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RECENT AND SUBRECENT TRACHYLEBERIDIDAE AND HEMICYTHERIDAE (*OSTR., CRUST.*) FROM THE WESTERN NIGER DELTA, NIGERIA

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Abstract. Twenty species of Trachyleberididae, 15 of which are new, representing 9 genera and 4 subfamilies; and 24 species of Hemicytheridae, 17 of which are new, representing 10 genera and 4 subfamilies are described and discussed in relationship to their taxonomy, ecology and distribution. They occur off the western coast of the Niger Delta proper. Three new genera, *Neocythereis, Dakrika* and *Mackenziella* are proposed. A fourth, *Campylocythereis*, has already been described (Omatsola 1970 d).

The proposed new species and subspecies are *Ruggieria tricostata, R. lekkii, R. beninensis, R. triangulata, R. martinssoni, Buntonia foliata, Soudanella africana, S. africana reticularis, Neocythereis nigeriensis, N. simplex, Dakrika robusta, Phacorhabdotus hazeli, Cativella iyemojai, Chrysocythere foveostriata minuta, C. boldi, Reymentia reticulata, Basslerites elongata, B. (Loculiconcha) punctata, Puriana rugosa, P. mediocastata, P. akparaia, P. trituberculata, Hermanites foveolata, H. batei, H. macrodictyota, Mackenziella lagosensis, Aurila punctoreticulata, Mutilus nigeriana, Caudites africana, Neucaudites puri, N. rectangularis* and *N. tuberculata.*

Ecological factors studied indicate that substrate, to some extent depth, and probably food supply, are of vital importance in the distribution of species of these two and other ostracode families in the western Niger Delta. Offshore biofacies have fewer species, individuals and mature carapaces.

Taxonomic investigation of the trachyleberidid and hemicytherid groups is based mainly on morphologic characters and broadly fits into Hazel's (1967 a) classification. At the family level, the dorsal group of muscle scars is studied in detail and is found to be useful for the taxonomic delimitation between the Trachyleberididae and Hemicytheridae. Two roughly rounded to oblong muscle scars are typically found ventral to the anteromedian hinge element in most Trachyleberididae *sensu stricto*, whilst in most Hemicytheridae, a group of three elongate muscle scars is found in the same position. Dorsal to the adductor and frontal scars of trachyleberidid species are two rounded muscle scars, whilst in the same position, a group of three subtriangular to oblong scars is found in the hemicytheridid species. Inter- and intraspecific variation of the frontal muscle scar pattern occurs in genera such as *Chrysocythere* Ruggieri, *Basslerites* Howe, *Puriana* Coryell and Fields and the subgenus *Basslerites* (*Loculiconcha*) Omatsola. Such variations weigh heavily on the degree of usefulness of the frontal muscle scar as an important taxonomic character.

Most trachyleberidid species encountered in this study possess *only* simple normal pores, whereas most hemicytheridid species, with the exception of species of *Puriana, Basslerites* and *Basslerites* (*Loculiconcha*), possess compound normal pores, in addition to simple normal pores in some groups. The compound normal pores show various degrees of structural complexity and seem to indicate positive environmental adaptations. The compound normal pores of some species of Hemicytheridae show strong sexual dimorphism; ornamental dimorphism between sexes is also very common in this group.

Detailed morphological examinations resulted in reclassification within the Trachyleberididae—Hemicytheridae groups. The genera *Basslerites* and *Reymentia* and the subgenus *Basslerites* (*Loculiconcha*) are classified under the subfamily Campylocytherinae. *Chrysocythere*, grouped under the Campylocytherinae (Hazel 1967 a), has been reclassified within the subfamily Echinocythereidinae Hazel. The genus *Neocaudites* Puri, originally placed in the Trachyleberididae is here tentatively grouped within the Hemicytheridae under *incertae* subfamily.

Faunal components of the trachyleberidid and hemicytheridid ostracodes in the western Niger Delta are found, at the generic level, to possess genera known to

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be endemic to the tropical—subtropical parts of the Americas, especially the Florida Bay—Gulf of Mexico realm, and the Mediterranean.

Though a detailed survey of Ostracoda of the whole of the Niger Delta has not been carried out, the results of this study and a cursory examination of ostracodes from other parts of the delta confirm Reyment's (1969 p. 122—123) conclusion that the western Niger Delta is hydrologically and faunistically different from the central and eastern parts of the delta proper. The western Niger Delta is more akin to the western (Ghana—Ivory Coast) parts of the Gulf of Guinea.

INTRODUCTION

The fossil ostracodes of the Cretaceous and Lower Tertiary of coastal Nigeria are relatively well known (Reyment 1960, 1963 and 1966 a), but their living descendants, inhabiting the shallow open waters of the Nigerian continental margin, are poorly known.

Professor R. A. Reyment has for several years been concerned with various problems of the paleoecology, ecology and history of the Cenozoic-Recent sediments of Nigeria. In April 1965, he conducted an orientatory sampling cruise in the western Niger Delta. The stations A1 through to A10 were occupied (Fig. 1) in connection with the above cruise. More extended sampling was carried out in April—May 1966 during which nine transects, located along the entire Nigerian coastline, were sampled. The most western transect, transect J, in which three stations J2, J3 and J4, and a "test" station GT were successfully occupied (see Fig. 1), is included in this study. For details see Reyment (1966 b and 1969). As part of this project, the author was given the opportunity of studing the ostracodes of sediment samples collected from both surveys. For details of the results of physicochemical and some biological investigations, see Reyment (1966 b, 1967 and 1969) and Reyment and Van Valen (1969).

PREVIOUS STUDIES

Previous studies of the Ostracoda of the Nigerian continental margin, and for most of the Gulf Guinea, are rare. Bainbridge (in Longhurst 1964) in his discussion of zooplankton blooms off Lagos, Nigeria, mentioned the frequently occurring ostracode species *Euconchoecia chierchae* Müller as being one of the important "permanent" components of the zooplankton. Reyment (1966 b) treated drilled ostracode individuals in relation to gastropod predation. Bayagbona (1967) mentioned the occurrence of *Euconchoecia* sp. and other ostracode species as part of the fish food in the waters of the Nigerian coast. Reyment and Van Valen (1969), carried out a morphometric and taxonomic investigation on *Buntonia olokundudui,* reported to be the single most abundant species of cytheracean Ostracoda in the Niger Delta. Reyment (1969), in his study of the interstitial ecology of the Niger Delta, mentioned the occurrence of species of *Buntonia, Cytheropteron, Bythocypris, Leguminocythereis, Bradleya, Costa, Hemicythere* and *Cytherella.* Omatsola (1970 a, b, c and e) described Recent Ostracoda of parts of the Lagos Lagoon and off Lagos.

In this study, the geologically important and taxonomically interesting families Trachyleberididae and Hemicytheridae are dealt with from the points of view of ecology, distribution, taxonomy and environmental adaption.

MATERIALS AND METHODS

Sediment samples used in this study were those, as stated above, from Reyment's 1965 and 1966 surveys. For details of methods and techniques of sampling and preservation of samples see Reyment (1966 b, and 1969).

The sediment samples were carefully washed through a series of sieves with 5—400 mesh, and thereafter air-dried. Materials between the 18 through 230 mesh were examined and their ostracode contents were mounted for study. Specimens from each station were examined, identified and compared with those of others for intraspecific variation and to determine the distribution of species.

It is appropriate to mention that the Rose Bengal staining technique employed for the identification of "living" specimens at the time of collection was not found to be a positive indication of the presence of living shelled organisms. In Table I,

asterisks denote specimens that stained pink and are supposed to indicate living animals at the time of collection. Most of the stained adult carapaces when opened showed either decayed soft parts or a total absence of soft parts. This might suggest that the staining could have come from other organisms posthumously inhabiting the empty carapaces, usually algae, shown by a very bright red and perhaps, to a certain degree by deterioration of the formalin solution before it was replaced by 70 % alcohol. This probably suggests that the use of Rose Bengal as a means of counting living — dead ratios should be done with precautions. Instances of unstained living specimens were also found.

For surface and interior morphological features, the JEOLCO USM II and Cambridge Scanning Electron microscopes were used. Transmitted light photography was carried out on a Leitz light microscope using a yellow filter in order to compensate for the yellowish tinge of most fresh ostracode shells. This gives a better and stronger contrast to the air-filled spaces such as the vestibule, radial pores and normal pores. The text-figures of muscle scar patterns were prepared from scanning electron micrographs. All measurements are quoted in mm; marginal denticles are not included.

