* Cushman and Ponton, already present in the Paleocene of North America (Cushman, 1951), and Scandinavia (Troelsen, 1955a); Höglund (1947) has suggested that *R. wilcoxensis* is a *Robertinoides*. Thus *Robertinoides* and *Robertina* are not related directly (lineally) to *Cerobertina*. The close mutual relationship of *Robertina* and *Robertinoides* has not been questioned; Troelsen (1954) suggests tentatively that *Robertinoides* is the more "primitive." We have learnt virtually nothing of the ancestry of *Robertinoides* and *Robertina* since 1937, when Glaessner recognized their similarity to *Ceratobulimina*, etc. Subsequent studies have confirmed this similarity (*e.g.* the aragonite wall), but the globally distributed oldest representatives of *Robertinoides* and *Robertina* known are much closer morphologically to the Recent species than to any possible ancestor among genera known to us.

Next, we have the problem of the origin of *Pseudobulimina.* It is low-spired like *Ceratobulimina* and *Cerobertina;* internally it recalls *Robertinoides,* as noted by Loeblich and Tappan (*l.c.*). There is no conclusive evidence as to which way *Pseudobulimina* evolved: no intermediate forms are known. Hofker (1951, 1956), having emphasized rightly the similarity of their toothplates, concluded that *Pseudobulimina* arose from *Robertinoides.* But in the light of the parallelism in the acquisition of chamberlets, primary septal foramen and toothplate absorption (Table 2) of *Cerobertina* with *Robertinoides,* it is thought far more likely that *Pseudobulimina* developed its *Robertinoides*-like characters independently of that genus, arising presumably from the low-trochospirally coiled *Ceratobulimina s.s.* or perhaps *Cerobertina.* The differences in orientation of chamberlets among *Cerobertina, Geminospira* and *Pseudobulimina* probably are of little importance, although Loeblich and Tappan (*l.c.*) regard them as diagnostic. The few species known of *Pseudobulimina* appear to be confined to the Recent, apart from the Eocene *P. glaessneri* Howe and Roberts. *P. glaessneri* has the same arrangement of chambers as *P. chapmani* but it is more elongate, like *Geminospira.* There is no compelling reason to regard this Eocene species as ancestral to the Recent species; however, *P. glaessneri* deserves a detailed study.

To summarize, various similarities among the various genera have been acquired by allochronous parallelism. For all these forms were derived, ultimately, from *Ceratobulimina s.l.;* though in the case of *Robertinoides* and *Robertina* this is something of an affirmation of faith in the predominating number of characters in common. If these suggestions are correct, then we can say that the root stock has the latent potential to give rise to more than one offshoot following the same trends. This is neither new nor metaphysical: it is a guiding principle in the unravelling of the homeomorphic complexities of ammonoid sutures, for instance. The overall pattern, at any rate, is becoming clearer. The basic and always recognizable structure is a toothplate continuous by infolding with the umbilical wall on one side of the aperture (the same side in all tests coiling in the same direction). Three evolutionary trends in particular have occurred, independently but coinciding in part: first, the development of chamberlets whose formation is not concerned directly with toothplate folding; second, the increase in complexity of this toothplate; third, the change from a secondary to a primary septal foramen.

A group examined briefly but not examined in detail in this study is made up of *Alliatina* Troelsen, *Alliatinella* Carter, and *Cushmanella* Palmer and Bermudez. The studies of several workers (Troelsen, 1954, Hofker, 1956, Carter, 1957, Wade, unpubl. thesis, 1958, Loeblich and Tappan, 1964) have given us quite a clear understanding of the internal structures in these closely related genera. These authors have shown—by comparative morphology only, since the transitional forms are not known—that the group has several important similarities to *Ceratobulimina* and *Robertinoides.* The same basic toothplate form and orientation still is detectable. Their chamberlets and primary septal foramina suggest yet another independent example of the overall trend in the same general direction. In culminating in the almost planispiral *Cushmanella,* this trend at the same time has arrived in a considerably divergent position.

Classification

The recent classification of the superfamily Robertinacea by Loeblich and Tappan is the most comprehensive effort attempted to date. Several genera are poorly known and placed here only tentatively, as Loeblich and Tappan have acknowledged. Since they were preparing an exhaustive treatise, obviously they were forced to classify in several cases where the data were patently inadequate, and where other studies, such as the present one, need not and indeed should not be comprehensive in this particular sense. There is little point in discussing several aspects of their classification further until there has been more research on toothplates and wall structure. But there is one major aspect on which issue must be taken with Loeblich and Tappan. This is the combining of the Ceratobulimininae with the Epistomininae, and opposing this combination (Ceratobuliminidae) at the family level to the Robertinidae.

In this system Loeblich and Tappan have followed Troelsen (1954). Troelsen stressed repeatedly the difference (which he believed to be fundamental) between septal foramina which are secondary, that is, are distinct from the old aperture, and septal foramina which are "homologous" with part of the old aperture. This difference was explained in diagrammatic but informative sections showing the two basic relationships (Troelsen, 1954, fig. 2). The aperture-foramen has acquired, through Troelsen's studies, diagnostic importance at family level. Other recent authors have been rather less committal in that they have ranked the Epistominids, Ceratobuliminids and Robertinids equally, whether at family or subfamily level (Pokorný 1958, Bykova *et al.,* in Rauser-Chernoussova and Fursenko, 1959, Reiss, 1963).

The present study has emphasized the similarity in toothplate structure of a rather diverse group of genera. This group forms one of the two main branches within the Epistominidae of Brotzen (1942, 1948) the other being represented by *Epistomina, Hoeglundia,* etc. (Several genera included by Brotzen have been excluded subsequently on account of their wall composition and structure.) Recent studies (Espitalié and Sigal, 1963, and references therein) on Jurassic and early Cretaceous forms have of course tended to blur the distinctions in some respects (*cf.* Brotzen, 1948), but on the whole they seem to have reinforced them. A glance at the contents of the Epistomininae of Loeblich and Tappan (*l.c.*) will illustrate this. The two divergent groups accordingly should be ranked equally, as they were by Brotzen, regardless of those problems of transition encountered eventually in the zone of emergence of any higher taxon. Since the whole complex has been raised to superfamily rank (Robertinacea) on broader grounds (Loeblich and Tappan, *l.c.*), these taxa become the families Epistominidae and Robertinidae.

As discussed in the preceding section, evolutionary trends within the Robertinidae have produced considerable divergence without obscuring the basic structure. Troelsen (1954, 1956) has emphasized the nature of the septal foramen. A case can be made out on this basis for a subfamily including the *Robertinoides* group, the *Alliatina* group, and the *Pseudobulimina* group; and such a subfamily would be monophyletic because all members probably have arisen from a taxon of lower rank (genus *Ceratobulimina*). But there is no apparent reason why chamberlets or toothplate complexity could not have been chosen instead. More important, the significance of the foramen has been overstressed. Troelsen's diagrams (1954, fig. 2) are correct but misleading, because the contrast shown is almost all destroyed by secondary resorption of the toothplate. Moreover, there seems to be little significance in whether a septal foramen is formed by modification of an old opening or whether it is created entirely at a single instar.

It is thought that a more nearly evolutionary classification is achieved by a different approach from the *a priori* method of first ranking the characters in order of importance (Loeblich and Tappan, 1964, p. C153) and then ordering and ranking the taxa on this basis. The first step has been to emphasize the phyletic unity of the group (which for reasons of priority must be called the family Robertinidae) by opposing it to the Epistominidae. Secondly, there is no apparent, adequate twofold division within the Robertinidae. At least three trends (probably more) seem to have caused parallelism. A twofold division, based for instance on the septal foramen, ignores the divergence of the *Robertinoides complex* and the *Alliatina* complex, and separates *Cerobertina dehiscens* from the remainder of this obviously closely knit genus. Such a scheme is unacceptable. Indeed, Troelsen (1954), while recognizing the nature of the foramen and toothplate in *Alliatina,* still was not prepared to commit himself on the systematic position of the genus because it was so clearly divergent from other genera which shared these characters.

The final conclusion is the recognition of three subfamilies in the Robertinidae. Further studies, especially of the toothplates in other genera in the Ceratobuliminiae and Robertinidae, *sensu* Loeblich and Tappan, may modify as well as expand the classification presented here, but it is expected that this can be done without upsetting the classification seriously. A particularly interesting case concerns the aragonitic *Conorboides* Hofker and *Colomia* Cushman and Bermudez, which Hofker (1958) and Taylor (1964) regard as related but which Loeblich and Tappan (1964) place in separate families. Whichever interpretation is correct, it is certain that these genera do not belong in any of the three subfamilies discussed here; nor does it appear at all likely that they will be placed even in the Robertinidae as a separate subfamily.

The classification proposed is as follows:

Family ROBERTINIDAE

Subfamily CERATOBULIMININAE. Includes *Lamarckina, Ceratobulimina, Cerobertina, Pseudobulimina, Geminospira.* Coiling low trochospiral.

Subfamily ROBERTININAE. Includes *Robertina, Robertinoides.* Coiling high trochospiral.

Subfamily ALLIATININAE, subfam. nov. Includes *Alliatina, Alliatinella, Cushmanella.* Coiling nearly planispiral.

Thus, the gross form of the test emerges as the diagnostic character. This is not to disparage those more "fundamental" characters whose study has taken up most of this paper. But in the analysis of trends and the attempt in classifying to resolve conflicts of parallelism, almost any character may emerge *in a specific situation* as the most diagnostic, regardless of any *a priori* considerations. A corollary to this is that there is no legitimate objection, *a priori,* to the combination, in a single genus, of two or more species which fail to share a so-called fundamental character, other requirements for their combination having been fulfilled. In the present situation the character is the nature of the septal foramen, and the genus is *Cerobertina.*

CONCLUSIONS

(1) The traditional separation of *Lamarckina* from *Ceratobulimina* is supported by the distinctness of their toothplates which, however, at the same time demonstrate their close relationship.

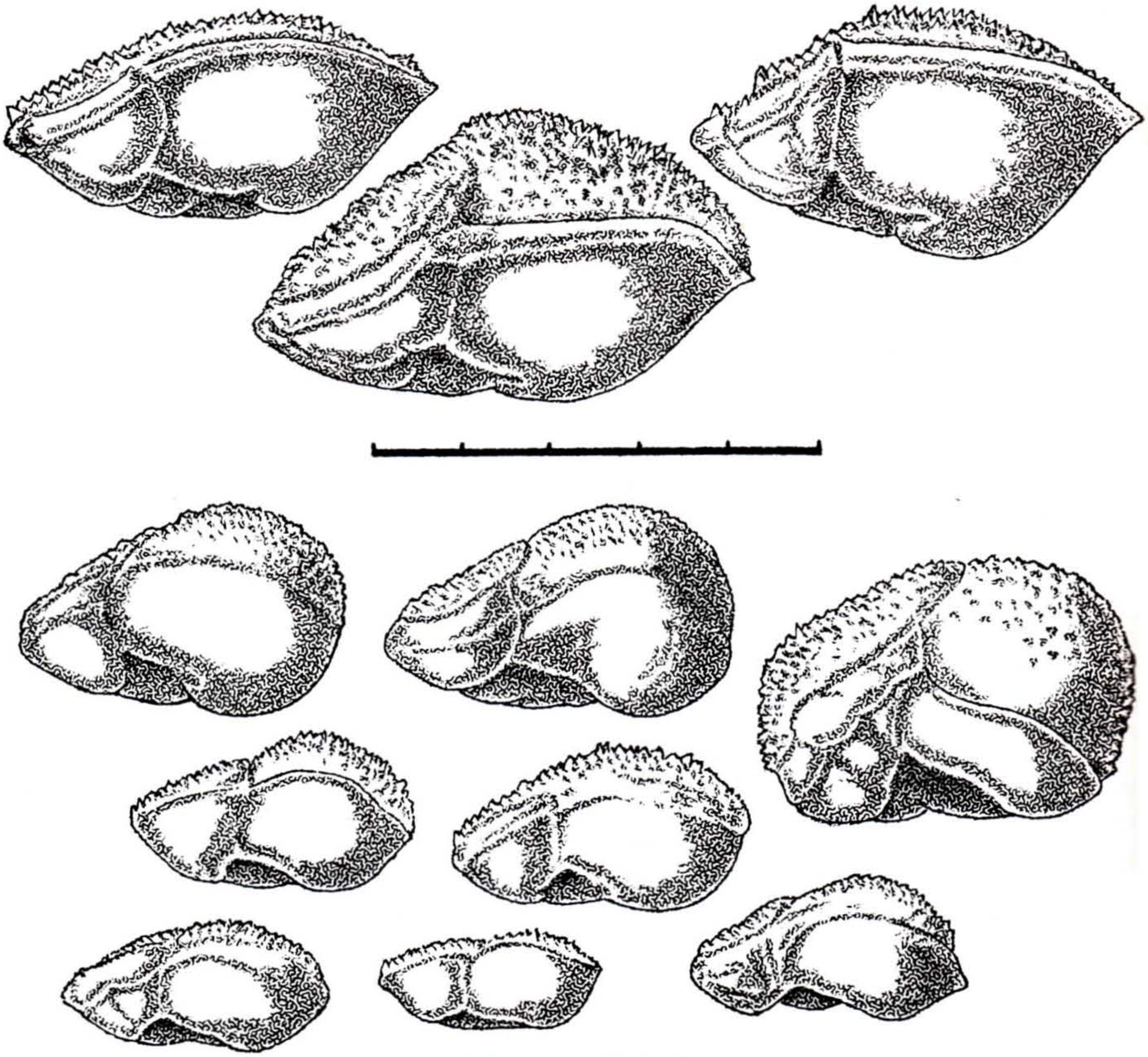
(2) In contrast to *Lamarckina*, *Ceratobulimina* is a ramifying group. A study and review of the morphology and distribution of *Ceratolamarckina*, *Ceratobulimina* s.s. and *Ceratocancris* shows that these taxa are acceptable on a solid evolutionary basis. They are classified as subgenera of *Ceratobulimina*, a return to the conclusions of Troelsen.