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DESCRIPTION OF STUDY AREA AND ENVIRONMENTAL FACTORS

The area covered in this study extends from off the city of Lagos in the west to approximately 160 kilometers east at the mouth of the Escravos river, (Fig. 1), and out into the Atlantic Ocean to a maximum distance of about 30 kilometers (long. 03° 35′ to 05° 41′ E, and lat. 05° 10′ to 06° 20′ N). Samples were collected as close as 1 kilometer and as far as 70 kilometers from each other, but most localities are within 30 kilometers of the coast. The coastline is practically devoid for a long distance of any major river flowing to the sea. It is, however, broken in the west by the narrow estuarine discharge outlet of the Lagos Lagoon and in the east by the Benin and Escravos rivers — the most western discharge outlets of the complex network of the distributaries of the

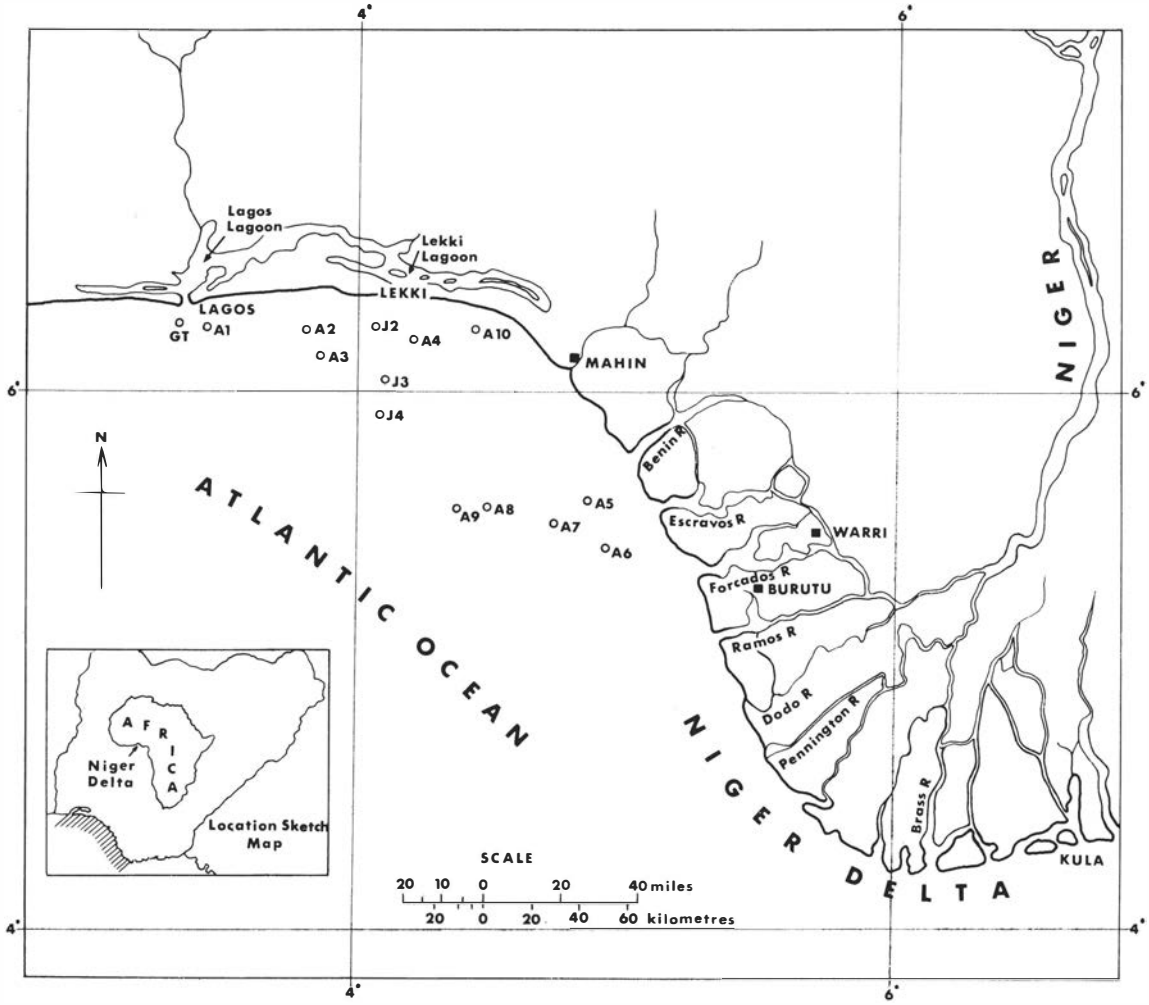


Fig. 1. Map showing the location of sampling stations in the western Niger Delta. (Modified after R. A. Reyment, 1966, 1969.)

Niger River, (Fig. 1). The area is bounded on the coast by an interlocking chain of brackish to fresh water lagoons — the barrier lagoon complex of Allen (1965); tropical rain forest and brackish and fresh water mangrove swamps.

The geology, hygrography, oceanography, sedimentology and ecology of the study area and the whole of the Niger Delta and its continental margin, have been studied in detail by NEDECO (1954 and 1961), Allen and Wells (1962), Longhurst (1964), Allen (1963, 1964 and 1965), Reyment (1966b, 1967 and 1969) and Short and Stäuble (1967).

The principal environmental factors to which ostracode distribution may be related and for which data are available are substrate, currents and waves, temperature, depth and salinity. The data for other factors such as dissolved oxygen, oxidizable organic matter, pH, Eh, turbidity and trace elements are to be found in Reyment (1969).

Substrate and bottom topography

The sedimentological composition of the Nigerian continental margin is in the main made up of sand, silt and clay facies, with in some places mixtures of these components. In the western

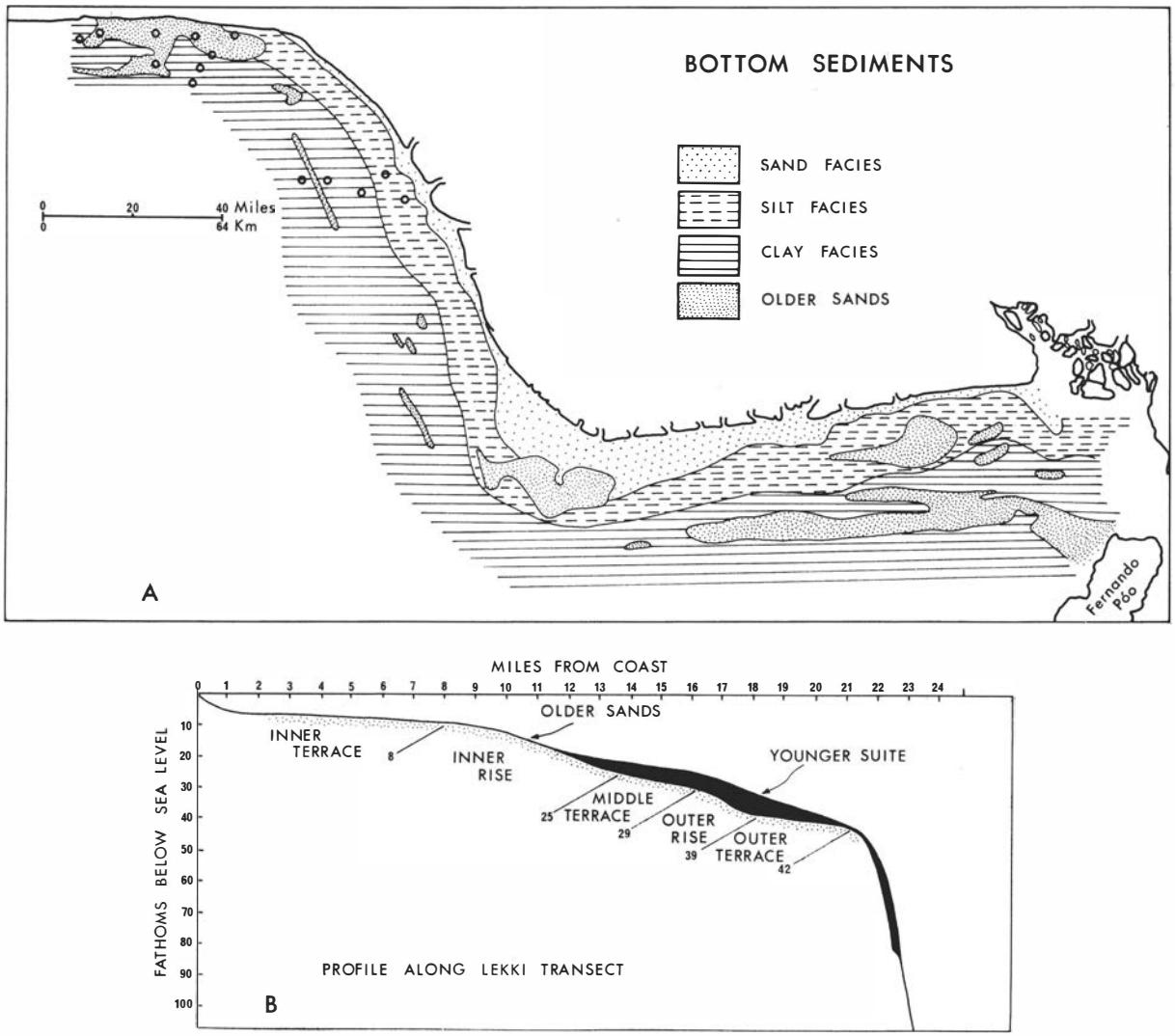


Fig. 2. A. Map showing the distribution of sedimentary facies of the bottom sediments of the continental shelf of Nigeria. (Modified after Allen, 1963.) Open circles indicate the sampling stations.
B. Topographic profile of the continental shelf of Nigeria along the Lekki transect. (After Allen, 1963.)

Niger Delta, sands are more important to the west, and to the east, sandy silt, silt and clay become more important. From the coastline there is a concentric sedimentary zonation from sand in the shallow near-shore areas to silt at moderate depths and clay on the deep shelf and slope (Fig. 2 a). The sediments forming this concentric pattern is the "Younger Suite" of Allen (1964). There are irregularly outcropping bodies of coarse to fine-grained quartzose sands, rich in calcareous debris and glauconite, the "Older Sands" of Allen (1964), which are of different geologic age (late Pleistocene to early Holocene) from the "Younger Suite" (Fig. 2 a). The Older Sands are said to be of terrigenous origin and are found in places to be locally rich in fecal pellets, foraminiferal shells and other calcareo-phosphatic organic materials. Stations GT, A1, A2, A3, A4 and A10 were sampled on "Older Sands"; J2, on the border between the "Older Sands" and the clay facies, and

contains about 15—20 % of finer fractions; A5 and A6 were from the silty facies, and A7, A8, A9, J3 and J4 were from the clay facies.

The surface of deposition is topographically uneven. That of the "Younger Suite" is morphologically simple, the only significant features of relief are river mouth bars and an inshore terrace and rise. The "Older Sands" form a series of rises (Fig. 2 b) which are the most prominent topographic features of the surface of the sediments of the Niger Delta.

Waves, tidal currents and water transparency

Tidal flows are a principal factor affecting the distribution of practically all other environmental properties and consequently that of benthonic and other organisms in the western delta. Allen (1965, pp. 553—556) discussed such relationships and indicated (*op. cit.*, fig. 6 a) that strong inshore currents (velocity of 20—40 cm/sec.) sweep along most of the coast. Maximum velocities decrease outwards from the shallow shore waters to deep continental slope waters. The shoreline and shallow waters of the continental margin are strongly affected by intense wave action. The principal winds are the south-westerly winds which generate the Guinean North Equatorial currents. These currents are largely stable but may undergo variability in June—September, when phosphate-rich oceanic waters invade the coastal waters.

The high-energy tidal currents and riverine discharge along the coast, result in a highly turbid water with low transparency. Water transparency of the Niger Deita as a whole is low compared with most tropical oceanic standards (Longhurst 1964, p. 379; Allen 1965, and Reyment 1969, p. 130). Secchi disc values of between 2 and 34 metres have been recorded at different periods for the Nigerian coast. The turbid water is mainly due to (i) planktonic organisms, (ii) suspended fine sand and silt and (iii) suspended organic matter (Longhurst 1964, p. 379).

Temperature

Surface temperatures of the coastal waters of the Nigerian continental margin are fairly constant throughout the year. This supra-thermocline water, with a temperature range of 26°—29°C, overlies an upper thermocline with a temperature range of 20°—25°C. These two form the "tropical water body" (Reyment 1969, p. 129). Results of detailed thermal analysis (Allen and Wells 1964; Longhurst 1964 and Reyment 1969, p. 129) indicate that three underlying water bodies are present and these are separated under the following temperature ranges, 15°—24°C, 11°—14°C and 11°C. Below the 20°C isotherm (lower limit of the upper thermocline), seasonal thermal variation is slight. This is an important factor to benthonic organisms and especially in this case study where practically all species of ostracodes encountered are benthonic. This important thermocline is located throughout the year in the Lagos area at a maximum depth of 61 metres in September and 40—50 metres nearest the surface in July (Reyment, 1969, p. 130). Bottom temperatures in the western Niger Delta range from 25.8°C in the nearshore station A4 to 18.2°C as recorded for station J4 at greater depths (see Table 1).

Salinity

Surface salinity readings recorded by Reyment (April 1965) range between 25.30—31.64 $^0/_{00}$, and bottom salinity ranges between 30.35 $^0/_{00}$ and 35.50 $^0/_{00}$. These were recorded between the depths of 18 and 73 metres. Salinity values show in general a gradual rise with increasing depth, reaching an average of 34.75 $^0/_{00}$ at a depth of 400 metres. Surface salinity is never in excess of 34.5 $^0/_{00}$ over the continental shelf, except during periods of upwelling.

Seasonal salinity change during the year in the supra-thermocline water, shows a rather complex cycle with two maxima, (Longhurst 1964). These maxima are known to be the results of separate processes: (i) basic salinity differences related to the rainfall regime with a maximum value in March and minimum value in August—September, and (ii) an upwelling of sub-thermocline water in August with salinity at times in excess of 35 $^0/_{00}$.

Depth

The depth of water is inseparable from other factors such as sediment distribution, temperature,

tidal currents, wave base and transparency. The aggregate of these factors seem to be of major influence on the distribution of ostracode species in the Niger Delta as a whole.

In general, most ostracodes are concentrated to depths shallower than 50—75 metres and species of the Trachyleberididae and Hemicytheridae tend to be confined to a depth range of between 6 and 30 metres (see Table 1).

Other environmental factors

Other environmental factors of possible importance in the distribution of benthonic organisms and on which some data are available are dissolved oxygen, pH, Eh, oxidizable organic matter, carbonate content, relationship to other organisms and the distribution of trace elements. For details of results and mode of analysis of these factorss, see Reyment (1969, pp. 124—129, and 147—154).

pH readings with a mean value of 7.52 have been reported for the interstitial water, and a mean value of 7.86 has been recorded for the supernatant water (Reyment 1969, p. 125).

The carbonate content, from analysis of samples from the whole of the delta, varies from zero to more than 16 %. In the western Niger Delta, the value ranges from 1.38—7.74 % (Reyment, 1969, Table 1); the highest value was recorded from station J4. Oxidizable organic matter shows values ranging from 0.3—5.5 % for the whole of the Niger Delta and a value of 0.8—2.6 % for the western Niger Delta (*op. cit.*, Table 1).

Results from analysis of the trace elements Cd, Pb, Zn, V, Cu and Co indicate a tendency to increase in concentration with distance from shallow to deep waters. Phosphorus shows a high correlation with depth.

Biological factors such as population dynamics and predation, have been discussed by Reyment (1966 b, 1967 and 1969, pp. 144—147). Predation by naticids and muricids on species of ostracode genera such as *Chrysocythere*, *Phacorhabdotus*, *Cytherella*, *Cytheropteron*, *Soudanella*, *Aurila*, *Campylocythereis*, *Bythocypris*, *Carinocythereis* and *Puriana* occurs throughout the Niger Delta.

Ecological effects on ostracode distribution

An examination of the pattern of distribution and a close comparison of this with all available ecologic factors seem to indicate that although several factors may affect ostracode distribution, the major factors are substrate, temperature, depth and food-supply.

In a high-energy level area such as the Western Niger Delta, a true spatial distribution of mostly dead ostracode carapaces and valves is dependent on the gross effect of many physical factors such as waves, tidal currents and bottom topography. These factors are of great importance in the post-mortal sorting and distribution of ostracode shells. The occurrence therefore of both adult and juvenile specimens and the presence of living specimens at the time of collection, are indications of the natural distribution pattern.

Table I indicates that about 85 % of ostracodes recorded are confined to depth of between 10 and 30 metres. Below a depth of 35 metres, the number of ostracodes per 50 grams of sediment is in general less than 10. Irregular distributional patterns are associated with outcrops of the older sands. Reasons for such distribution are not clear. Allen (1965, p. 563) indicated that the coarse to fine-grained "Older Sands" are in places rich in clay-silt fractions, algal debris and usually contain a high percentage of fecal pellets, glauconite, carbonate and "concentrated organic debris", the latter being an important source of nutrient to benthonic organisms. Such ecologic niches as these are sites of high activity and concentration for benthonic organisms. Allen (*op. cit.*) stated that "there is no need to suggest that any of the shell debris of the "Older Sands" was derived from older "formations", thus suggesting that all the benthonic organisms encountered are present inhabitants of these ecological niches.

The effects of depth and temperature are closely interrelated. This relationship is especially important as the position of the main thermocline which is at the depth of about 60 metres along the western coast (off Lagos) may probably act as a thermal barrier to stenothermal ostracodes. Such a thermal barrier has been described for corals by

Table I. Ecology and numerical distribution of Trachyleberididae and Hemicytheridae from the Western Niger Delta, Nigeria.

Sampling stations	GT	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	J2	J3	J4
Sediment type	Pale-brown quartz sand with shell debris and glauconite	Clean quartz sand with shell debris and glauconite	Pale-brown quartz sand with shell debris	Grey clayey silt with faecal pellets and calcareous algae	Pale-brown silty sand with shell debris and glauconite	Fine grey silt with abundant faecal pellets, algae and shell debris	Grey silty mud	Grey clayey silt with faecal pellets	Dark-grey silty clay	Grey silty clay	Fine silty sand	Pale-brown silty sand with shell debris and glauconite	Dark-grey silty mud with faecal pellets	Fine dark-grey silt
Depth in metres	20	20	24	35	26	30	35	42	60	80	10	24	45	75
Temperature °C (bottom)	—	25.1	20.4	—	25.8	21.3	19.1	—	—	—	—	—	19.6	18.2
Salinity ‰ / Ostracode species	Range: Bottom 30.35—35.50; Surface 25.5—31.64													
Ruggieria tricostata	60 (101)	33 (28)					NO OSTRACODES				4	5 (24)	NO OSTRACODES	2 (1)
Ruggieria lekkii	2 (3)	7										10 (34)		
Ruggieria nigeriana	6	5										3 (8)		
Ruggieria beninensis	14	6 (1)				9 (96)						3 (1)		
Ruggieria triangulata	2 (6)	10			11 ★ (9) ★	(2)				4				3
Ruggieria martinssoni	(4)	5			4 ★ (2) ★									
Phacorhabdotus hazeli	2 (3)	6 (2)												
Buntonia olokundudui	2 (11)	10 (21)		5 ★		34 (1659)		3 (1)				(47)		
Buntonia foliata	1	3							2 (4)	2 ★				(1)
Soudanella africana	1 (15)	29 (11)										4 (40)		
Soudanella africana reticularis	2	4 (3)										5 (4)		
Neocythereis nigeriensis	26	18												
Neocythereis? simplex	1	2				3								
Carinocythereis asterospinosus	30 (116)	4			7 (1)					(2)		(1)		2 (1)
Carinocythereis sp.						2								
Cativella iyemojai	10	8 (2)				4 (21)					2			1
Neocaudites purii		2				6								
Neocaudites rectangularis	1	3												