(3) *Ceratolamarckina* is the oldest subgenus, ranging from Lower Cretaceous to Paleocene and perhaps Eocene. *Ceratocancris* and *Ceratobulimina* *s.s.* both evolved from *Ceratolamarckina* in the early Tertiary; *Ceratocancris praecursoria* sp. nov. (Paleocene, Western Australia) is the oldest *Ceratocancris* known.

(4) *Cerobertina* also evolved from *Ceratolamarckina* in the early Tertiary. The basic structure of the oldest species known (aperture, toothplate, foramen) is the same. Younger species developed a primary septal foramen and also secondarily resorbed toothplates. Nevertheless *Cerobertina*, as conceived by Finlay, is a good genus.

(5) *Pseudobulimina* resembles *Robertinoides* very closely in its double aperture, chamberlets, and enrolled toothplate, but the test is coiled in a low instead of high spire and there is no "lip tube" or "window."

(6) The chamberlets of *Cerobertina, Pseudobulimina,* and *Robertinoides* have no direct connection with the main chamber lumen of the same instar. They are not homologous with the cavity under the toothplate in *Ceratobulimina*. The wall of the chamberlet is homologous with the secondary lamella covering the old aperture in this genus.



TEXT FIGURE 10

Profiles of *Lamarckina rugulosa* Plummer, Rivernook Member, Dilwyn Clay, Paleocene, western Victoria (lower group); compared with profiles of *L. airensis* A. N. Carter, Brown's Creek Clays, Upper Eocene, western Victoria (upper group). All × 106; scale intervals each represent 0.1 mm.

(7) The development of chamberlets, primary septal foramen and secondarily resorbed toothplates in *Cerobertina* represents parallelism with these developments in *Robertinoides*. It is likely that *Pseudobulimina* evolved also in parallel with these genera. And the same trends are evident in *Alliatina* and closely related genera.

(8) Consequently the basis for the recent classification by Loeblich and Tappan, who, following Troelsen, have stressed the nature of the septal foramen, is rejected.

(9) The two major trends recognized by Brotzen as the subfamilies Epistomininae and Ceratobuliminae are regarded as of equal and family rank: Epistominidae and Robertinidae. The Robertinidae contains three groups based on broad evolutionary divergences. Each divergence involves considerable parallelism, but on the basis of test form we can recognize the subfamilies Ceratobuliminae and Robertininae, and the new subfamily Alliatininae.

DESCRIPTIONS OF SPECIES

Lamarckina rugulosa Plummer

(Plate 8, figure 1; text figs. 1, 2, 10)

1926, *Lamarckina rugulosa* Plummer, Texas Univ. Bull. 2644, p. 140, pl. 9, fig. 3.

1965, *Lamarckina rugulosa* Plummer. McGowran, Proc. roy. Soc. Victoria, v. 79, p. 57, pl. 5, fig. 6.

Description.—Test wedge-shaped, dextrally coiled; flattened on spiral side and elongate in early growth stages and in some larger specimens, but usually becoming inflated in larger specimens. Umbilical side with broad axial depression and semilunate to crescentic umbilicus, depending upon form of apertural lip. Periphery distinct, subangular, and becoming thickened secondarily especially in early stages, later angular to well rounded with peripheral ridge usually present but sometimes absent from inflated chambers. About 6 chambers in adult whorl. Sutures recurved on spiral side, marked by ridges of secondary shell material earlier, becoming obliterated by ornamentation or slightly depressed later; very indistinct on umbilical side. Surface granular to strongly spinose on spiral side, smooth and polished on umbilical side. Aperture short, with serrate lip, straight or arched; toothplate small, folded, restricted to umbilical part of chamber. Maximum diameter of test 0.45 mm.

Variation.—The tests with more flattened spiral side and more elongate form tend to have more distinct sutures, and the ornamentation on the final chamber may be absent or expressed by a few granules only. Such forms, including all the juveniles and several larger specimens, intergrade with specimens characterized by inflated adult chambers which in profile appear almost globular (text fig. 10). Also, the keel is restricted to the earlier part of the test in these inflated forms, and the peripheral ridge delimiting the granulate surface tends to disappear. In most specimens the aperture and umbilicus are as shown in the specimens figured, but in some the hollow is distinctly crescentic.

Remarks.—The larger, inflated specimens agree excellently with *Lamarckina rugulosa* as described and figured by Plummer (*l.c.*), and with a specimen from Plummer's Station 24 (Willis Point Formation, Texas) kindly forwarded by Professor L. D. Toulmin. Olsson (1960) figures a specimen of *L. rugulosa* from the Maastrichtian of New Jersey in which the smooth polished part of the surface is restricted to a small circumumbilical area. This type is not found in the Paleocene of Australia.

The more elongate and compressed variants may be compared with the Upper Eocene (Brown's Creek Clays) *Lamarckina airensis* Carter, 1958, and the New Zealand species of similar age, *L. novozelandica* Dorreen, 1948, which is very close to *L. airensis* but distinct according to Carter (*l.c.*). *L. airensis* is a large, lenticular species with powerfully developed peripheral and sutural ridges and a strongly crescentic apertural-umbilical hollow (text fig. 2.8). The specimens at hand from the Brown's Creek Clays (see profiles in text fig. 10) are all distinct from the Paleocene assemblage; but the angular variants of the latter with more crescentic aperture indicate a linear evolutionary relationship. Accordingly we may interpret the Australian Paleocene species as *Lamarckina rugulosa* in which the range of variation is greater in the American Paleocene, foreshadowing the rise of Indo-Pacific species such as *L. novozelandica, L. airensis* and *L. glencoensis* Chapman and Crespin (see Carter, 1958).

Occurrence.—Rivernook Member of Dilwyn Clay, Pebble Point coastal section, western Victoria (55 specimens). King's Park Shale, subsurface, Perth, Western Australia (2 specimens). Paleocene.

Lamarckina naheolensis Cushman and Todd

(Plate 8, figure 2; text fig. 2)

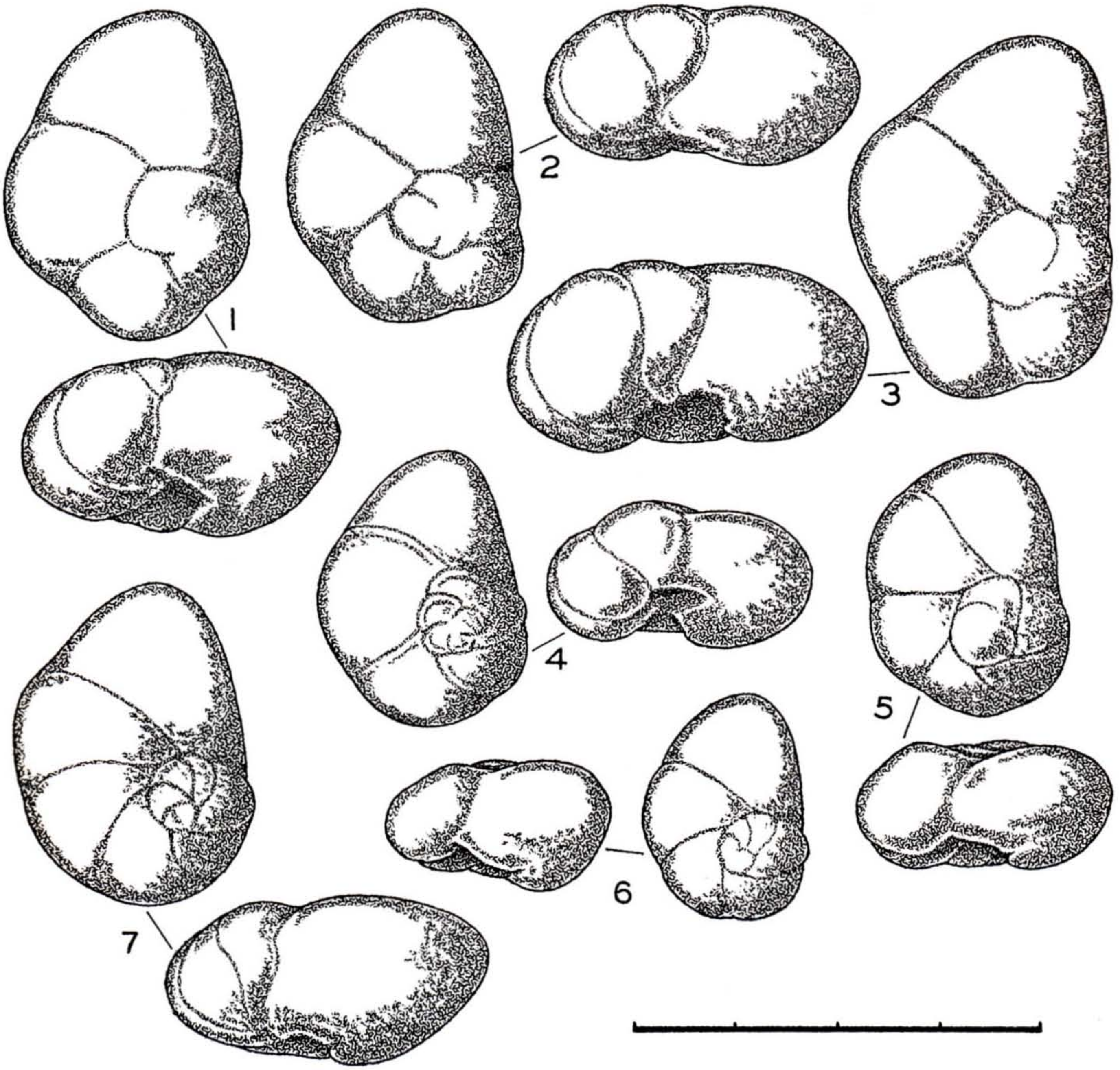
1942, *Lamarckina naheolensis* Cushman and Todd, Cushman Lab. Foram. Research Contr., v. 18, p. 39, pl. 7, fig. 5-7.

1944, *Lamarckina naheolensis* Cushman and Todd. Cushman, Ibid., v. 20, p. 45, pl. 7, fig. 24.

1948, *Lamarckina naheolensis* Cushman and Todd. Brotzen, Sver. Geol. Undersok., Ars. 42, no. 493, p. 122, pl. 17, fig. 6.

1965, *Lamarckina naheolensis* Cushman and Todd. McGowran, Proc. roy. Soc. Victoria, v. 79, p. 56, pl. 5, fig. 8.

Remarks.—The four specimens from the Rivernook Member of the Dilwyn Clay agree well with



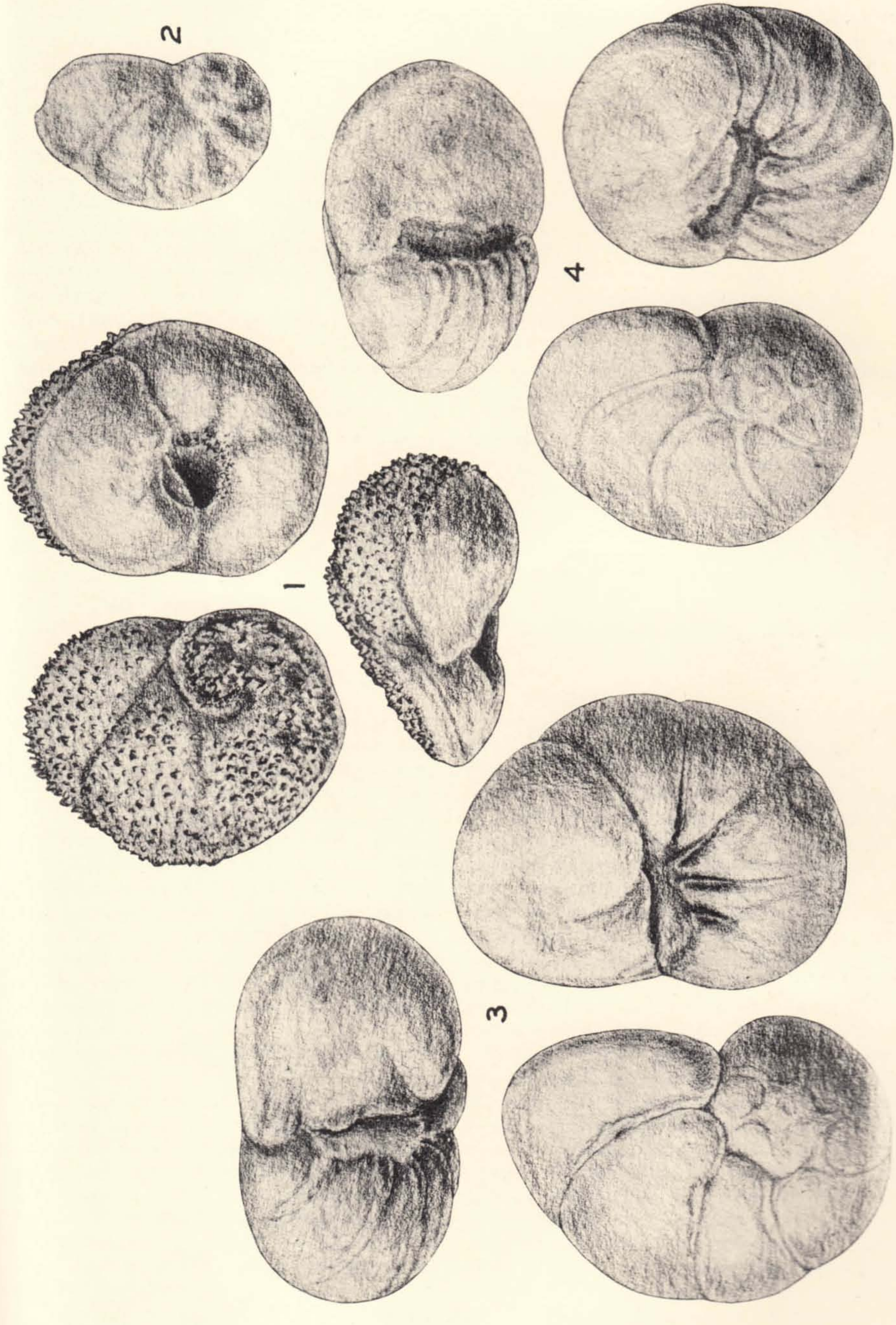
TEXT FIGURE 11

Ceratobulimina (*Ceratolamarckina*) *jutlandica* Troelsen, spiral views and profiles. 1-3 Pebble Point Formation, Paleocene, western Victoria; 4-6, Paleocene, La Trobe No. 1 bore, western Victoria; 7, Paleocene, Basballe, Denmark. All × 132; scale intervals each represent 0.1 mm.