Dakrika robusta						2	NO OSTRACODE	7		[illegible] ★			NO OSTRACODE	
Reymentia ijebuorum	117 (1)	8										[illegible] ([illegible])		
Reymentia microdictyota	(14)	2										37 ★ (2)		
Reymentia reticulata	10	6												
Basslerites elongata	6	5		6 ★		19						3		
Basslerites (Loculiconcha) ikoroduensis	11													
Basslerites (Loculiconcha) punctata	3	4	2			94 ★ (1)						7		
Puriana rugosa	92 (30)	59												
Puriana aff. *interrasilis*	15	10												
Puriana mediocostata	10	4												
Puriana akparaia	29	8												
Puriana trituberculata	2 (3)													
Puriana sp.	(2)													
Chrysocythere foveostriata	194 (138)	60 (40									5	3		
Chrysocythere foveostriata minuta	45	57 (4)										1		
Chrysocythere boldi	4 (7)	50 (107)				54 (1263)						9 (29)		
Hermanites foveolata		8		4	3									
Hermanites batei		11		3										
Hermanites macrodictyota		8			2	3								
Aurila punctoreticulata	5 (37)	9 (21)												
Mutilus nigeriana	17 (1)	6												
Mackenziella lagosensis	6 (1)	10			2									
Campylocythereis sandbergi	49 (10)	37 (21)										2		
Campylocythereis nuxa	6 (5)	15 (7)										3		
Campylocythereis leguminopsis	5	7												
Caudites africana	8													

Notes: (i) The upper numbers represent all available adult specimens, and numbers in parentheses represent juvenile instars. (ii) Asterisks indicate probably living specimens at the time of collection. (iii) *Neocaudites tuberculata* n. sp. is not included in the table (station A5).

Allen and Wells (1962). Table I shows the occurrence of species that are probably eurythermal and are distributed below 60 metres. In general, ostracode frequencies in the western Niger Delta are negatively correlated with depth.

In Table I, the total ostracode population for species of Trachyleberididae and Hemicytheridae is numerically indicated to show the occurrence of both adult and juvenile individuals. Table II shows the frequency distribution of adult individuals of species of both families.

Out of 44 species of Trachyleberididae and Hemicytheridae identified, 17 are confined to pale-brown quartzose *sand* rich in shell debris and glauconite. These are:

Phacorhabdotus hazeli n. sp.
Neocythereis nigeriensis n. gen., n. sp.
Neocythereis? simplex n. gen., n. sp.
Neocaudites purii n. sp.
Neocaudites rectangularis n. sp.
Reymentia reticulata n. sp.
Aurila punctoreticulata n. sp.
Mutilus nigeriana n. sp.
Basslerites (Loculiconcha) ikoroduensis Omatsola, 1970
Puriana rugosa n. sp.
Puriana aff. *interrasilis* (Bold), 1966
Puriana mediocostata n. sp.
Puriana akparaia n. sp.
Puriana trituberculata n. sp.
Puriana sp.
Caudites africana n. sp.
Campylocythereis leguminopsis Omatsola, 1970

Thirteen species occur on pale-brown quartzose *sand* and pale-brown *silty sand,* rich in shell debris and glauconite. These are:

Ruggieria tricostata n. sp.
Ruggieria lekki n. sp.
Ruggieria nigeriana Omatsola, 1970
Ruggieria triangulata n. sp.
Ruggieria martinssoni n. sp.
Soudanella africana n. sp.
Soudanella africana reticularis n. sp.
Reymentia ijebuorum Omatsola, 1970
Reymentia microdictyota Omatsola, 1970
Chrysocythere foveostriata (Brady) 1870
Chrysocythere foveostriata minuta n. subsp.
Campylocythereis sandbergi Omatsola, 1970
Campylocythereis nuxa Omatsola, 1970

Twelve other species do not seem to show preference for a particular substrate. These are:

Ruggieria beninensis n. sp.
Buntonia olokundudui Reyment and Van Valen, 1969
Buntonia foliata n. sp.
Carinocythereis asterospinosus Omatsola, 1970
Cativella iyemojai n. sp.
Basslerites elongata n. sp.
Basslerites (Loculiconcha) punctata n. sp.
Chrysocythere boldi n. sp.
Hermanites foveolata n. sp.
Hermanites batei n. sp.
Hermanites macrodictyota n. sp.
Mackenziella lagosensis n. gen., n. sp.

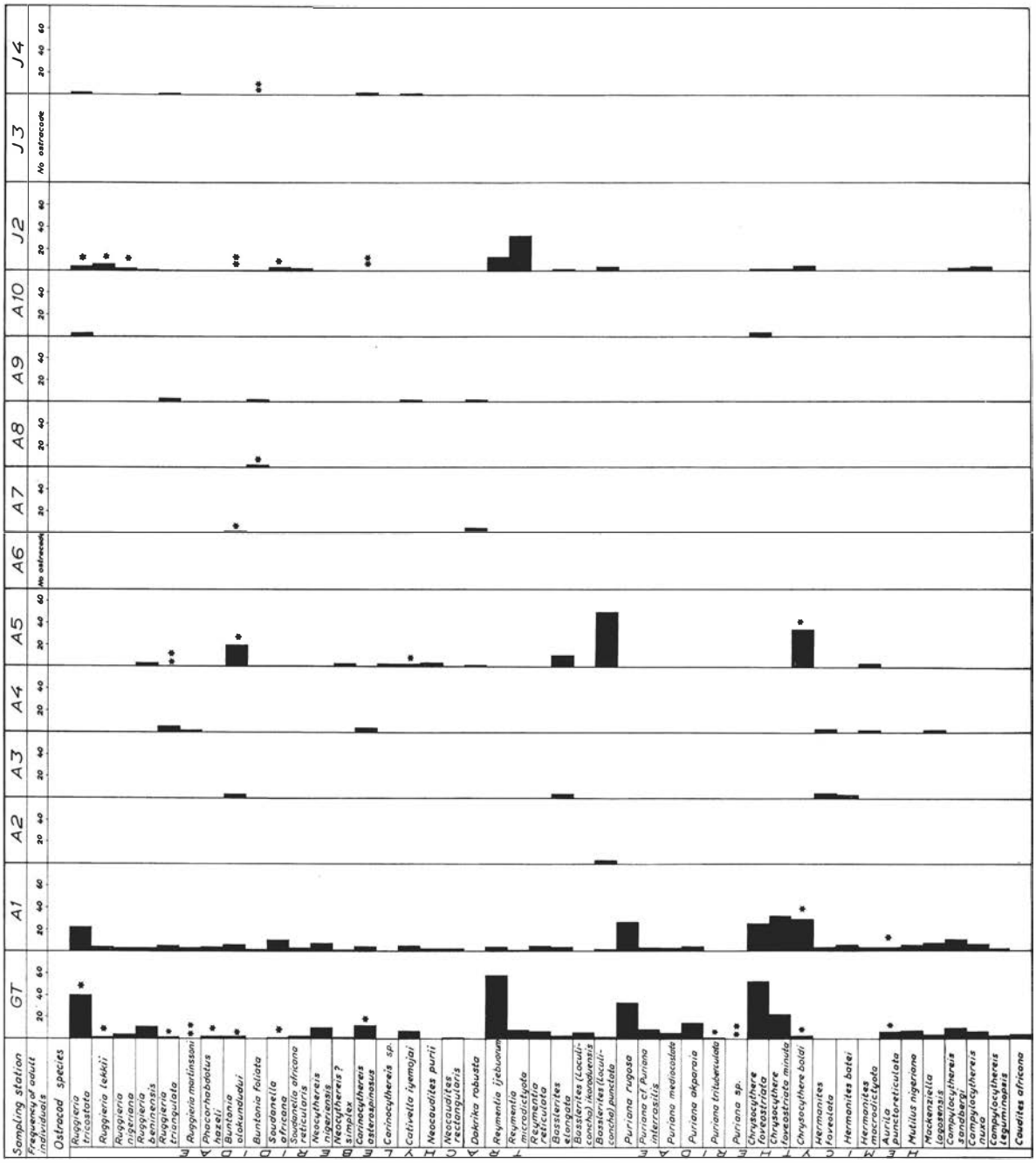
These species are found to occur on practically all types of substrate such as quartzose sand, silty sand, fine silty sand, fine grey to grey dark silt with abundant faecal pellets, algae and shell debris, and mud.

Seemingly confined to finer fractions such as fine grey to dark-grey silt and muddy silt are *Dakrika robusta* n. gen., n. sp., and *Carinocythereis* sp. These observations are of a preliminary nature.

Comparison with other regions

A broad comparison of the general distribution pattern of ostracodes of the western Niger Delta with the results of Curtis (1960) in her study of the relationship of environmental energy levels and ostracode biofacies in East Mississippi Delta, indicates that contrary to her findings, offshore (low energy level) biofacies in the western Niger Delta contain fewer species and individuals than inshore (high-energy level) biofacies.

A further comparison of the Trachyleberididae and Hemicytheridae of the delta, with those of the tropical and subtropical fauna of North, Central and South America and those of the warm temperate Mediterranean fauna, indicates that the Niger Delta possesses faunal components at the generic level that occur in these two areas, especially the Florida Bay—Gulf of Mexico—Caribbean realms. Such genera as *Neocaudites*, *Puriana* and *Cativella* that are well established and probably endemic to the Americas, are abundantly found in the western Niger Delta. The genus *Chrysocythere,* characteristic of the Mediterranean realm, is also found in the delta, and along most of the inner neritic environments of the coast of West Africa (Brady 1870; and van den Bold, 1966, p.



161—162). Cosmopolitan genera such as *Mutilus* and *Aurila* also occur, but are rare and mainly restricted to the western Niger Delta. Genera common to the Americas, Western Europe, the Mediterranean and the delta are *Buntonia*, *Phacorhabdotus*, *Caudites*, *Basslerites*, *Carinocythereis*, *Ruggieria* and *Hermanites*, (Müller (1894); Ruggieri (1959); Ascoli (1964); Benson (1964); Puri, Bonaduce and Malloy (1964); Rome (1964); Puri (1966); van den Bold (1966); MacKenzie (1967); Puri, Bonduce and Gervasio (1969) and Yassini (1969)). Seemingly endemic to the West African

tropical realm, are genera such as *Soudanella*, *Neocythereis*, *Dakrika*, *Reymentia*, *Basslerites* (*Loculiconcha*), *Mackenziella* and *Campylocythereis*, most of which are new.

Environment and morphology

A relationship seems to occur between the particle size of the substrate and the ornament of the ostracode carapaces, especially among some members of the Hemicytheridae. Thick, heavy, highly ornamented large carapaces are however found in genera of both families such as *Carinocythereis*, *Aurila, Chrysocythere*, *Mackenziella*, *Hermanites*, *Soudanella*, *Campylocythereis*, *Ruggieria*, *Buntonia*, *Phacorhabdotus*, *Neocythereis* and *Dakrika.* These genera characterize near-shore coarse-grained sediments; especially the outcrops of the "Older Sands". Müller (1894), Remane (1940), Elofson (1941), Triebel (1941), Benson (1959), Hartmann (1964 c), Puri (1966) and others, indicated such relationship in their respective areas of study.

Besides such interrelationship between size, ornament and particle size of substrate, it is also found, for example, that intraspecific variation in ornament could be associated with different sedimentological niches inhabited by the animals. Individual specimens of the following species: *Hermanites batei* (Pl. 22, Figs. 3 and 9), *Hermanites macrodictyota* (Pl. 23, Figs. 1, 2 and 3), *Hermanites foveolata* (Pl. 21, Figs. 1—2) and *Mackenziella lagosensis* (Pl. 18, Figs. 4 and 9), develop finer denticulation, reticulation or surface pitting. The specimens with the finer ornament were recorded from silty and silty-sand bottoms (see Table I), in areas relatively far from the high-energy dynamic shoreline. In the near-shore areas affected by strong onshore currents, waves etc., representative individuals develop heavier and more coarsely reticulated carapaces (see Pl. 22, Fig. 1; Pl. 23, Fig. 14; Pl. 21, Fig. 9 and Pl. 18, Figs. 1 and 2; respectively for the above-mentioned species) with either the absence of denticulations or, when present, strongly developed.

The general shape of species of *Hermanites batei*, *H. macrodictyota* and *H. foveolata* seems to differ between individuals inhabiting coarse sediments and those on silt, silty clay or mud. Slight differences in size are found to occur intraspecifically within individuals of *Buntonia olokundudui*, *Chrysocythere boldi*, *Basslerites* (*Loculiconcha*) *punctata*, *Hermanites foveolata*, *H. macrodictyota* and *Phacorhabdotus hazeli.* Individuals of species of these genera inhabiting sandy bottoms are larger than those found on finer bottoms. Interspecific variation of size in relation to substrate is also to substrate. *Neocythereis? simplex* and *Neocaudites.* These genera show a correlation of species size to substrate. *Neocythereis ? simplex* and *Neocaudites tuberculata* recorded from a silty bottom are relatively smaller in size than their generic relatives, *Neocythereis nigeriensis*, *Neocaudites rectangularis* and *Neocaudites purii* (see Figs. 4 and 35).

The flattening of the venter, which characterises genera inhabiting silty or muddy bottoms, is a characteristic feature of the new genus *Dakrika* whose distribution is practically confined to fine-grained sediments (see Table I).

An interesting adaptive morphology is found in the normal pores of, especially, hemicytherid species. The "compound" normal pores of individuals of *Mackenziella lagosensis* (Pl. 17, Fig. 6), *Hermanites foveolata* (Pl. 20, Fig. 7) and *H. macrodictyota* (Pl. 23, Fig. 9) inhabiting the high-energy near-shore sandy bottoms, show heavy calcifications of the radiating calcareous plates through which the micropores of the sieve plates run. A comparison of these highly modified "compound" normal pores with those from individuals inhabiting silty or muddy bottoms (on the respective plates) emphasizes the differences. This feature may indicate morphologic adaptation by species inhabiting the turbulent near-shore waters.

TAXONOMY

The problem of a proper taxonomic delimitation between the Trachyleberididae and Hemicytheridae has been the subject of close study by workers such as Puri (1953 a and b), Pokorný (1955, 1958, 1964), van Morkhoven (1962, 1963), Hartmann (1963, 1964 b), Hazel (1967 a) and Plusquellec and Sandberg (1969, pp. 427—429) and in the treatises edited by Chernysheva (1960) and Moore

(1961). I shall not deal with the bibliographic aspect of this subject more than as stated above.

Paleontologically, the most up to date and natural classification of these two families is that of Hazel (1967 a). In the systematic section of the present paper, Hazel's (1967) classification is adopted with some modifications based on results of morphologic investigations carried out in this study.

Some morphologic characters used in delimitation

The basic differences that exist between neontological and paleontological classification of the trachyleberidid—hemicytherid groups are well recognized. As a result these two groups are respectively considered either as subfamilies of the family Cytheridae (Hartmann 1963 and 1964 b, and van Morkhoven 1962, 1963), or families of the superfamily Cytheracea (Howe in Moore /ed./ 1961, Hazel 1967, Plusquellec and Sandberg 1969, and others).

Anatomic differences such as the number of segments of the antennules (5 or 6), and the degree of complexity of the mandibular branchial plate, are well established for the delimitation of the Trachyleberididae and Hemicytheridae. In the absence of soft parts, it becomes necessary to depend on the total weight of the most important morphologic characters. At the family level, these are the frontal muscle scars, and the adductor muscle scars (Pokorný 1958; Neal 1962; Hartmann 1963 and 1964 a and b; Benson 1966; Hazel 1967 a, and Plusquellec and Sandberg 1969, p. 428). A third character, the dorsal group of muscle scars, currently becoming closely studied in the Cytheracea (Plusquellec and Sandberg 1969), may be of some importance in the delimitation between the trachyleberidid and hemicytherid families.

Other morphologic features such as radial pores, degree of fusion of the outer and inner lamella, type of duplicature, normal pores, hinge and details of shape, are also considered, though their values are much lower than at the subfamilial, generic and specific levels where they become important.

Characters herein considered as diagnostic are the frontal muscle scars, the adductor muscle scars, the dorsal group of muscle scars and to some extent, the normal pore canals.

Frontal Muscle Scars

Van Morkhoven's (1962, p. 48) recommendation of the use of "frontal scar" for the muscle scar (s) in front of the adductor and above the mandibular scars, has been proved (Smith 1968, pp. 808—809) to be useful. Smith's (*op. cit.*) in his investigation of the musculature and origin of the scars constituting the frontal scars of *Actinocythereis vineyardensis* Cushman, (Trachyleberididae) and *Muellerina lienenklausi* (Müller) (Hemicytheridae) stated that "one transverse and one mandibular muscle form the frontal scars on each valve in both the trachyleberines and hemicytherines". This result eliminates the connotation "antennal scar". Smith (*op. cit.*, p. 808) continued by saying that ..."bifurcation of the transverse muscle into anterior—posterior bundles (trachyleberines), and into dorsal—venral bundles (hemicytherines), and the mandibular muscle position, account for the different frontal scar patterns..." in the two groups. Similar muscles are therefore involved in the formation of the frontal scars in both families. As indicated by Smith (1968), the nature of bifurcation of the transverse muscle and the position of the mandibular muscle attachment is an important factor in determining the resultant pattern of the frontal muscle scars in the Trachyleberididae and Hemicytheridae. Considering the results of Smith (1968), it is natural to expect that the variability in the position and the degree of coalescence of the muscles forming the frontal scars in both families may lead to divided as well as single J- or U-shaped frontal scars. This might explain such occurrences as are found in *Anticythereis* (Reyment 1963; van den Bold 1964), *Leguminocythereis* (Howe and Law 1936, Howe in Moore 1961, p. 306, Butler 1963, and van Morkhoven 1963, p. 176), *Campylocythereis* (Omatsola 1970 e), and in species of *Puriana*, *Chrysocythere* and *Basslerites*.