EXPLANATION OF PLATE 8

Specimens deposited in the Paleontological Collections, Department of Geology, University of Adelaide (AUGD, F series) and in the Paleontological Collections, Department of Geology, University of Western Australia (UWAGD). Specimens of *Lamarckina rugulosa, L. naheolensis, Ceratobulimina* (*Ceratolamarckina*) *westraliensis* and *C.* (*Cl.*) *jutlandica* are figured on plates in a study of Paleocene faunas from Victoria (McGowran, 1965).

FIGS.		PAGE
1.	*Lamarckina rugulosa* Plummer. AUGD-F17130. Rivernook Member of Dilwyn Clay, Princetown, Western Victoria; Paleocene. × 132	97
2.	*Lamarckina naheolensis* Cushman and Todd. AUGD-F17131. Rivernook Member of Dilwyn Clay, Princetown, western Victoria; Paleocene. Spiral view, × 132	97
3, 4.	*Ceratobulimina* (*Ceratocancris*) *praecursoria* sp. nov. 3, holotype, UWAGD 55294, Langley Park bore, 208-224 feet. 4, UWAGD 55295, King's Park bore No. 2, 150 feet. Umbilicus filled with matrix in 3; apertural lip broken in 4. King's Park Shale, Perth, Western Australia; Paleocene. Both × 132	101



McGowran: Australian Paleocene Robertinids the Scandinavian Paleocene forms discussed and figured by Brotzen. Cushman and Todd state that the wall is distinctly perforate on the spiral side, but smooth and polished on the umbilical side. The contrast presumably refers to a light, scattered spinosity on the spiral side, seen in topotypes supplied by Professor L. D. Toulmin but not present in the Australian specimens. The latter are sufficiently close to the topotypes to be included in the same species. Brotzen (*l.c.*) emphasizes the importance of *L. naheolensis* as a Paleocene index fossil. However, the species must be very close to the Eocene species *Lamarckina cristellaroides* (Terquem), for Kaasschieter (1961) distinguishes them only by the "more coarsely perforated dorsal side" in *L. naheolensis,* a character not found in any other member of the superfamily Robertinacea.

Occurrence.—Rivernook Member, Dilwyn Clay (4 specimens). King's Park Shale (1 specimen). Paleocene.

Ceratobulimina (Ceratolamarckina) jutlandica Troelsen

(text figs. 3, 11)

1954, *Ceratobulimina (Ceratolamarckina) jutlandica* TROELSEN, Medd. fra Dansk Geol. Forening. København, Bd. 12, p. 456, pl. 10, fig. 7-9.

1965, *Ceratobulimina jutlandica* Troelsen. McGOWRAN, Proc. roy. Soc. Victoria, v. 79, p. 57, pl. 5, fig. 5.

Description.—Test inflated, coiled dextrally, roughly 4-sided or 5-sided in plan, biconvex in profile; margin broadly rounded, slightly lobate. Chambers inflated, rounded-triangular in form, increasing rapidly in size with four and one-half to five and one-half in final whorl on spiral side. Sutures somewhat tangential and recurved slightly, flush and indistinct, or depressed in final stages of growth. Apertural-umbilical hollow more or less rounded, aperture short, with angle or blunt notch at axial end, and toothplate attachment extending into apertural face as faint groove. Wall polished, finely perforate, tuberculate in umbilical area. Maximum diameter 0.38 mm.

Remarks.—The toothplate has been discussed in Part One, above.

Variation in this species, which is not great, is shown in text fig. 11. The specimens consistently are more inflated than the holotype, from the Paleocene of Denmark (Troelsen, *l.c.*). However, several specimens from the Danish Paleocene kindly forwarded by Dr. Arne Buch show that the Danish and Australian samples overlap in this respect (see text fig. 11). The general form of the test and the nature of the toothplate also are the same.

Occurrence.—Pebble Point Formation (14 specimens). Rivernook Member of Dilwyn Clay (8 specimens). La Trobe bore No. 1, core 54A, 970 ft., near mouth of Gellibrand River, western Victoria (6 specimens kindly supplied by Mr. D. J. Taylor). Paleocene.

Ceratobulimina (Ceratolamarckina) westraliensis Parr

(text figs. 4, 12)

1938, *Ceratobulimina westraliensis* PARR, J. roy. Soc. W. Aust., v. 24, p. 83, pl. 2, fig. 12.

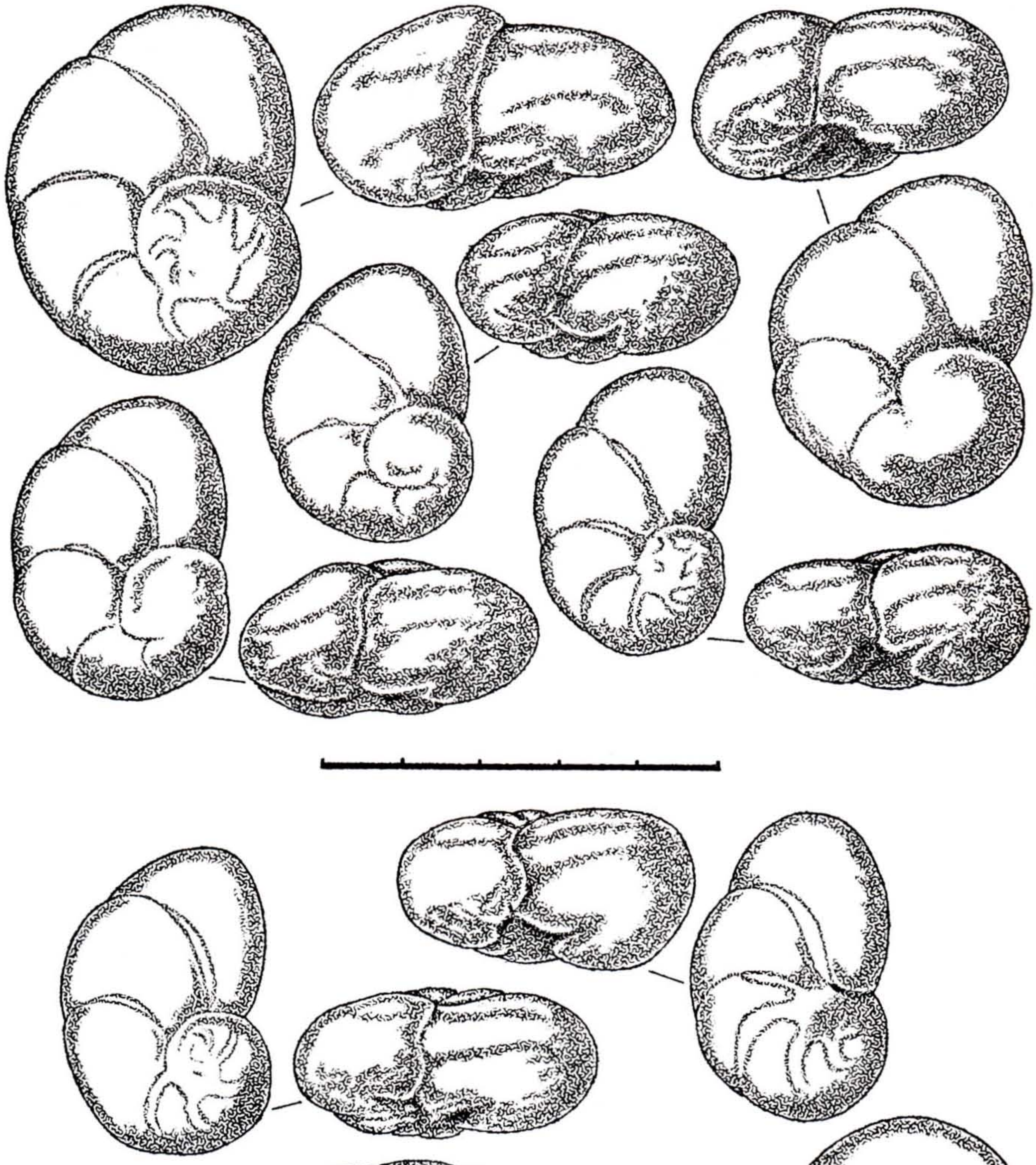
1946, *Ceratobulimina westraliensis* Parr. CUSHMAN, Lab. Foram. Research Contr., v. 22, p. 110, pl. 17, fig. 9.

1965, *Ceratobulimina westraliensis* Parr. McGOWRAN, Proc. roy. Soc. Victoria, v. 79, p. 57, pl. 5, fig. 1.

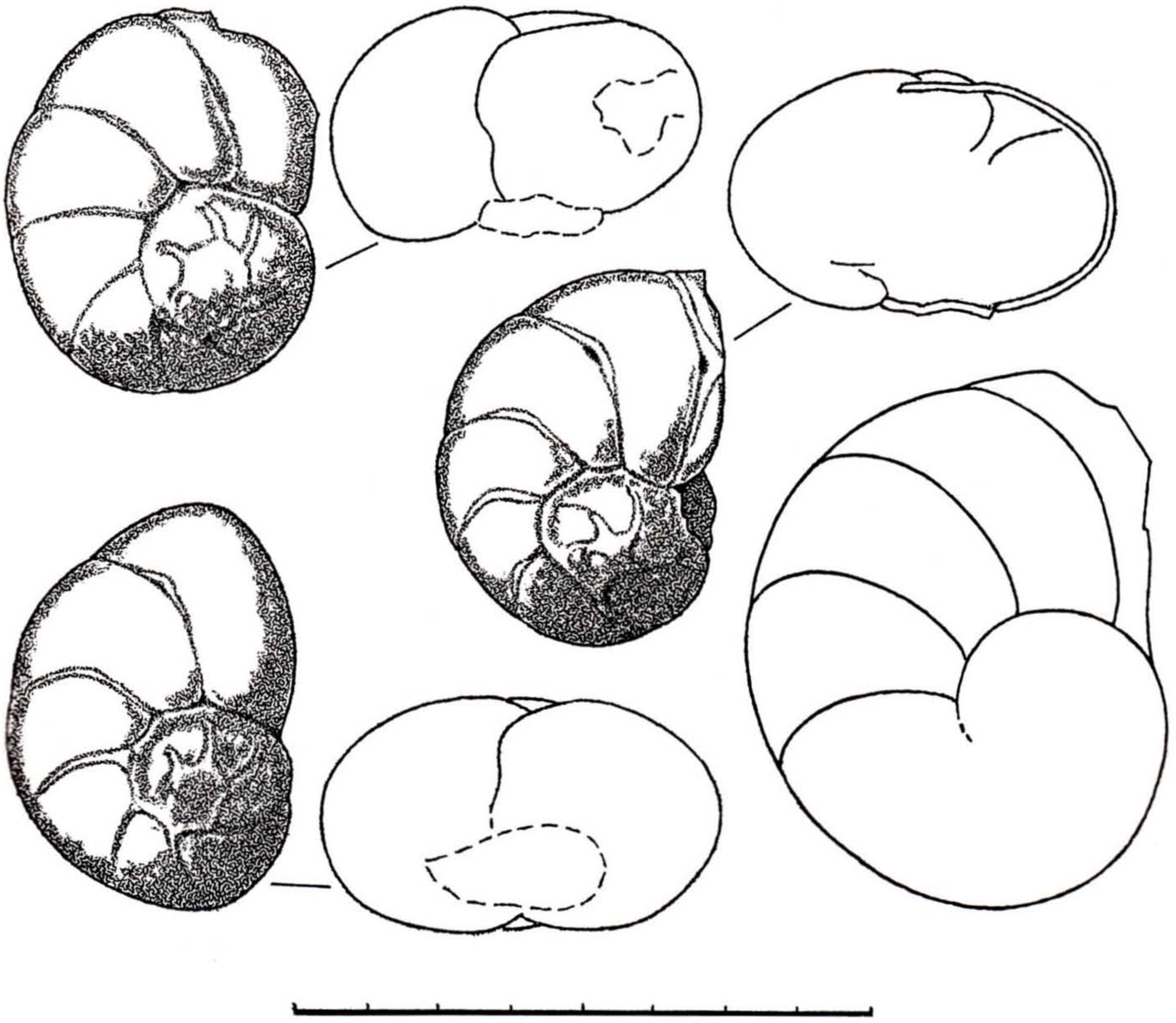
Description.—Test coiled dextrally in about 2 rapidly expanding whorls; in plan elongate to almost equilateral; in profile inflated to compressed and flattened, with rounded periphery. Chambers inflated, increasing rapidly in size, usually 6 or 7, varying between 5 and 8 in adult whorl (spiral side); sutures varying from flush and strongly limbate to nonlimbate and depressed on spiral side, depressed around umbilicus. Surface smooth with tubercles developed variably in umbilical depression and on septal face below toothplates. Aperture umbilical, with serrate lip, and with notch in apertural face often prominent; apertural face flattened, or inflated within curvature of aperture, or inflated generally. Maximum diameter 0.55 mm., most specimens less than 0.5 mm.

Variation.—The species is one of the most common in the Paleocene of southern Australia. Some of the variation is shown in two views of the test in text fig. 12. Apart from the holotype, the King's Park Shale specimens tend to be more elongate than those from the Paleocene of Western Victoria. Also, they tend to have a more strongly flattened apertural face and typically 7 chambers in the final whorl instead of 6. Nevertheless the assemblages overlap and they are certainly conspecific. The holotype of *C. westraliensis* is rather atypical of the King's Park Shale assemblages in its size, quadrate appearance in plan, and general inflation. In general form it is closer to the larger Victorian specimens.

Remarks.—Parr (1938) distinguished *C. westraliensis* in the King's Park Shale from *C. perplexa* (Plummer) by the lower chamber count, smaller umbilicus and smaller apertural notch in *C. perplexa.* Topotypes from Professor L. D. Toulmin support this distinction. In another paper (McGowran, 1965) doubts were raised about the specific distinctness of *C. westraliensis, C. perplexa* and the other related Paleocene species, *C. tuberculata* Brotzen (1948), because there seems to be some overlap among these in the gross form of the test. However, the differences in the attachment of the toothplate (see Part One, above) separate the Australian species clearly from the others. Finlay



TEXT FIGURE 12



TEXT FIGURE 13

Ceratobulimina (*Ceratocancris*) *praecursoria* sp. nov., spiral views and profiles. King's Park Shale, Paleocene, Western Australia. Earlier sutures usually obscured by secondary lamellae; shown here as clarified. All × 88; scale intervals each represent 0.1 mm.

(1939) compared *C. lornensis Finlay* (Upper Eocene, New Zealand) with *C. westraliensis*. Dr. N. de B. Hornibrook (pers. comm.) has stated that *C. lornensis* is much larger and has a more inflated apertural face.

Occurrence.—Pebble Point Formation (170 specimens). Rivernook Member of Dilwyn Clay (214 specimens). King's Park Shale (about 150 specimens). Paleocene.

Ceratobulimina (Ceratocancris) praecursoria sp. nov.

(Plate 8, figures 3, 4; text figs. 5, 13)

Description.—Test large and robust; coiled dextrally; ovoid in general form. In profile biconvex and strongly inflated, with periphery broadly rounded; periphery non-lobate in plan or very slightly lobate in later stages of growth. Chambers increasing rapidly in width; up to about two and one half whorls with 7 or 8 in final whorl. Sutures on spiral side flush, limbate, very indistinct in early part of adult test, becoming slightly depressed later, radial and recurved, bent and thickened at junction with toothplate and sometimes with small, distinct depression; on umbilical side recurved, limbate, depressed around umbilicus with chamber ends raised or thickened. Wall polished. Umbilicus narrow. Aperture basal, between long axial groove with notch and small but distinct marginal notch; apertural face flattened.

EXPLANATION OF TEXT FIGURE 12

Ceratobulimina (*Ceratolamarckina*) *westraliensis* Parr, spiral views and profiles. Lower group, King's Park Shale, Paleocene, Western Australia (large specimen at lower right is holotype, redrawn); upper group, Pebble Point Formation, Paleocene, western Victoria. All × 106; scale intervals each represent 0.1 mm.

Toothplate large; foramen large. Maximum diameter (broken specimen) 0.78 mm.; maximum diameter of largest complete specimen 0.69 mm.

Remarks.—A relatively small specimen was chosen as holotype because it is the best preserved specimen available. It does not differ otherwise from the largest specimens. Variation is low: the apertural face may be more or less broad in apertural view; the toothplate suture (*i.e.* the axial groove) varies in its angle to the apertural lip; the circumumbilical thickenings vary in prominence.

C. praecursoria appears to have evolved from *Ceratobulimina westraliensis,* though this is not observable directly in the sample sequences from the King's Park Shale. In addition to the subgeneric differences, *C. praecursoria* is larger, more robust with thicker walls, and usually more inflated. *C. praecursoria* replaces *C. westraliensis,* becoming dominant in the highest samples from King's Park bores 1 and 2. There is some doubt about the identification of one or two specimens, but this is due probably to inferior preservation.

The species of *Ceratocancris* closest morphologically and stratigraphically to *C. praecursoria* are the Eocene forms *C. eximia* (Rzehak), *C. stellata* Bandy, and *C. alazanensis* Cushman and Harris of some authors (*e.g.* Debourle and Sacal, 1957; but Finlay (1939) has pointed out that *C. alazanensis* is a true *Ceratobulimina* s.s.). All these forms differ from *C. praecursoria* most clearly in their profiles. *C. praecursoria* is broadly oval in profile and inflated (text fig. 13) whereas the Eocene species are more compressed marginally, the periphery being rounded more narrowly while not actually acute (see figures in Cushman and Harris, 1927; Plummer, 1936; Cushman, 1946; Bandy, 1949; Debourle and Sacal, 1957).

Occurrence.—King's Park Shale (76 specimens). Paleocene.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
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319. *ASTEROROTALIA TRISPINOSA* (THALMANN), A SPINOSE ROTALIID FROM DIGHA BEACH, SOUTHERN BENGAL

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ABSTRACT

The occurrence of **Asterorotalia trispinosa** (Thalmann) in the Bay of Bengal faunal province is reported. The variation of the species has been studied and its nomenclature discussed.

INTRODUCTION

Recent forms ascribable to *Asterorotalia trispinosa* (Thalmann) have previously been reported only from Java (Thalmann, 1933; Hofker, 1951). In the beach sands of Digha it is well represented, occurring in association with *Ammonia beccarii* and other smaller foraminifers.

This form has been adequately described by Flint (1899), Hofker (1951) and Thalmann (1933). A few points in connection with its morphology will, however, be noted. For the calculation of statistical parameters in the following discussion, the methods advocated by Simpson, Roe and Lewontin (1960) have been followed. The sample distribution will be fitted to a standardized curve, and in all the calculations it has been assumed that the observed frequencies are normally distributed.

I am indebted to Dr. H. E. Thalmann for sending me a reprint of his paper on *Rotalia trispinosa* and to Dr. S. H. Rao of our department for translating it for me. I express my thanks to the authorities of the Indian Institute of Technology and to Dr. T. C. Bagchi, Head of the Department of Geology and Geophysics, for providing laboratory facilities, and to Mr. N. G. Sarkar of our Department for preparing the figures.

MORPHOLOGICAL DESCRIPTION

The shape of the test is, in most cases, distinctly triangular; in only 7% of the forms studied was the outline circular. A complete gradation between the two forms is observable, as was found by Huang (1964) to be true of *A. subtrispinosa*. The test is nearly discoidal, but the umbilical region is slightly concave and the dorsal side is slightly convex. The calcareous plug may or may not be distinct; it is never prominent. The last two or three chambers are much inflated, so that their dorsal and ventral walls are not flush with the respective surfaces. In the last quarter whorl, the deep sutural grooves of the ventral side do not stop at the margin but continue to the peripheral part of the dorsal side; here the spiral suture of the dorsal side is also deep. Spines are supra-marginal; the extension of the spines towards the center is visible from the dorsal side. The chamber of the last whorl may not completely enclose the spine wall. The number of spines externally visible varies from 1 to 4, but the majority (81%) of the 88 specimens studied have three. Two spines are present in 16%, four in 2% and one in 1% of the specimens, all aberrant forms, not to be regarded as distinct types. The spines are usually stout, but in some cases, especially in tests with four spines, they are slender. The length of the visible part of the spine, though variable, rarely exceeds the maximum diameter of the test. The actual length, of course, is much greater; it may be considered to include the visible length plus one-half the mean diameter of the test itself.

The statistical parameters for length of the spines are given in table 1. The variability is high, as can

Tables of standard errors and confidence intervals for various estimates of the parameters calculated for the test of *A. trispinosa*. All measurements are in microns.

TABLE 1
Spine length

Parameter	Estimate	Standard Error	95% confidence limits
μ	308.64	16.51	275.55 - 341.75
σ^2	15005	-	10711 - 23078
σ	122.49	-	103.49 - 151.91
V	39.69	3.78	32.28 - 47.10

N = 55
Actual range = 50 - 625
O.R. = 29 - 589

TABLE 2
Spine-length index

μ	.5236	.0263	.4735 - .5791
σ^2	.0381	-	.0586 - .0272
σ	.1952	-	.2420 - .1649
V	37.28	3.55	30.32 - 44.24

(Confidence limits have been calculated in the usual way, assuming that the distribution is normal).
N = 55
Actual range = 0.1 - 1.2.

TABLE 3

Maximum diameter

μ	592.3	9.79	572.8 - 611.8
σ^2	8439	-	6431 - 11727
σ	91.86	-	80.19 - 108.29
V	15.59	1.18	13.28 - 17.90

N = 88

Actual range = 400 - 875

O.R. = 366 - 818

S.R. = 295 - 890

TABLE 4

Coefficients for regression of spine length (y) on maximum diameter (x) and x (max. dia.) on y (sp. 1.)

Coefficient		95% confidence limits
a_y	—0.29	−195.33 to + 194.75
b_{yx}	0.52	0.20 to 0.84
a_x	495.33	429.96 to 560.70
b_{xy}	0.32	0.12 to 0.52

Correlation coefficient: —0.41

For the 53 degrees of freedom the probability that P = 0 is between .01 and .001.

Equation for Bartlett's "best fit line": $Y = -41.87 + .59x$

Regression equations: $y = -0.29 + .52x$; $x = 495.33 + .32y$

be seen from the large coefficient of variation (39.69). The ratio of spine length to maximum test diameter (which may be called the spine length index) is as variable as the length of the spine itself (see table 2); they have nearly the same coefficient of variation. However, in spite of the variability there is a tendency for the ratios to fall more frequently in the two classes represented by the mid-points 0.5 and 0.6, as is evident from the histogram showing the frequency distribution of spine length index (text fig. 1). It may be noted that the 95% confidence limits for μ are .47 and .58, very close to the values for model classes of the sample.

To find out whether there is any linear relation between maximum test diameter and spine length, regression and correlation coefficients have been calculated (table 4), and the regression lines and Bartlett's "best fit line" are shown (text fig. 2).

It is interesting to note that the "best fit line" nearly coincides with the line showing regression of spine length on maximum diameter.

Table 4 shows that the confidence limits for all the coefficients are very wide, so the expressions derived from them are not very useful as prediction equations, particularly if one wishes to predict the maximum diameter from the length of the spine. In connection with the coefficients of regression of spine length on maximum diameter, two points should be noted. Firstly, in the equation the spine length becomes 0 when the maximium diameter is 0. Here the logical situation is supported by statistical inference. Secondly, the value for the coeffi-

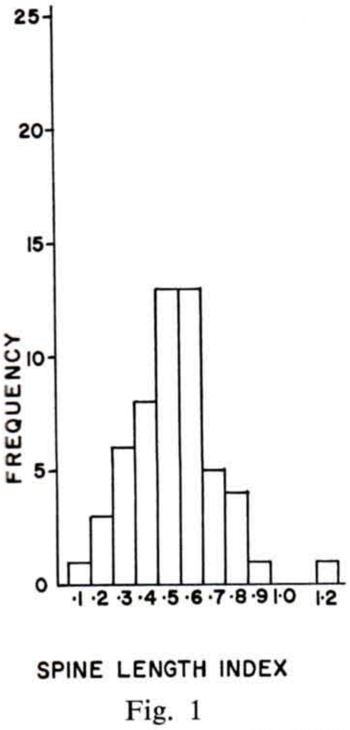

Fig. 1

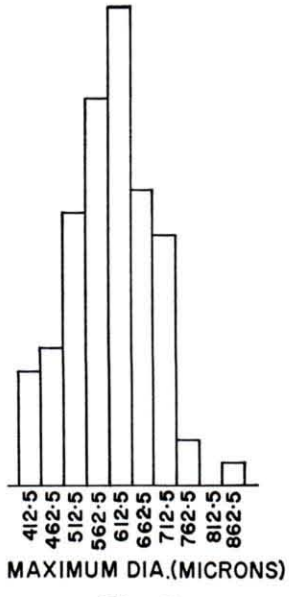

Fig. 3

FIGURE 1

Histogram showing the frequency distribution of spine length index (*i.e.* spine length/maximum diameter).

FIGURE 3

Histogram showing frequency distribution of maximum diameter. Class mid-points are given.

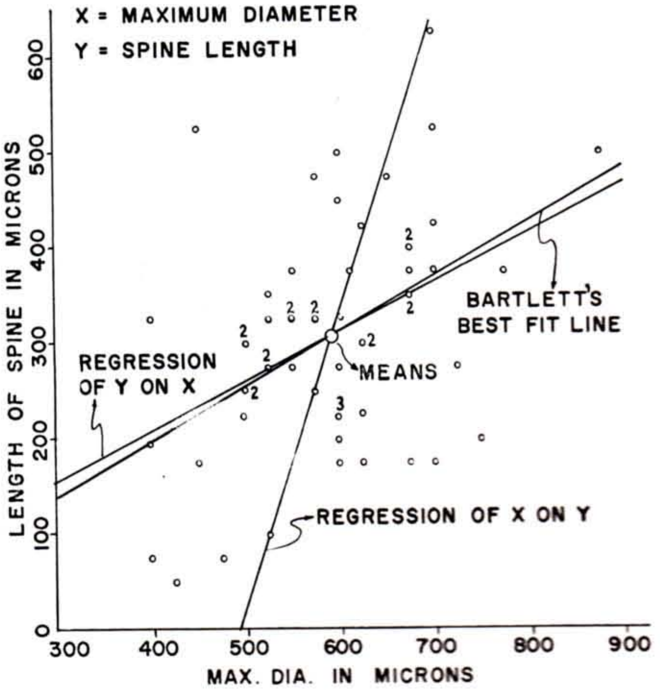

FIGURE 2

Scatter diagram, regression lines and Bartlett's "best fit line" for lengths of maximum diameter and visible spine length. The numbers indicate that the same position is occupied by more than one point.

cient *byx,* which is 0.52, is the same as for the mean spine length index. The correlation coefficient indicates that the correlation is weak but significant.