It has been anatomically proved (Smith 1968), that a basic difference does exist in the patterns in which the muscle bosses forming the frontal scars are attached to the ostracode carapace in

the Trachyleberididae and Hemicytheridae. This as Smith (*op. cit.*) intimated, confirms the fact that trachyleberidid genera are mostly characterized by a J-, V- or U-shaped frontal scar, while the hemicytherid genera possess two or three discrete frontal scars *in most cases.* There are exceptions to the rule in both families. Omatsola (1970 e) reported the occurrence of single J- and U-shaped, two- and three-discrete frontal scars in a single species of the genus *Campylocythereis* Omatsola, of the Campylocytherinae. The situation for *Campylocythereis*, seems to be in opposition to Hazel's (1967 a) hypothesis that at least in the Campylocytherinae "... there is a polymorphogenic trend towards the division of the frontal scars...". It might be that the present case is one of an independent "conservative" evolutionary trend.

Another example of variation of the frontal scar pattern is provided by *Puriana* Coryell and Fields. Most illustrations and descriptions of species of *Puriana* do not show the frontal muscle scar pattern, and where figured it is either as a J-, V- or U-shaped scar (Puri 1960, p. 127, pl. 1, Figs. 7—8; van den Bold 1963, p. 390; 1966, p. 48, Pl. 4, Figs. 4—5, and Pl. 5, Fig. 2), or rarely as two discrete scars (Benson 1959, p. 60, Pl. 5, Fig. 5 a—b, Pl. 10, Fig. 1; and Benson and Kaesler 1963, p. 30, Fig. 19). Anatomic evidence, as stated by Hazel (1967, p. 7) indicates that *Puriana* is a hemicytherine genus, and Hazel (1967 a) classified it under his new subfamily Thearocytherinae. In the present study, species of *Puriana* were found to possess single and divided frontal scars inter- and intraspecifically. Figure 28 is a diagrammatic representation of the variation in four species of *Puriana. Puriana rugosa* (Fig. 28 a), *P.* aff. *interrasilis* v. d. Bold (1966) (Fig. 28 B) and *P. akparaia* (Fig. 28 C) are shown to possess single and double frontal scars, whereas *P. trituberculata* (Fig. 28 D) is found to possess three scars (see also Pl. 28, Fig. 7). Inter- and intraspecific occurrence of both single and double frontal scars are also found in other genera such as *Chrysocythere* Ruggieri (see Fig. 13) and *Basslerites* (*Loculiconcha*) Omatsola, (see Figs. 19, 21 and 22). In all the examples reported here, the ratio of the frequency of occurrence of individuals with single, to those with double scars is about 1:10.

Intrageneric occurrences of both single and double scars have been reported for species of *Bradleya* Hornibrook, (Hornibrook 1952, p. 42; Ruggieri 1962, p. 21), *Hermanites* Puri, (Howe in Moore 1961, p. 338; van Morkhoven 1963, p. 204; Ruggieri 1962, p. 22), *Echinocythereis* Puri, (Benson and Coleman II 1963, p. 1963, p. 46—47, Fig. 30 a—b; v. d. Bold 1966, Pl. 5, Fig. 6) and *Henryhowella* Puri. *Bradleya* and *Hermanites* are known hemicytherids; *Echinocythereis* has a trachyleberidid anatomy, but the precise taxonomic position of *Henryhowella* is doubtful. Species of these genera possess single and double frontal scars.

Hazel (1967 a) reported that *Chrysocythere* Ruggieri (1962), possesses two frontal muscle scars. Ruggieri (1962, p. 27 and Pl. 12, Fig. 11 a) mentioned, with illustrations, two frontal scars for the type species of *Chrysocythere—C. cataphracta* Ruggieri (1962), but stated that it is possible that in some examples, the second (smaller) frontal scar could be fused to the first (large). This suggests that other species may probably have a single frontal scar (see van den Bold 1966, p. 162). Both Ruggieri (1962 *op. cit.*) in his original description and van den Bold (1966 *op. cit.*) classified *Chrysocythere* with the Trachyleberididae. Hazel (1967 a) classified *Chrysocythere* with the Campylocytherine on the bases of "...two frontal muscle scars and an outline in dorsal and lateral view that require its consideration as a member of the Campylocytherinae". Three species of *Chrysocythere* are here studied in detail; these are *Chrysocythere foveotsriata* (Brady) Bold 1964; *C. fovoestriata minuta* (n. subsp.) and *C. boldi* n. sp. Only in one species, *C. foveostriata*, are double frontal scars found, and even in this case most specimens possess a single J- or U-shaped frontal scar (see Pl. 15, Fig. 8). Considering the variability of the frontal scar as indicated above, the occurrence of simple normal pores, and the fact that the shape and habitus of *Chrysocythere* are similar to that of *Echinocythereis* Puri 1953 and *Henryhowella* Puri 1957, I have tentatively

placed *Chrysocythere* in the new subfamily Echinocythereidinae Hazel (1967 a) of the Trachyleberididae.

Up till the present, the proper grouping of the genus *Basslerites* Howe, 1937, has been problematic. Various authors (Howe 1937, Leroy 1943, van den Bold 1958, van Morkhoven 1963, p. 207, Hazel 1967 b and Plusquellec and Sandberg 1969, p. 428) classify this genus under the Trachyleberididae mainly on the bases of the V- or heart-shaped frontal scar and shape. Accepting the fact that in the absence of *positive* anatomical evidence the natural classification of *Basslerites* is not possible, efforts should be made in the use of taxonomically important morphologic characters for a logical assignation of the genus. Evidence for the division of the frontal muscle scars in species of *Basslerites s. str.* and the subgenus *B.* (*Loculiconcha*) (see Pl. 18, Figs. 5 and 8, Pl. 19, Figs. 4, 6, 7 and Fig. 19) adds to the problems of a proper classification. Plusquellec and Sandberg (1969, p. 428) indicated that the possession of a V-shaped frontal muscle scar, simple, open normal pores and the shape of *Basslerites* do not allow the genus to fit in the subfamily Campylocytherinae. The problem of simple normal pores does not arise since these are found in some hemicytherine groups such as *Puriana*, and as Hartmann (1963, p. 138) and Pokorný (1964, p. 208) agreed, both single and sieve-type normal pores are found in both trachyleberidid and hemicytherid families. The evidence of the similarity in the dorsal muscle scar pattern (discussed below) indicates the close relationship of *Basslerites* and *B.* (*Loculiconcha*) with the hemicytherid group. G. W. Müller's (1894, Pl. 31, Figs. 35—39) illustrations of the soft parts of *Cythere berchoni* Brady (= *Cythere teres* Brady of Müller = *Basslerites teres* of other authors, e.g. Ruggieri 1950, 1953; van den Bold 1957; Hartmann 1962, p. 145; van Morkhoven 1963 and Ascoli 1967) might be correct. This however awaits reconfirmation for living species. I group *Basslerites* Howe, *B.* (*Loculiconcha*) Omatsola, *Reymentia* Omatsola and the new genus *Campylocythereis* Omatsola, in the Campylocytherinae. These genera have in most cases a single frontal muscle scar.

Adductor scars

The question of the importance of divided and undivided adductor muscle scars within the trachyleberidid and hemicytherid groups has been critically examined by Hartmann (1963, p. 138—139), Pokorný (1964) and Hazel (1967 a). It is well accepted that undivided adductor scars are found in all trachyleberidid genera. So far no evidence of divided adductor scars (except in the Brachycytherinae tentatively included in the Trachyleberididae, Hazel 1967 a, p. 8) has been recorded for a trachyleberidid genus or species. Pokorný's (1964, p. 278) argument that "...the tendency towards the subdivision of some adductor muscle scars, especially of the second from above..." in many Trachyleberidinae, needs clarification. Plusquellec and Sandberg (1969, p. 433) also stated that "...occasionally, the second scar from the top..." is found to show a "tendency" to split. An examination of the illustrated example (*op. cit.*, Pl. 5, Fig. 8) does not show any "tendency" to split, but seems to be an elongate, pear- or club-shaped scar. Such a "tendency" is commonly found in some genera of the Echinocythereidinae such as *Echinocythereis* (see van den Bold 1966, p. 168, and Pl. 5, Fig. 6) and *Chrysocythere*, and also in the genera of the Pterygocytherinae. The second adductor muscle scar from the top in these groups is typically pear- or club-shaped. Such occurrences are also found in typically hemicytherine genera as *Puriana* (see Fig. 28) *Campylocythereis* (Fig. 23) and *Reymentia.*

Dorsal group of muscle scars

The dorsal group of muscle scars have not until recently (Plusquellec and Sandberg 1969) been put to use among the cytheracean ostracodes. Studies of the dorsal muscle scar group in some genera of the Cypridacea, and its possible use in taxonomy, have been carried out by Benson and Macdonald (1963), Smith (1965) and Benson (1967). Van Morkhoven (1962, p. 48) suggested that the dorsal scars represent points of attachment of various muscles running to the first and second antennae, the mandibles and the endoskeleton. Smith's (1965) investigation of *Chlamy-*

dotheca arcuta Sars, and Kesling's (1965) study of the anatomy of *Candona suburbana* Hoff, indicate that the dorsal group of muscle scars of these representative species of Cypridacea are points of attachment of muscle bosses from the endoskeleton, furca and all appendages. Smith (1968, p. 808) stated that "some of the dorsal group of muscle scars are composed of powerful muscle attachments from the mandible..." in the two representative individuals of trachyleberine and hemicytherine species he studied. The nomenclature of the dorsal muscle scar group is however poorly known, and although the usability of these scars as a taxonomic criterion among the Cytheracea is uncertain, attempts by Plusquellec and Sandberg (1969) seem promising.