The maximum diameter varies from 400 to 875μ. Text fig. 3 is a histogram showing the frequency distribution of the maximum diameter. The statistical parameters calculated for this dimension are given in table 3. For the purpose of calculation, raw data have been used where the class interval is 25μ, but for the purpose of constructing the histogram, secondarily grouped data with a class interval of 50μ have been used. As can be seen, the mean is 592.3μ, very near the value for the modal class, 612.5μ. The coefficient of variation is 15.59; a value that may not be considered high in the case of foraminifera. It should be remembered that in this case the size depends on the number of whorls, which varies from 2¼ to 3. χ^2 for goodness of fit of the observations has been calculated to be 4.22. For 6 degrees of freedom, the probability for this value of χ^2 is about .65, so the agreement between observed and expected distribution may be considered satisfactory, although not so under very stringent conditions. In the original measurements the whole sample was taken to be completely homogeneous, disregarding the fact that in the sample both megalospheric and microspheric generations are represented. Such a course was taken because it was very difficult to separate the two generations in most of the cases. Even if we admit that the size distributions for the two are slightly different and the sample is not strictly homogeneous, there must be a large amount of overlap between the two distributions, resulting in a combined distribution which, for all practical purposes, may be treated as normal.

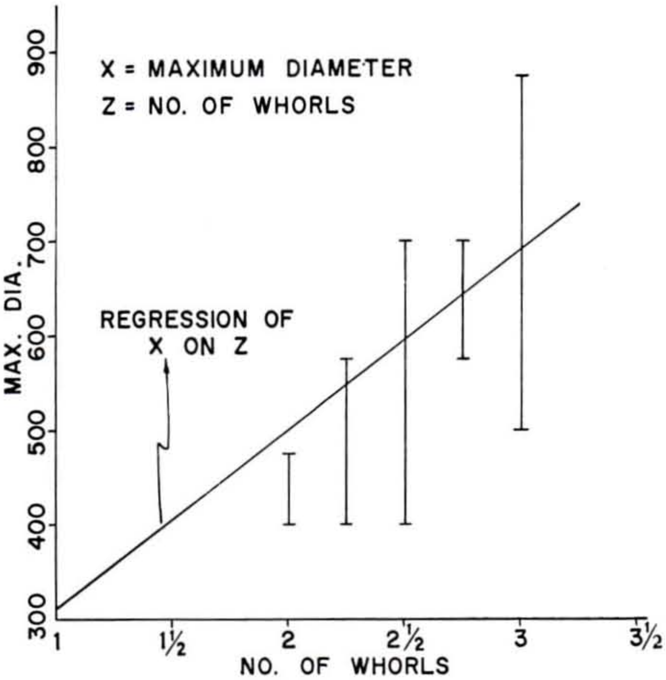

FIGURE 4

Regression line showing regression of maximum diameter on number of whorls. The vertical lines show the range of maximum diameters for a particular number of whorls.

To find out the relation between number of whorls and maximum diameter, coefficients of regression of maximum diameter on number of whorls and the correlation coefficient have been calculated (table 5 and text fig. 4).

TABLE 5

Coefficients for regression of maximum diameter (x) on number of whorls (z).

Coefficient		95% confidence limits.
a_x	119.7	143.4 to 237.8
b_{xz}	190.6	1.4 to 238.0

Correlation coefficient = 0.67

For the 82 degrees of freedom the probability that P = 0 is less than .001.

Regression equation: $y = 120 + 190.6x$

The expression thus obtained can be used as a prediction equation. For a test with 3 whorls, for example, the predicted maximum diameter would be 691.8, with 95% confidence limits at 663.9 to 717.7μ. The mean maximum diameter calculated for tests with 3 whorls is 663.0μ, nearly the same as the lower confidence limit.

One interesting feature of the expression is that when z (*i.e.* number of whorls) is zero, x (*i.e.* maximum diameter) is 120μ. In other words it may be said that whorls start with an initial mean diameter of 120μ, which may be taken as the diameter of the proloculus. This estimate is rather high because the observed diameter of the proloculus varies between 20 and 50μ. As expected, the correlation coefficient indicates that the correlation is moderately strong and highly significant, because with .66 as the coefficient and with 82 degrees of freedom, the probability that P is 0 is less than .001 for a two-sided test. (As we definitely know that the correlation is positive, we can even employ the one-sided test, in which case the probability would be even less).

In respect of size, this form is comparable with Brady's, which has an average diameter of 0.5 mm., but the form described by Thalmann (1933) is much larger. Thalmann says that specimens having a diameter of 2 to 3 mm. are common, but the probability of a test of that size occurring in a population represented by the sample here studied is less than .001 (as shown by the *t*-test). It is possible that Thalmann's form and the present one are two distinct ecotypes.

The aperture (text fig. 5), with very small neck, is areal, interomarginal, and nearly medial (but

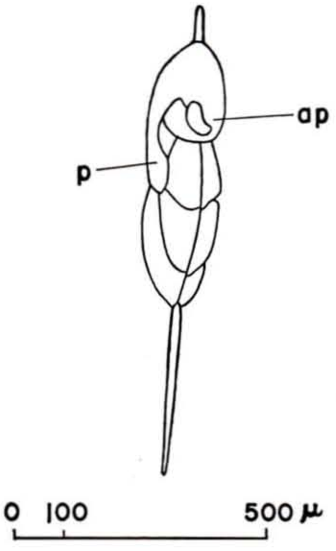

FIGURE 5
Freehand sketch of the apertural view of the test; *ap* = aperture; *p* = plate-like extension of the ventral wall of the chambers.

more towards the ventral side); it is elongated and extended towards the venter and exterior.

An equatorial section (text fig. 6) shows the nature of the spine and aperture distinctly. As noted by Hofker (1951), the spine shows the presence of a distinct lumen. Another feature brought out by the section is that, although the spines develop in the very first whorl and extend outward by penetrating the chambers of the succeeding whorls, the walls of the chambers contribute to the development of a thicker and stouter spine. As a result, the outer part of the wall of the spine is continuous with the wall of the chamber.

NOMENCLATURE

There is some confusion regarding the nomenclature. Thalmann (1933) renamed *R. pulchella* (d'Orb.) 1839 as *R. trispinosa,* because he considered it to be a secondary junior homonym of *R. pulchella* d'Orb. 1826. Hofker (1951) referred the same species to his genus *Asterorotalia.* He however restored d'Orbigny's original trivial name and designated the form as *Asterorotalia pulchella.* This manner of restoring a secondary homonym is permitted, however, only if a name is rejected after 1960 (Art. 59c of I.C.Z.N.). Considered from this standpoint, *Asterorotalia trispinosa* Thalmann is a valid name. Another point must be considered, however. Thalmann regarded *R. pulchella* (d'Orb.) 1839 as a secondary junior homonym of *R. pulchella* d'Orb. 1826, because, accepting Galloway's view that *Rotalia* Lamarck and *Eponides* de Montfort are congeneric, he did not take into consideration Parker, Jones and Brady's referral of this species to the genus *Eponides.* It is now believed that *Eponides* is distinct from *Rotalia.* If their referral is correct, *R. pulchella* d'Orb. 1826 becomes *Eponides pulchella* (d'Orb.) 1826; in that case the name *Rotalia pulchella* (d'Orb.) 1839 remains valid, as it can no longer be regarded as a junior homonym of *R. pulchella* d'Orb. 1826. But before the question of restoring the original trivial name for *Asterorotalia trispinosa* is considered, one should be certain that *R. pulchella* d'Orb. 1826 can definitely be referred to *Eponides* as now defined. The author neither has access to the original material nor does he know of any subsequent study of this question; under such circumstances it seems unwise to restore the original name.

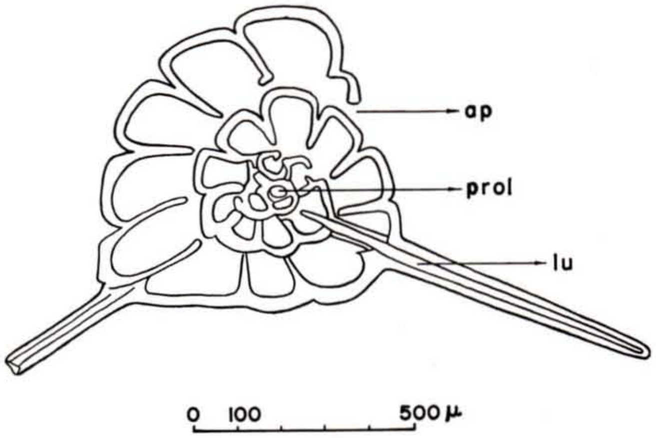

FIGURE 6
Camera lucida drawing of the section of the test; *ap* = aperture; *prol* = proloculus; *lu* = lumen of the spine.

MODE OF OCCURRENCE AND CONCLUSION

As noted by Thalmann for the Javanese forms, the species also ocurs here with fine-grained materials, probably because its long spines give buoyancy to the tests and allow them to remain suspended for a longer period and to be deposited along with the finer material. The grain size of sediments in which the test of this form are common is between 100 and 300μ; this contrasts markedly with that of the average size of the tests (600μ).

The presence of this shallow-water form in the faunal province of the Bay of Bengal is interesting in that it indicates a close connection between the Indonesian and the Bay of Bengal faunal provinces.

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APPENDIX

Raw data on which the statistical analysis is based.

Max. diam. (in microns)	Spine length (in microns)	Max. diam. spine 1	No. of whorls	No. of spines
400	x	x	2	3
400	x	x	2¼	3
400	75	0.19	2¼	3
400	325	0.81	2½	3
425	50	0.12	2	3
450	x	x	2	3
450	x	x	?	3
450	175	0.39	?	3
450	550	1.22	2	3
475	x	x	2	2
475	75	0.16	2	2
500	x	x	2½	2
500	x	x	2½	3
500	225	0.45	2¼	4
500	250	0.50	2¼	3
500	250	0.50	2¼	3
500	300	0.60	2½	3
500	300	0.60	3	3
525	100	0.19	2½	3
525	275	0.52	2¼	3
525	275	0.52	2¼	2
525	325	0.62	2½	2
525	350	0.67	2½	3
550	x	x	2½	3
550	x	x	2½	1
550	275	0.50	2½	2
550	325	0.59	2½	3
550	325	0.59	2½	3
550	375	0.68	2½	2
575	x	x	3	3
575	x	x	2½	3
575	x	x	2½	3
575	x	x	2½	3
575	x	x	2½	3
575	x	x	2¼	3
575	x	x	2¾	2
575	250	0.43	3	3
575	325	0.57	3	3
575	325	0.57	2½	3
575	475	0.83	2½	3
600	x	x	2½	3
600	x	x	2½	3
600	175	0.29	2½	3
600	200	0.33	2½	2
600	225	0.38	3	3
600	225	0.38	2½	3
600	225	0.38	2½	3
600	275	0.46	2½	3
600	325	0.54	2½	3
600	375	0.63	3	3
600	450	0.75	2½	3
600	500	0.83	2½	3
625	x	x	2½	3
625	x	x	2½	3
625	x	x	2¾	3
625	x	x	3	3
625	175	0.28	3	3
625	225	0.36	2½	3
625	300	0.48	2½	3
625	300	0.48	?	3
625	425	0.68	3	3
650	x	x	2½	3
650	x	x	3	2
650	x	x	2½	3
650	x	x	2½	3
650	475	0.73	3	3
675	x	x	2½	3
675	x	x	2½	3
675	175	0.26	2½	3
675	350	0.52	2½	3
675	350	0.52	3	2
675	375	0.56	?	3
675	400	0.59	3	3
675	400	0.59	3	3
700	x	x	2½	3
700	x	x	3	2
700	x	x	3	2
700	x	x	3	2
700	x	x	3	3
700	175	0.25	2¾	3
700	375	0.54	2½	3
700	425	0.61	2¾	3
700	525	0.75	2¾	3
700	625	0.89	3	3
725	275	0.38	3	3
750	200	0.27	3	4
775	375	0.48	3	3
875	500	0.57	3	3

x = Spine broken.

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RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ALIJULLA, KH. K Izucheniju Predstavitelej *Vaginulina* (Foraminifery) Kon'jakskikh Otlozhenij Vostochnykh Predgorij Malogo Kavkaza.—Akad. Nauk Azerbajdzhan. SSR, Baku, Izvestija, ser. geol.-geogr. nauk, No. 2, 1965, p. 12-18, pls. 1, 2.—Two new species, one with a new subspecies, in the Coniacian.

ARNOLD, ZACH M. A laboratory system for maintaining small-volume cultures of foraminifera and other organisms.—Micropaleontology, v. 12, No. 1, January 1966, p. 109-118, text figs. 1-3 (drawings of apparatus).

BANDY, ORVILLE L. Restrictions of the "*Orbulina*" datum.—Micropaleontology, v. 12, No. 1, January 1966, p. 79-86, pl. 1, text figs. 1-4 (graph, diagrams, distrib. chart).—*Orbulina* first appears at the base of the Burdigalian in tropical and warm-temperate areas, but in temperate regions it does not appear until later. A multiple origin of *Orbulina* from several different globigerinids is suggested by the finding—through dissection—of several different globigerinid species attached inside *Orbulina* tests. Thus, *Orbulina* may represent a float chamber, reproductive stage, or growth phenomenon rather than a true genus.

BASOV, V. A., and SLOBODIN, V. Y. Complexes of Recent and Late Cenozoic Foraminifera of western Soviet Arctic (English summary of Russian text).—Russia. Nauchno-issl. instit. geol. arktiki, Trudy, tom 143, 1965, p. 190-210, text figs. 1-18 (map, pie diagrams).—Quantitative analyses of species in Recent bottom sediments from around Franz Josef Land and in the Kara Sea and of deposits from adjacent parts of the West Siberian Lowland. Four horizons, based on Foraminifera, are recognized in the Pliocene?-Pleistocene sequence, the earliest one deposited under warmer temperature.

BAUZA RULLAN, JUAN. Fauna de las formaciones del Terciario superior de La Puebla (Mallorca).—Estudios Geol., Instit. Invest. Geol. "Lucas Mallada," v. 20, No. 3-4, Dec. 1964 (Sept. 1965), p. 187-215, pls. 1-5.—Sixty-nine species of Foraminifera recorded, none new.

BELJAEVA, N. V. Raspredelenie Planktonnykh Foraminifer v Indijskom Okeane (with English abstract).—Okeanologicheskie Issledovanija, Sbornik Statej, Rasdel Programmy MGG, No. 13, 1964, p. 205-211, text figs. 1, 2 (maps).—Areas of 5 faunas—cold, transition, temperate, transition, and warm—are mapped.

BERMUDEZ, PEDRO J., and SEIGLIE, GEORGE A. *Eoeponidella mineacea* sp. nov. del Paleoceno de Guatemala.—Bol. Soc. Geol. Mexicana, v. 27, No. 1, 1964, p. 13, 14, pl. 1.

BHALLA, S. N. Foraminifera from the Infra-Trappean beds of the Pangadi area, India.—Jour. Paleontology, v. 40, No. 2, March 1966, p. 343-353, pl. 40, text figs. 1-6 (map, line drawings, distrib. chart).—Eight species (2 new and 3 indeterminate) from beds of Paleocene age.

BLAIR, DONALD G. The distribution of planktonic Foraminifera in deep-sea cores from the Southern Ocean, Antarctica.—Sedimentology Research Lab., Dept. Geol., Florida State Univ., Contr. 10, Dec. 1965, p. i-x, 1-141 (mimeo.), pl. 1, text figs. 1-29 (maps, diagrams, distrib. maps, range charts, graphs), tables 1-6.—Study based on tops of 76 cores from the Drake Passage and South Pacific sectors. Area studied extends from about 160°W to 44°W and about 50°S to 64°S. Nine species are found: *Globigerina pachyderma* approaching 100 percent of the fauna south of the convergence, 3 cold temperate species randomly distributed on both sides of the convergence, and 5 temperate species indicative of warmer waters increasing in abundance north of the convergence. Percentage of left-coiling *G. pachyderma* (100 percent south of the convergence) decreases northward into warmer waters. Long cores from north of the convergence show alternation of short warm intervals (high $CaCO_3$ content) and long cold intervals. In the cores variations in fauna are interpreted as a result of fluctuations in mean position of the convergence, but warm intervals in 3 of the cores are tentatively correlated and interpreted as having resulted from a significant climatic event.

The study of planktonic Foraminifera in Antarctic deep-sea cores, *in* Marine Geology USNS *Eltanin* Cruises 9-15.—Sedimentology Research Lab., Dept. Geol., Florida State Univ., Contr. 11, Dec. 1965, p. 36-41 (mimeo).—Some preliminary and general observations concerning changes of species percentages and coiling direction at the Antarctic convergence in Drake Passage.

Boccaletti, Mario, and Sagri, Mario. Strutture caotiche dell'Appennino. I. Età, assetto e giacitura del complesso argilloso-calcareo affiorante nella parte occidentale del F° 129 "S. Fiora."—Boll. Soc. Geol. Ital., v. 83, fasc. 4, 1964 (1965), p. 461-510, pls. 1-6, text figs. 1-30 (graphs, maps, geol. sections, outcrop photos, diagrams).—Includes illustrations of Cenomanian-Turonian planktonic Foraminifera.

Buday, Tibor, Cicha, Ivan, and Senes, Jan. Miozän der Westkarpaten.—Geol. Ustav Dionyza Stura, Bratislava, 1965, 295 p., 12 pls., 9 text figs. (paleogeographic maps), 5 stratigraphic tables, generic range chart, correl. chart, 4 illustrated range charts for species, 5 geol. maps, tectonic map.—An important reference work covering the stratigraphy (by Cicha and Senes) and the tectonics (by Buday). Paleogeographic maps are included for 9 stages, series, or zones between Aquitanian and lower Sarmatian, and typical assemblages of smaller Foraminifera are illustrated from the same ages from various basins. Foraminifera are the major fossils included, and illustrated range charts show the ranges of 10 coiled agglutinated species, 9 species of *Cyclammina,* 20 of *Uvigerina,* and 24 planktonic species.

Choubert, G., Hottinger, L., Marçais, J., and Suter, G. Stratigraphie et micropaléontologie du Néogène au Maroc septentrional (with English summary).—Instit. Invest. Geol. "Lucas Mallada," Cursillos y Conferencias, fasc. 9, Nov. 1964, p. 229-257, text figs. 1-23 (map, range chart, line drawings).—Includes illustrations of the planktonics and the heterostegines that are locally useful for age determinations.

Cicha, I., and Zapletalova, I. Die Biostratigraphische Bedeutung der Gattung *Bolivina* (Foraminifera-Protozoa) im Miozän der Westkarpaten. —Instit. Invest. Geol. "Lucas Mallada," Cursillos y Conferencias, fasc. 9, Nov. 1964, p. 119-121.

Clark, David L., and Bird, Kenneth J. Foraminifera and paleoecology of the upper Austin and lower Taylor (Cretaceous) strata in north Texas.—Jour. Paleontology, v. 40, No. 2, March 1966, p. 315-327, text figs. 1-5 (map, histograms, graphs), table 1.—Study based on 62 samples crossing the Austin-Taylor contact, some where the contact is disconformable and some where it is transitional. Quantitative analyses were made of genera, using the first 200 mature good specimens. Paleoecologic interpretation made through comparison of families and genera with Recent foraminiferal ecology in the Gulf of Mexico indicates that both formations may be treated as a single depositional environment at depths between 200 and 1700 feet. *Globigerina* s. l. predominates over *Gümbelina* s. l. in the definite Taylor, but the reverse is true in the definite Austin.

Cole, W. Storrs. Additional comments on the foraminiferal genus *Camerina.*—Bull. Amer. Pal., v. 50, No. 228, May 6, 1966, p. 229-265, pls. 20-27.—In defense of *Camerina* (as opposed to *Nummulites*). Many specimens are illustrated to demonstrate the synonymity of *Operculina, Operculinella, Operculinoides, Ranikothalia, Paraspiroclypeus,* and *Palaeonummulites* with *Camerina.*

Cotillon, Pierre. Étude Micrographique et Micropaléontologique d'une coupe du Crétacé Inférieur néritique de la région de Castellane (Basses-Alpes).—Colloque sur le Crétacé Inférieur (Lyon, Sept. 1963), Mém. Bureau de Recherches Géol. et Min., No. 34, 1965, p. 711-721, text figs. 1-3 (map, columnar section, range chart).—Occurrence and range shown for 44 species of Foraminifera in the section from Berriasian to Albian.

Curry, D., Murray, J. W., and Whittard, W. F. The geology of the Western Approaches of the English Channel. III. The *Globigerina* Silts and associated rocks.—Proc. Seventeenth Symposium Colston Research Soc., April 5-9, 1965, p. 239-264, text figs. 103, 104 (map, range chart), tables 14-19.—Foram assemblages from the submarine formation, *Globigerina* Silts, studied from 33 core samples, indicate its Miocene age.

Dallan, Laura, and Nardi, Raffaello. Polymorphinidae nel Retico delle Alpi Apuane (Zona ad *Avicula contorta* Portl.).—Boll. Soc. Geol. Ital., v. 83, fasc. 4, 1964 (1965), p. 191-202, pl. 1, text fig. 1 (geol. section).—Four species of *Eoguttulina* and 1 new *Pyrulinoides* from the Hettangian.

Dieni, Iginio, and Massari, Francesco. Osservazioni sul genere *Paalzowella* Cushman 1933 (Foraminifera).—Atti Accad. Naz. Lincei, Rend., v. 39, fasc. 1-2, July-Aug. 1965, p. 113-117, text figs. 1-3.—Transfer of 2 species from *Paalzowella* to *Patellina.*

Douglass, Raymond C. Restudy of *Triticites secalicus* (Say), the type species of *Triticites.*—Micropaleontology, v. 12, No. 1, Jan. 1966, p. 71-78, pl. 1, text fig. 1 (graphs), tables 1, 2.—Based on 200 specimens (100 axial sections and 100 equatorial sections).

Durand Delga, Michel, García Rodrigo, Bernardo, Magné, Jean, and Polvêche, Jean. A propos du Miocène de la région d'Alcoy (province d'Alicante, Espagne).—Instit. Invest.

Geol. "Lucas Mallada," Cursillos y Conferencias, fasc. 9, Nov. 1964, p. 213-217, text-fig. 1 (geol. section), table.—List of Foraminifera dated as Vindobonian.

ECKERT, HANS RUEDI. Une station d'observation sur les foraminifères planktoniques actuels dans le Golfe de Guinée.—Eclogae Geol. Helvetiae, v. 58, No. 2, Dec. 31, 1965, p. 1039-1058, text figs. 1-8 (maps, graphs).—Quantitative study based on seasonal collections taken at 14 localities off the mouth of the Bandama River shows a tropical fauna from January to June, an intermediary one (chiefly *Globigerina bulloides*) in September, and no living planktonics in October and November.

ERIKSSON, K. GÖSTA. The sediment core No. 210 from the western Mediterranean Sea.—Repts. Swedish Deep-Sea Exped., v. 8, Sediment cores from the Mediterranean Sea and the Red Sea, No. 7, 1965, p. 393-594, pls. 1-26 (map [1], graphs [2-8], photographs [9], photomicrographs [10-26]), text figs. 1-62 (graphs, maps, profiles, diagrams, histograms), tables 1-117.—The single core, centrally located in the basin, is 898 cm. long and penetrates Post-Glacial, Late Würm, and Middle Würm. Dating is by C^{14} and temperature-sensitive forams. The section consists of a sequence of 71 beds, the basal bed about 30,000 years old. Sediments are of two types: primary deposited and redeposited. Beds are separated by (a) surfaces representing stratigraphic breaks (erosion or discontinuity) or (b) sedimentation boundaries (gradational change in grain size and/or mineral composition—a result of change in material being deposited). Frequency curves for 7 species of planktonic Foraminifera are included for core 210 and compared with those for 11 other adjacent cores.

EWING, MAURICE, SAITO, TSUNEMASA, EWING, JOHN I., and BURCKLE, LLOYD H. Lower Cretaceous sediments from the northwest Pacific.—Science, v. 152, No. 3723, May 12, 1966, p. 751-755, text figs. 1-5 (map, seismic-profile records, depth profile, photo of core, drawings of forams).—In a deep-sea core from 3500 meters, a 21-cm. section overlain by 24 cm. of Pleistocene or Recent ooze, is dated as Albian by 5 species of planktonic Foraminifera.

FOURCADE, E., and NEUMANN, M. A propos des genres *Labyrinthina* Weynschenk, 1951 et *Lituosepta* Cati, 1959.—Revue de Micropaléontologie, v. 8, No. 4, March 1966, p. 233-239, pls. 1, 2, text figs. 1, 2 (drawings).—*Labyrinthina mirabilis* in the Kimmeridgian of Spain, with *Lituosepta* placed in synonymy.

FOURY, GENEVIÈVE, and MOULLADE, MICHEL. Orbitolinidae nouveaux du Barrémien (faciès urgonien) des Alpilles (Bouches-du-Rhône).—Revue de Micropaléontologie, v. 8, No. 4, March 1966, p. 249-257, pls. 1, 2, text figs. 1, 2 (drawings).—Two new species, one in the new genus *Urgonina* (type species *U. protuberans* n. sp.).

GIBSON, THOMAS G. Eocene and Miocene rocks off the northeastern coast of the United States. —Deep-Sea Research, v. 12, No. 6, Dec. 1965, p. 975-981, text figs. 1, 2 (map, drawings).— A predominantly planktonic Foraminifera assemblage in a grab sample from 115 miles south of Cape Cod is correlated with the *Globorotalia rex* zone of early Eocene age. Dredged blocks from Georges Bank are correlated by mollusks and forams with the late Miocene Yorktown.

VAN GINKEL, A. C. Carboniferous fusulinids from the Cantabrian Mountains (Spain).—Leidse Geol. Mededel., deel 34, May 12, 1965, p. 1-225, text figs. 1-13 (zone chart, measurement tables, graphs, correl. charts, geol. map, paleogeographic map, diagrams), 5 appendices (species lists, geographic and stratigraphic data, index map and 9 local. maps, 63 tables of measurements, 53 plates of thin-section photomicrographs), 2 plates of correlated stratigraphic columns.—Monograph consists of 2 parts: a section on their systematic paleontology, about 180 species in 18 genera (17 species and 11 subspecies new), and a section on their evolution, zonation, and correlation. Assemblage zones have been subdivided into locally useful subzones and subdivisions. Lack of good correlation with NW European and Russian stages indicates possibility of differences in rates of evolution.

GOEL, R. K. Contribution à l'étude des Foraminifères du Crétacé supérieur de la Basse-Seine.—Bureau Recherches Géologiques et Minières, Bull. No. 5, 1965, p. 49-157, pls. 1-11, text figs. A-C (map, drawings), tables 1-13.—About 237 species and varieties of Foraminifera are tabulated from already-established megafossil zones and subzones in Cenomanian, Turonian and Senonian. Detailed descriptions, illustrations, and ranges are included only for *Cristellaria, Bolivinoides, Globorotalites, Pseudovalvulineria,* and *Gavelinopsis*. Of the 57 species in these 5 genera, 43 are described as new.

GOHRBANDT, K. H. A. Some Cenomanian Foraminifera from northwestern Libya.—Micropaleontology, v. 12, No. 1, Jan. 1966, p. 65-70, pl. 1, text figs. 1-4 (map, sections, diagram).— Two agglutinated species (1 new) and an alveolinid from shallow-water facies.

Golev, B. T., and Sovchik, J. V. On the first finding of an oligocenic species of *Nummulites intermedius* d'Archiac on the southern slope of Ukrainian Carpathians (in Russian).—Akad. Nauk SSSR, Doklady, v. 165, No. 6, 1965, p. 1369-1370, pl. 1.

Gramann, Franz. *Bolivina* (*Brizalina*) *beyrichi* (Reuss) und verwandte Foraminiferen aus dem deutschen Oligozän.—Geol. Jahrb., Hannover, Band 82, Sept. 15, 1965, p. 437-446, fig. 1 (pl.).—Two subspecies (1 new) of *Bolivina beyrichi*. *Brizalina* is included as a subgenus of *Bolivina*.