The dorsal muscle scar pattern of all genera and most species of Trachyleberididae and Hemicytheridae herein encountered, is studied in some detail. I have tried to establish the possibility of using this character as a differentiating feature between these two families.

Plusquellec and Sandberg (1969, pp. 433—434, Text-fig. 1) described and figured the dorsal group of muscle scar pattern of three species of genera of the Campylocytherinae — *Campylocythere laeva* Edwards 1944, *Acuticythereis laevissima* Edwards 1944, and *Proteoconcha proteus* Plusquellec and Sandberg 1969. In this study, they (*op. cit.*, pp. 433—434) distinguished three sets of dorsal scars: (i) a group just below the anteromedian hinge element, (ii) another group dorsal to the frontal and adductor scars, and (iii) a third group situated just below the anterior hinge element (Plusquellec and Sandberg 1969, Text-fig. 1, Pl. 7, Fig. 7). This system of grouping could be referred to as basic in most of the examples here studied of trachyleberidid and hemicytherid genera. The number of scars in each group, especially in groups (i) and (ii) as specified above, varies, and this variation seems to indicate in a broad sense, some differences between representative genera of the two families.

Though a rather indefinite picture seems to emerge, the attempt at using these groups of dorsal muscle scars in differentiating between the trachyleberidid and hemicytherid groups does show (as discussed below) that a close relationship exists between the two families.

Most genera of the Trachyleberididae, such as *Neocythereis* n. gen., *Cativella*, *Ruggieria*, *Buntonia*, *Dakrika* n. gen., *Soudanella* and *Chrysocythere* possess two, or very rarely, three scars in group (i) of the dorsal group of muscle scars. (See Fig. 5, Pl. Fig. 5, *Neocythereis nigeriensis*; Fig. 6, *N.? simplex*; Pl. 4, Fig. 5, *Cativella iyemojai*; Fig. 7, Pl. 5, Fig. 4, Pl. 6, Fig. 4 and Pl. 7, Fig. 5, for species of *Ruggieria*; Pl. 10, Fig. 7, *Buntonia olokundudui* Reyment and Van Valen 1969; Pl. 12, Fig. 5, *Soudanella africana* and Fig. 13, *Chrysocythere foveostriata* Brady 1870).

In the representative genera of the Hemicytheridae of the Niger Delta, three elongate scars are commonly found in the dorsal scars group (i) (see Fig. 17, *Mackenziella lagosensis*; Figs. 20, 21, 22, respectively for *Basslerites elongata, B.* (*Loculiconcha*) *ikoroduensis* and *B.* (*Loculiconcha*) *punctata*; Fig. 23, *Campylocythereis sandbergi* Omatsola; Figs. 24, 26, 27, respectively for *Hermanites foveolata*, *H. batei* and *H. macrodictyota*; Fig. 30, *Aurila punctoreticulata*; Fig. 32, *Mutilus nigeriensis* and Fig. 33 b, *Caudites africana*).

In the dorsal muscle scar group (ii), the group of scars dorsal to and situated between the frontal and adductor and the dorsal scars group (i), the number of scars as Plusquellec and Sandberg (1969, Text-fig. 1) illustrated, vary between three, as in *Actinocythereis laeva* (Edwards), and four, as in *Campylocythere laeva* (Edwards) and *Proteoconcha proteus* (Plusquellec and Sandberg). Regarding the illustrations referred to above, there are in each case two or three scars, *immediately* above the frontal and adductor muscle scars. These latter are in my opinion of greater importance if any use is to be made of the dorsal muscle scars in taxonomy within the Trachyleberididae—Hemicytheridae groups, and probably among cytheracean Ostracoda as a whole. I found that in practically all representative genera of the Trachyleberididae studied (see figures and plates of species of *Neocythereis*, *Ruggieria*, *Buntonia*, *Dakrika*, *Soudanella*, *Cativella* and *Chrysocythere*) two fairly rounded scars occur *immediately* dorsal to the frontal and adductor scars. In representative genera

of the Hemicytheridae investigated (see figures and plates of species of *Basslerites*, *B.* (*Loculiconcha*), *Hermanites*, *Aurila*, *Mutilus*, *Puriana* and Fig. 23, for *Campylocythereis*), three subtriangular to elongate muscle scars are found in the same position. In the hemicytherids, the position, arrangement and size of these scars seem to vary between genera but it is constant within a genus (see Fig. 19, for *Basslerites* and *B.* (*Loculiconcha*), Pl. 24, Figs. 8—9; Pl. 25, Fig. 7; Pl. 26, Fig. 6 and Pl. 28, Figs. 4, 7 respectively for *Puriana rugosa*, *P.* aff. *interrasilis*, *P. akparaia* and *P. trituberculata*).

The dorsal muscle scars group (iii), those occurring just below the anterior hinge element, seem to vary in number between two and four, and are fairly constant in position in practically all species of both families. This set of dorsal muscle scar does not seem to be of much importance.

It is clearly premature to draw conclusions on the bases of the number, arrangement and position of the scars in each of the three specified groups with respect to the above discussion. In the absence of a precise nomenclature and knowledge of the phylogenetic importance of these scars, further work is necessary in order to ascertain the importance of the dorsal group of muscle scars in the taxonomy of cytheracean Ostracoda.

Normal pore canals

The use of the normal pore canals as a taxonomic character at the family level in the Trachyleberididae—Hemicytheridae groups, as indicated by van Morkhoven (1962, p. 127 and 1963, p. 7), has been rejected by several authors (Pokorný 1964, p. 280, Hartmann 1963, p. 138 and others) because simple and sieve-type normal pores occur in both families. Omatsola (1970 e) proposed the term "compound" normal pore for the sieve-type pores with variously placed, large setal pores, (type C of Puri and Dickau, 1969) in contrast to the "ordinary" sieve-type pores characteristic of the Loxoconchinae, Cytherideinae (see Omatsola 1970 c, d and e) and other groups of the Cytheracea.

In almost all the trachyleberidid genera and species studied by the author (see Omatsola 1970 a and c), simple normal pores are found to be characteristic. The only exception in this study is a species of *Phacorhabdotus* (*P. hazeli* n. sp.) in which "compound" normal pores were found. This is the first description of the normal pores of a species of *Phacorhabdotus.*

As would be expected, all three types, simple, sieve-type and compound normal pores are encountered in the Hemicytheridae. Genera such as *Puriana* (Thaerocytherinae, Hazel) and, according to the classification herein followed, *Basslerites* and *B.* (*Loculiconcha*) (Campylocytherinae), possess simple open normal pores. All other hemicytherid genera studied possess "compound" normal pores in addition to simple normal pores in some cases.

As the precise functional morphology and phylogenetic importance of the sieve- and "compound"-type normal pores are poorly understood, their use in the delimitation of the Trachyleberididae—Hemicytheridae groups is limited. It can, however, be stated that *most* Trachyleberididae are characterized by simple, open normal pores, whilst simple, sieve- and "compound"-type normal pores are found in the Hemicytheridae. This latter fact can be qualified further by saying that among the Hemicytheridae, the subfamily Hemicytherinae (Puri 1953) is characterized by the abundant occurrence of sieve- and "compound"-type normal pores; the subfamilies Thaerocytherinae (Hazel 1967 a) and Campylocytherinae (Puri 1960) possess all three types of normal pores.

DIMORPHISM IN CYTHERACEAN OSTRACODA

Dimorphism in post-Paleozoic Ostracoda has mainly been discussed in relation to size differences between males and females especially in marine groups.

Loculate dimorphism has been recorded for the genus *Loculicytheretta* Ruggieri 1954. Omatsola (1970 c) described a new subgenus, *Basslerites* (*Loculiconcha*), which shows loculate dimorphism. In the present study, a new species of the latter genus, *Basslerites* (*Loculiconcha*) *punctata*, also shows such characteristics.

Ornamental dimorphism is common among Paleozoic and a few post-Paleozoic ostracode groups.

Omatsola (1970 c) indicated the existence of such dimorphism in the form and distribution of spines and tubercles in *Phlyctocythere hartmanni* Omatsola. Ornamental features such as reticulation, tubercles, punctation, costae etc., are also involved in sexual differentiation. A tendency towards smoothening of the reticulation in, for example, females of *Hermanites foveolata* (Pl. 21, Fig. 1—4) and *Reymentia microdictyota* Omatsola (1970 c), or males of *Campylocythereis sandbergi* Omatsola (1970 e) and *Basslerites* (*Loculiconcha*) *ikoroduensis* Omatsola (1970 c) is commonly found. The degree of development of marginal denticulation and surface ornament in some species such as *Chrysocythere boldi* (Pl. 16, Figs. 1 ♂, and 3 ♀) and *Neocaudites rectangularis* (Pl. 33, Figs. 1, 3 and 4 ♂, and 6 and 9 ♀) is also found to be related to sexual differentiation.