Groiss, J. Th. Eine Foraminiferen-Fauna aus Ätzrückständen von Massenkalken des süddeutschen Ober-Malm.—Geol. Bl. NO-Bayern, Erlangen, Band 16, heft 1, March 16, 1966, p. 39-49, text fig. 1 (pl.).—Thirteen species, 3 indeterminate.

Hanzawa, Shoshiro. Notes on some discocyclinid and nummulitid Foraminifera from Java and Saipan.—Sci. Repts. Tohoku Univ., 2nd Ser. (Geol.), v. 37, No. 1, Dec. 10, 1965, p. 41-47, pls. 1-8.—Three species of *Discocyclina* (1 new) and 1 of *Nummulites*.

Hedley, R. H., Hurdle, C. M., and Burdett, I. D. J. A foraminiferal fauna from the western continental shelf, North Island, New Zealand. —New Zealand Dept. Sci. Industr. Res., Bull. 163, 1965, p. 1-46, pls. 1-7, text figs. 1-6 (drawings).—Partially illustrated systematic catalog of 53 species (none new) found in a single sample from 87 meters off the west coast of New Zealand.

Hillebrandt, Axel von. Foraminiferen-Stratigraphie im Alttertiär von Zumaya (Provinz Guipúzcoa, NW-Spanien) und ein Vergleich mit anderen Tethys-Gebieten.—Bayerische Akad. Wiss. Math.-Naturwiss. Kl., Abh., Neue Folge, No. 123, 1965, 62 p., 3 profiles, 3 maps, 5 tables (range charts, correl. charts).—Zones A to M established on the basis of planktonic species, three having subzones, are set up between Danian and Cuisian, and correlation is shown with zonations in USSR, Egypt, Italy, northern Alps and Trinidad. Range and abundance of planktonic and nummulitic species are indicated throughout the section.

van Hinte, J. E. *Orbitoides* from the Campanian type section. Part I and Part II.—Proc. Kon. Nederl. Akad. Wetenschappen, ser. B, v. 69, No. 1, 1966, p. 79-110, pls. 1, 2, text figs. 1-14 (charts, graphs, line drawings), tables 1-18.—Three species within an evolutionary lineage are recognized by analysis of external and internal morphologic features of specimens in a continuous stratigraphic section. Existence of a break between uppermost Campanian and Maestrichtian is supported by the lack of transitional specimens of *Orbitoides*.

Hofker, J. La position stratigraphique du Maestrichtian type.—Revue de Micropaléontologie, v. 8, No. 4, March 1966, p. 258-264, pls. 1, 2, text figs. 1-3 (columnar sections).—The zone of *Globigerina eugubina*, recently described in Italy as existing at the base of the Danian, is present in Holland and Denmark as a thin bed below the type Maestrichtian. Several of the Italian species are placed in synonymy. In Holland and Denmark the type Maestrichtian and type Danian represent contemporaneous deposition; the type Maestrichtian characterized by worn and glauconitic specimens of the Cretaceous fauna redeposited in a Danian sea with fresh Tertiary specimens.

Hornibrook, N. de B. *Globigerina angiporoides* n. sp. from the upper Eocene and lower Oligocene of New Zealand and the status of *Globigerina angipora* Stache, 1865.—New Zealand Jour. Geology and Geophysics, v. 8, No. 5, Nov. 1965, p. 834-838, text figs. 1, 2 (plates of drawings).—Description and illustration of *G. angiporoides* to replace *G. angipora* of Finlay and others (not *G. angipora* Stache, a *nomen dubium*).

Hornibrook, N. de B., and Jenkins, D. Graham. *Candeina zeocenica* Hornibrook and Jenkins, a new species of Foraminifera from the New Zealand Eocene and Oligocene.—New Zealand Jour. Geology and Geophysics, v. 8, No. 5, Nov. 1965, p. 839-842, text figs. 1-5 (drawings).—A minute (0.25 mm.) species possibly unrelated to the globigerinids.

Jenkins, D. Graham. A re-examination of *Globorotalia collactea* Finlay, 1939.—New Zealand Jour. Geology and Geophysics, v. 8, No. 5, Nov. 1965, p. 843-848, text figs. 1-27 (drawings on 2 plates).—The species has small supplementary apertures on the spiral side and is therefore transferred to *Truncorotaloides*.

Lazzarotto, A., Mazzanti, R., and Salvatorini, G. Stratigrafia Neogenica Toscana: Esame geologico e micropaleontologico di alcune sezioni del complesso neoautoctono delle Valli di Cornia e di Milia.—Boll. Soc. Geol. Ital., v. 83, fasc. 4, 1964 (1965), p. 401-460, pl. 1 (geol. map), text figs. 1-11 (geol. sections, microphotographs, diagram, columnar sections), tables 1-4.—Includes check list of about 180 species of Foraminifera in 11 samples.

Ludbrook, N. H. Tertiary fossils from Christmas Island (Indian Ocean).—Jour. Geol. Soc. Australia, v. 12, pt. 2, 1965, p. 285-294, pls. 21, 22, text figs. 1, 2 (map, range chart).—Illustrations of Foraminifera in thin section from late Eocene (Tertiary *b*) and early Miocene (Tertiary *e* to *f*) limestones.

Occurrence of Foraminifera in salt lakes.—Geol. Survey So. Australia, Quart. Geol. Notes, No. 14, April 1965, p. 6, 7.

LUTZE, GERHARD F. Zur Foraminiferen-Fauna der Ostsee.—Meyniana, v. 15, Nov. 1965, p. 75-142, pls. 1-15, text figs. 1-32 (maps, variation diagrams, scatter diagrams, distrib. diagrams, line drawings).—The area sampled extends from about 10° E., 54° 20′ N. to about 21° E., 59° N. Abundance diagrams show the different quantitative patterns of major components of the living and dead populations across 11 selected profiles in different parts of the Baltic. Diagrams show variation at different localities and various depths for *Reophax dentaliniformis, Miliammina fusca,* and *Cribrononion excavatum*. Twenty-five species, none new, are described and illustrated. The species are classified in 4 environmental groups: brackish lake, shallow brackish, marine, and arctic-boreal brackish.

MAGALHAES MACEDO, ANTONIO C. As microfaunas do sambaqui de Sernambetiba e do Litoral de Magé, Estado do Rio de Janeiro.—Brazil Div. Geol. e Min., Notas Prelim. e Estudos, No. 128, 1965, p. 1-63, pls. 1-5, text figs. 1-9 (photos, graph), histograms 1-5, maps 1, 2, tables 1-3.—A few Foraminifera from raised beaches and shell mounds.

MAGNÉ, JEAN, and MASCLE, GEORGES. L'Argovien d'Andelot-en-Montagne (Jura). Revision du stratotype.—Colloque du Jurassique, Luxembourg, 1962, Comptes Rendus et Mem., 1964, p. 307-332, pls. 1-7, text figs. 1-6 (map, columnar sections, check lists).—Argovian Foraminifera listed and illustrated.

MAGNÉ, J., and OBERT, D. Niveaux à microfaunes dans le Lias de la région d'Arbois (Jura).—Revue de Micropaléontologie, v. 8, No. 4, March 1966, p. 265-273, text figs. 1-3 (map, columnar sections), 2 range charts.—Foraminifera in Lotharingian, Domerian, and Toarcian (several levels) are listed, and the faunas are compared with those from equivalent levels in 3 other localities.

MAJZON, LASZLO. On the value of Foraminifera in stratigraphic correlation (in Hungarian with English abstract).—Bull. Hungarian Geol. Soc., v. 95, No. 4, Oct.-Dec. 1965, p. 406-411.—Using benthonics from deep boreholes in Hungary.
pls. 16-20 (1-5), text fig. 1 (map).—Includes

MALAPRIS, MADELEINE. Les Gavelinellidae et formes affines du gisement Albien de Courcelles (Aube).—Revue de Micropaléontologie, v. 8, No. 3, Dec. 1965, p. 131-150, pls. 1-5, text figs. 1-6 (sections, graphs).—Six Albian species (2 new) are described and illustrated; 4 in the new genus *Lingulogavelinella* (type species *L. albiensis* n. sp.) and 2 in *Gavelinella,* one of them in the new subgenus *Berthelina* (type species *Anomalina intermedia* Berthelin, emend.).

MAMEDOV, T. A. Krupnye Foraminifery Paleogenovykh Otlozhenij Kurinskoj Vpadiny.—Akad. Nauk Azerbajdzhan. SSR, Izvestija, ser. geol.-geogr. nauk, no. 5, 1965, p. 34-45, pls. 1-3.—Twelve nummulites (1 subspecies new) and 2 orbitoids.

MARIANOS, A. W., and ZINGULA, R. P. Cretaceous planktonic foraminifers from Dry Creek, Tehama County, California.—Jour. Paleontology, v. 40, No. 2, March 1966, p. 328-342, pls. 37-39, text figs. 1-3 (map, correl. chart, strat. column).—Twenty-seven species (5 new and 4 indeterminate) from a 14,300-foot section that spans the interval from Hauterivian-Barremian to Turonian. Range of each species is shown.

MARLOWE, J. I. Probable Tertiary sediments from a submarine canyon off Nova Scotia.—Marine Geol., v. 3, No. 4, Aug. 1965, p. 263-268, text figs. 1, 2 (map, profile), tables 1, 2.—Age based on Foraminifera.

MCTAVISH, R. A. Planktonic foraminifera from the Malaita Group, British Solomon Islands.—Micropaleontology, v. 12, No. 1, Jan. 1966, p. 1-36, pls. 1-7, text figs. 1-7 (maps), tables 1-6 (stratigraphic chart, range chart, coiling direction chart, correl. charts).—Ten units, based on lower and upper limits of planktonic Foraminifera, are established for the Malaita Group. The succession of faunas extends from upper Eocene to upper Miocene-Pliocene. Correlation with the European Time Scale, the Indonesian letter classification, and the West Indian planktonic zonation is indicated. Correlation with numerous stratigraphic sections in the central and western Pacific is discussed. About 80 planktonic species are illustrated and their ranges in the Malaita Group shown.

MOHAN, MADAN. Variation in *Nummulites fichteli,* Michelotti.—Geol. Soc. India Bull., v. 2, No. 4, Oct. 1965, p. 93-97, 1 pl., table 1.

MOSNA, SERGIO. Contributi micropaleontologico-stratigrafici allo studio dell'Oligocene del Bacino Terziario Ligure-Piemontese.—Istit. Geologico Univ. Pavia Atti, v. 16, 1965, p. 81-113, descriptions and illustrations of 34 species and subspecies of Foraminifera (none new), and photomicrographs of several faunal associations.

MOULLADE, MICHEL. Révision des stratotypes de l'Aptien: Gargas (Vaucluse).—Colloque sur le Crétacé Inférieur (Lyon, Sept. 1963), Mém. Bureau de Recherches Geol. et Min., No. 34, 1965, p. 201-214, text figs. 1-3 (geol. section, map, columnar section), range and abundance chart.—Occurrence and abundance shown for 57 species of Foraminifera in the Aptian and Albian in Vaucluse.

État actuel des connaissances sur les Orbitolinidae (Foraminifères) du Crétacé Inférieur Mesogéen.—Colloque sur le Crétacé Inférieur (Lyon, Sept. 1963), Mém. Bureau de Recherches Geol. et Min., No. 34, 1965, p. 513-523, text figs. 1-3 (graph, diagrams, range chart).

PASSERINI, PIETRO, and PIRINI, CAMILLA. Microfaune Paleoceniche nelle Formazioni dell' Arenaria del M. Ramaceto e degli Argilloscisti di Cichero.—Boll. Soc. Geol. Ital., v. 83, fasc. 4, 1964 (1965), p. 211-216, pls. 1, 2 (geol. map, photos of forams).

PERCONIG, ENRICO. La estratigrafía del Mioceno en Andalucía occidental (España). El limite Oligoceno-Mioceno y la fase terminal marina del Mioceno.—Instit. Invest. Geol. "Lucas Mallada," Cursillos y Conferencias, fasc. 9, Nov. 1964, p. 219-228, strat. range chart.—Planktonic and benthonic Foraminifera listed from Oligocene, Aquitanian, Burdigalian, Helvetian, Tortonian, and upper Miocene s.s.

PHLEGER, FRED B. Sedimentology of Guerrero Negro Lagoon, Baja California, Mexico.—Colston Papers, v. XVII, Proc. Seventeenth Symposium Colston Research Soc. held Univ. Bristol, Apr. 5-9, 1965, p. 205-235, text figs. 87-102 (maps, graphs, profiles, diagrams), tables 10-13.—Living Foraminifera populations from areas of tide flat and channel and of marsh as well as specimens from the sand lagoon barriers and cores in the lagoon are reported quantitatively. About 40 species are involved.

POZARYSKA, KRYSTYNA. Foraminifera and biostratigraphy of the Danian and Montian in Poland. —Palaeontologia Polonica, No. 14, 1965, p. 1-156, pls. 1-28, text-pls. 1-9 (maps, columnar sections, graphs, range chart, diagrams, correl. charts), tables 1-6.—Illustrated systematic catalog of about 150 species (1 new) in the Danian and Montian shows only slight faunal distinctions between the two (no index fossils restricted to the Danian but many to the Montian) combined with a sharp faunal break—but unaccompanied by a sudden change in facies —between upper Maestrichtian and Danian. The Maestrichtian/Danian faunal break is marked by a basal conglomerate or a corroded hard ground surface, representing a long time interval, but the facies change began in Poland earlier than elsewhere in Europe, *i.e.*, before the end of the Maestrichtian.

PRELL-MÜSSIG, RICARDA. Das jüngere Tertiär (Oberes Rupel bis Aquitan) bei Bruchsal (Foraminiferen, Fazies, Stratigraphie).—Jahreshefte Geol. Landesamtes Baden-Württemberg, v. 7, July 1, 1965, p. 229-301, pls. 19, 20, text figs. 22-25 (map, correl. diagram, facies diagram, drawings), tables 6-11.—About 110 species—mostly Tertiary but some reworked from Jurassic and Cretaceous—are recorded in four boring sections that encompass the interval from upper Rupelian to Aquitanian. A few Foraminifera are illustrated.

PROTO DECIMA, F. Precisazioni sull'età di una formazione marnosa e sul limite Cretaceo-Terziario nella zona tra Possagno e Pederobba (Trevigiano occidentale).—Boll. Soc. Geol. Ital., v. 84, fasc. 1, 1965, p. 165-171, text fig. 1 (outcrop photo), table 1.—Age determined by lower Eocene planktonics.

RAUZER-CHERNOUSOVA, D. M. Foraminifers in the stratotypical section of the Sakmarian Stage (Sakmara river, Southern Ural) (in Russian). —Moscow, Akad. Nauk SSSR, Geol. Instit., Trudy (nov. ser.), Trans., v. 135, 80 p., 6 pls., 5 text-figs. (photo, diagram, map, columnar sections, geol. section), 5 tables.—The section subdivided by fusulinids into 12 units. Thirty-five species (1 new) and 3 subspecies included in the systematic part.

REDMOND, C. D. A reply to Wolf Maync's "Some comments on C. D. Redmond's new lituolid Foraminifera from Saudi Arabia."—Revue de Micropaléontologie, v. 8, No. 3, Dec. 1965, p. 185-188.

ROSSET, CHRISTIANE. Foraminifères inclus dans le gypse oligocène de Portel (Aude): extraction et conséquences paléogéographiques.—C. R. S. Soc. Géol. France, fasc. 2, Feb. 7, 1966, p. 48, 49, 1 thin section microphotograph.—Numerous specimens of *Rosalina* and *Quinqueloculina* in gypsum indicate communication with the sea.

ROZOVSKAYA, S. E., and RAUZER-CHERNOUSOVA, D. M. Protozoa, *in* Razvitie i Smena Morskikh Organizmov na Rubezhe Paleozoya i Mezozoja, edited by V. E. RUZHENTHEV and T. G. SARYCHEVA.—Akad. Nauk SSSR, Paleont. instit., Trudy, tom 108, 1965, p. 137-146, pls. 1-5.—Twelve fusulinid species, all but one new.

RUGGIERI, G., and SPROVIERI, R. Alcuni neotipi di specie de Foraminiferi Tortoniani istituite da G. Seguenza nel 1879 (with English summary). —Riv. Ital. Paleont. Stratig., v. 71, No. 3, Sept.

1965, p. 951-962, pl. 93, text figs. 1-5.—Six neotypes; all but one are placed in synonymy. *Vaginulinopsis inversa* (Costa) is revised and is now denoted as *V. soluta* (Silvestri) and its keelless form as *subacarinata* n. subsp.

SADA, KIMIYOSHI. Carboniferous and Permian stratigraphy of the Atetsu Limestone in West Japan.—Jour. Sci. Hiroshima Univ., ser. C, v. 5, No. 1, Sept. 1965, p. 21-80, pl. 5 (geol. map), text figs. 1-9 (columnar sections), tables 1-4 (correl. charts, range chart).—Correlation with international fusulinid zones.

SAIDOVA, KH. M. Raspredelenie Donnykh Foraminifer v Tikhom Okeane.—Akad. Nauk SSSR, Okeanologija, tom 5, vyp. 1, 1965, p. 99-110, text figs. 1-3 (maps), tables 1, 2.

SAITO, TSUNEMASA, EWING, MAURICE, and BURCKLE, LLOYD H. Tertiary sediment from the Mid-Atlantic Ridge.—Science, v. 151, No. 3714, March 4, 1966, p. 1075-1079, text figs. 1-4 (maps, photographs, drawings), tables 1-3.—*Globigerina* ooze was found in cracks and embedded in the coating layers of vesicular glass that covers basalt boulders. Ages of the ooze from 2 dredge hauls, determined by planktonic Foraminifera, are Burdigalian and Vindobonian. Older and younger foram faunas are listed from numerous cores from the crestal area of the Ridge.

SAMUEL, ONDREJ. Die Zonengliederung des westkarpatischen Paläogän auf Grund der planktonischen Foraminiferen (German summary of Czeck text).—Geologické práce, Bratislava, No. 37, 1965, p. 183-198, correl. chart, illustrated range chart.—The ranges of 33 planktonic Foraminifera are indicated in the Danian to Sannoisian of the Westcarpathian region, and 11 planktonic zones are set up within this interval.

SAURIN, EDMOND. Fusulinidés de calcaires à *Yangchienia* du Cambodge et du Haut-Laos.—Archives Géologiques du Viêt-Nam, Saigon, No. 7, 1965, p. 78-116, pls. 1-8.—Thirty-nine Permian species (2 new, 11 indeterminate, and 1 given a new name).

SCHROEDER, ROLF. *Dictyoconus pachymarginalis* n. sp. aus dem Apt des Elburz-Gebirges (Nord-Iran) (Studien über primitive Orbitolinidae III).—Eclogae Geol. Helvetiae, v. 58, No. 2, Dec. 31, 1965, p. 975-980, pls. 1, 2.

SEIGLIE, GEORGE A. Dos foraminíferos nuevos del Eoceno de México.—Bol. Soc. Geol. Mexicana, v. 27, No. 1, 1964, p. 1-9, pls. 1, 2, table 1.—*Altasterella* and *Umboasterella*, subgenera of *Eoeponidella*, each with a new species from the Guayabal formation.

Cuadro preliminar sobre la distribucion estratigrafica de los Foraminiferos grandes de Cuba. —Lagena, Instit. Ocean., Univ. Oriente [Cumaná, Venezuela], 1965, No. 7, p. 23-30 (mimeo.), range chart.—Range is indicated for 145 species between Jurassic (Callovian) and Recent, in terms of already-known zones of planktonics and larger forams.

Un género nuevo y dos especies nuevas de foraminíferos de los Testigos, Venezuela.—Bol. Instit. Ocean., Univ. Oriente [Cumaná, Venezuela], v. 4, No. 1, July 1965, p. 51-59, pl. 1.—Three species, 2 new, and 1 new genus, *Polystomammina* (type species *Trochammina nitida* Brady, 1881), from Los Testigos reefs.

Notas sobre tres Lepidocyclinas de Cuba.—Bol. Instit. Ocean., Univ. Oriente [Cumaná, Venezuela], v. 4, No. 1, July 1965, p. 191-213, pls. 1-5, text fig. 1 (map).—Two species, one having a subspecies, (none new) of Oligocene age.

SEIGLIE, GEORGE A., and BERMÚDEZ, PEDRO J. Observaciones sobre foraminíferes rotaliformes con cámaras suplementarias o estructuras semejantes.—Bol. Instit. Ocean., Univ. Oriente [Cumaná, Venezuela], v. 4, No. 1, July 1965, p. 155-171, 1 pl.—Includes 2 new subfamilies, Eponidellinae and Reinholdellinae, and 1 new genus, *Biasterigerina* (type species *Asterigerina planorbis* d'Orbigny~~)~~., 1846).

SELLI, RAIMONDO. "El Mesinense."—Instit. Invest. Geol. "Lucas Mallada," Cursillos y Conferencias, fasc. 9, Nov. 1964, p. 63-70.—Foraminifera listed from various beds of the Messinian, and from two overlying beds in the Pliocene.

SERNA, FERNANDO ETAYO. Posición de las Faunas en los depósitos cretácicos colombianos y su valor en la subdivisión cronológica de los mismos.—Univ. Industrial de Santander, Bucaramanga, Colombia, Bol. Geol., Nos. 16-17, 1964, p. 5-142, text figs. 1-8 (map, columnar sections, correl. charts, range chart, graphs).—Foraminifera recorded in many formations.

SHENG, J. C. Fusulinids from the western part of Hainan Island, Kwangtung Province.—Acta Paleont. Sinica, v. 13, No. 4, Nov. 1965, p. 579-597, pls. 1-6.—Seven new species.

SKINNER, JOHN W., and WILDE, GARNER L. Permian biostratigraphy and fusulinid faunas of the Shasta Lake area, northern California.—Univ. Kansas Paleont. Contr., Protozoa, Art. 6, Nov. 1, 1965, p. 1-98, pls. 1-65, text figs. 1-3 (maps, range chart).—Formal descriptions and illustrations of 167 species, 156 species and 4 genera new. Eight faunal zones recognized.

SMITH, A. J., STRIDE, A. H., and WHITTARD, W. F. The geology of the Western Approaches of the

English Channel. IV. A recently discovered Variscan granite west-north-west of the Scilly Isles.—Proc. Seventeenth Symposium Colston Research Soc., April 5-9, 1965, p. 287-301, pls. 27-29, text figs. 110-113 (maps), tables 20, 21. —Foraminifera-bearing sediments of several Cretaceous ages (Turonian, Cenomanian, Albian) dredged from near Haig Fras in the Celtic Sea.

SOUAYA, FERNAND JOSEPH. Miocene foraminifera of the Gulf of Suez region, U. A. R. Part 2 —Systematics (Rotalioidea).—Micropaleontology, v. 12, No. 1, January 1966, p. 43-64, pls. 1-4, text fig. 1 (map).—Illustrated systematic catalog of about 80 species, 5 species and 1 subspecies new.

SPIEGLER, DOROTHEE. Biostratigraphie des Rupels auf Grund von Foraminiferen im nördlichen Deutschland.—Geol. Jahrb., Hannover, Band 82, Sept. 20, 1965, p. 447-485, pls. 22-26, text figs. 1, 2 (map, range chart), tables 1, 2.—Rupelian divided into 4 zones: Rupelian 1 (lowermost) and Rupelian 3 are poor zones with arenaceous tests and fish remains; Rupelian 2 and Rupelian 4 (uppermost) are rich zones with calcareous tests. Nine species are useful index forms; 5 for the lower Rupelian and 2 for the upper Rupelian.

STEWART, WENDELL J. New species of the fusulinid genus *Thompsonella* and a proposed change in wall terminology.—Jour. Paleontology, v. 40, No. 2, March 1966, p. 354-358, pl. 41, text figs. 1, 2 (map, drawings), tables 1, 2. —Two new species from the upper Pennsylvanian of New Mexico.

TEMNYUK, F. P., and BOYARINTZEVA, N. J. On the foraminiferal fauna of the Cretaceous and Paleogene Flysch of the north-western part of the Ukrainian Carpathians (English summary of Ukrainian text).—Mezhvedom. Respubl. Nauchnyj Sbornik, Paleont. Sbornik No. 2, vyp. pevyj, 1965, p. 91-95.

TIKHVINSKIY, I. N. Schwagerinid ecology (translation).—Internat. Geol. Review, v. 8, No. 1, Jan. 1966, p. 60-63, text figs. 1, 2 (maps).—Paleogeographic distribution of spherical genera of Schwagerininae in Asselian seas of the Tartaria region supports the possibility of the specimens having been planktonic when living and buoyant enough to be distributed by currents and wave motion after death.

TODD, RUTH. A new *Rosalina* (Foraminifera) parasitic on a bivalve.—Deep-Sea Research, v. 12, No. 6, Dec. 1965, p. 831-837, pls. 1-3.—*Rosalina carnivora,* attached to shell of living *Lima,* penetrated the clam shell, presumably by means of solution in its search for $CaCO_3$ for shell building. Reaction against the penetration is shown on the interior of the bivalve by mounded up shell deposits around some openings and complete sealing by shell of others. Numerous pits and scars of attachment on the exterior and scabs and areas of thickened shell on the interior give evidence of parasitism.

DE LA TORRE Y CALLEJAS, ALFREDO. Notas sobre algunos Foraminiferos de interes estratigrafico del Terciario Superior de Cuba.—Instit. Nac. Recursos Hidraulicos, La Habana, Oct. 1963, p. 5-10, text fig. 1 (correl. chart).—Correlation with formations in Jamaica and Puerto Rico. Five species of upper Miocene discussed.

VENGLINSKY, I. V., and BURINDINA, L. V. New discovery representatives of the *Hauerina* and *Peneroplis* in the Middle Sarmatian deposits of the Transcarpathians (English summary of Ukrainian text).—Mezhvedom. Respubl. Nauchnyj Sbornik, Paleont. Sbornik No. 2, vyp. pervyj, 1965, p. 71-76, 1 pl.—Three species and 2 subspecies, all new.

WADDELL, DWIGHT E. Pennsylvanian fusulinid biozones in southern Oklahoma.—Oklahoma Geol. Notes, v. 26, No. 5, May 1966, p. 123-133, text figs. 1-10 (chart, map, illustrations of specimens).—Seven zones.

WOLOSHINA, A. M. Species of the genus *Lituola* Lam. (Foraminifera) from Ukrainian Upper Cretaceous and Paleocene deposits (English summary of Ukrainian text).—Mezhvedom. Respubl. Nauchnyj Sbornik, Paleont. Sbornik No. 2, vyp. pervyj, 1965, p. 51-59, pls. 1-3.— Two species, one having 3 subspecies (2 new).

DE ZANCHE, V. Le microfacies Eoceniche nella Valle del Chiampo tra Arzignano e Mussolino (Lessini orientali).—Riv. Ital. Paleont. Stratig., v. 71, No. 3, Sept. 1965, p. 925-948, pls. 88-92, text figs. 1-3 (map, geol. sections), table 1.— Includes illustrations of larger Foraminifera (discocyclines, alveolines, nummulites, and others) in microfacies from lower Cuisian to middle Lutetian.

ZANFRÁ, SILVANA. Indagine biometrica sulla *Bolivina dilatata* Reuss (Foram.) nei piani Elveziano, Tortoniano, Piacenziano, Astiano e Calabriano dell'Appennino Bolognese (Nord-Italia). —Instit. Invest. Geol. "Lucas Mallada," Cursillos y Conferencias, fasc. 9, Nov. 1964, p. 123-130, text-figs. 1-7 (photos, drawings, scatter diagrams), tables 1-5.—Length and width measurements of 500 specimens (micro- and macrospheric forms).

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