Sexual dimorphism is not only confined to size and ornamental differences, it was also found in the "compound" normal pores, especially markedly in hemicytherid species. Members of the hemicytherid family studied seem to show the most advanced and complicated "sieve"-type normal pores. The "compound" normal pores of *Hermanites foveolata* (Pl. 21, Figs. 2, 4—6 and 7), *Neocaudites purii* (Pl. 32, Figs. 6—8 and 14) and *Neocaudites rectangularis* (Pl. 33, Figs. 8, 10—12) show strong structural dimorphism in the sexes. The normal pores of males of these three species possess coarse, relatively large micropores on the sieve plates, whereas micropores of females are smaller and more finely built. Strong dimorphism in the simple normal pores of the Trachyleberididae has not been found. Structural polymorphism of normal pores is however common in both families.

SYSTEMATIC SECTION

All types and illustrated specimens are deposited in the type collections of the museum of the Paleontological Institute, University of Uppsala, Sweden.

The dorsal group of muscle scars will be referred to in this section as groups (i), (ii) and (iii) as described in the foregoing text, and in accordance with Plusquellec and Sandberg (1969, pp. 433—434).

Class OSTRACODA Latreille, 1802
Order PODOCOPIDA Sars, 1865
Suborder PODOCOPINA Sars, 1865
Superfamily CYTHERACEA Baird, 1850
Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Genus NEOCYTHEREIS n. gen.
Type species *Neocythereis nigeriensis* n. sp.

Derivation of name. Neos (Gr.) — new, and the addition of the generic name *Cythereis*.

Diagnosis. A genus of the subfamily Trachyleberidinae, characterized by subrectangular to subquadrate carapace in lateral view; extremities denticulate; a strongly developed amphidont hinge; a prominent selvage; occurrence of a shallow crescent-shaped vestibule which in some cases may be absent; presence of 25—40 regularly spaced, straight, slightly dilating anterior radial pore canals; surface ornament consisting basically of moderately developed dorsal, anterior and ventral ridges, and a diagonal ridge which is commonly broken into tubercles; a low eye tubercle; occurrence of moderately few, large scattered

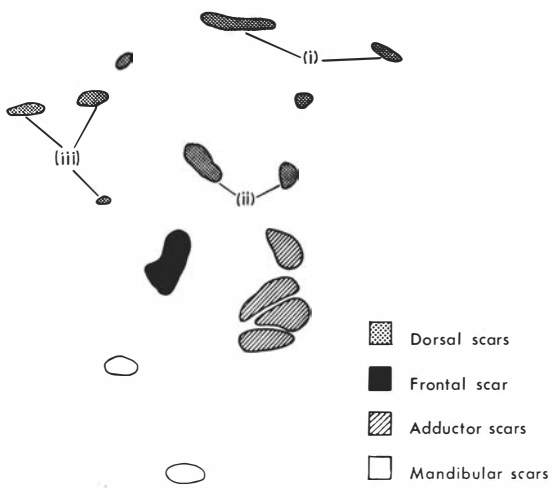


Fig. 3. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Neocythereis nigeriensis* n. gen., n. sp.

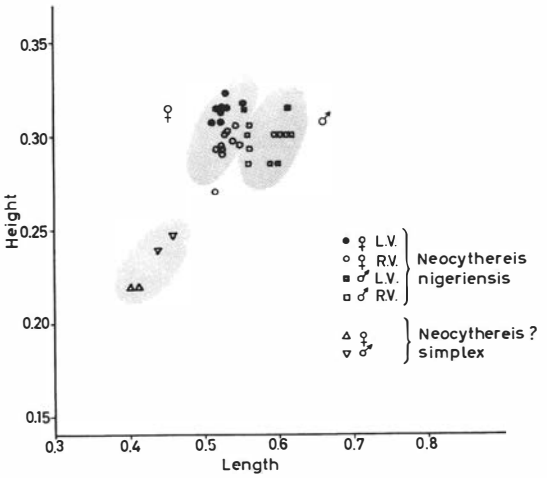


Fig. 4. Scatter diagram of length and height of *Neocythereis nigeriensis* n. sp. and *N. ? simplex* n. sp. Combined specimens from all localities. Note: Specific difference in size, and relationship of size to type of substrate. *N. nigeriensis* is restricted to quartzose sand while *N. ? simplex* is relatively abundant in silt (see Table I).

simple normal pores, and a subvertical row of four adductor muscle scars, a J-shaped frontal muscle scar, two muscle scars each in dorsal scar groups (i) and (ii). Dimorphism is pronounced.

Description

Carapace laterally compressed; subrectangular to subquadrate in lateral view and small to median in size. Dorsal margin is straight, slopes gently posteriorly where it turns acutely down to form the dorsoposterior margin; highest anteriorly at the anterior cardinal angle. Anterior margin broad, obliquely rounded, gently sloping in the anteroventral region. Posterior margin acute and downwardly pointing. The ventral margin is slightly convex with a sinuosity at the oral region. Left valve slightly higher and overlapping the right valve at the cardinal angles. Carapace slightly asymmetrical in dorsal view.

The valve is ornamented mainly by a low dorsal ridge which is parallel to the dorsal margin and continues posteriorly as a strong, smooth to slightly tuberculate posteromarginal ridge; a ventrally directed dorsoposterior ridge which is absent in some species; a narrow fairly prominent ventral ridge which anteriorly broadens and continues as a broad anteromarginal ridge. Postadjacent to the anteromarginal ridge is a shallow, submarginal groove parallel to the anterior margin. Prominent fairly massive tubercles may be present at the posterior cardinal angle of the valve from which extends a low diagonal ridge ending medially at a subcentral tubercle. Intercostal areas are finely punctate. Anterior and posterior margins are finely denticulate.

Eye tubercles low, internal ocular socket present. The inner lamella is widest in the anterior and posterior margins and narrow in the ventral margin. Line of concrescence and inner margin of duplicature not completely fused in the anterior and posteroventral regions where narrow vestibules are found. Smaller forms possess short, shallow anteromedian vestibules. Vestibule is totally absent in some forms. The selvage is strong and parallel to the anterior, ventral and posterior margins. The radial pore canals are straight to slightly wavy and with dilations near the outer margin, between 30 and 40 anteriorly and 11 and 20 posteriorly where they are sometimes paired.

Hinge holoamphidont; commences in the right valve with a conical anterior tooth, postadjacent to which is a circular, moderately deep anteromedian socket which is continuous with a weakly serrate posteromedian groove and a smooth, flat-topped posterior tooth of variable size.

Muscle scar pattern consists of a subvertical row of four fairly elongated adductor muscle scars, the dorsomedian scar longer than the others; a J-shaped frontal muscle scar and two fairly rounded mandibular muscle scars. There are two — an elongate anterior and a rounded posterior — muscle scars in dorsal scar group (i), three triagularly arranged muscle scars in dorsal scar group (ii), and three to four muscle scars in dorsal scar group (iii). Normal pores are moderately numerous, large, simple, open and countersunk below valve surface. They number between 35 and 50 per valve.

Sexual dimorphism is distinct. Females are shorter and more tuberculated than males, and usually possess finer marginal denticulations.

Stratigraphic range. Recent.

Geographic distribution. So far only reported from the Gulf of Guinea (West Africa).

Ecology. Abundantly occurring on medium to fine-grained quartzose sand and silt. Marine, inner neritic; warm tropical climate; bottom temperature 25.1 °C; bottom salinity 30.36—35.50 $^0/_{00}$.

Remarks. Neocythereis is similar in habitus to *Occultocythereis* Howe. Both genera possess tuberculate valves, denticulate extremities, marginal ridges, moderately broad duplicature, a holoamphidont hinge and simple normal pore canals. *Neocythereis* differs from *Occultocythereis* in having numerous straight radial pore canals; the occurrence of a crescentic vestibule, differently arranged adductor muscle scars, and the absence of the posteroventral wing-like projection occurring in *Occultocythereis.* The type species of *Neocythereis* has a longer carapace than that of *Occultocythereis.* Van Morkhoven (1963, p. 197) mentioned the occurrence of some Recent and Younger-Tertiary forms which resemble *Occultocythereis* in all respects, "...except that they have straight unbranching marginal pore canals". The new genus *Neocythereis* fits rather closely to such a description and may correspond to the forms to which van Morkhoven refers.

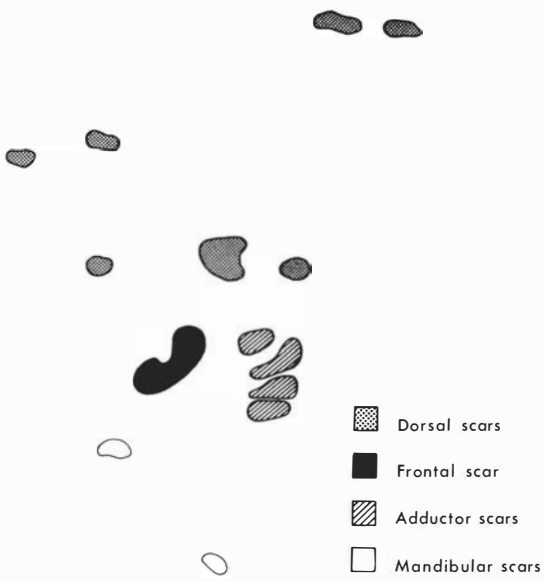


Fig. 5. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Neocythereis ? simplex* n. sp.

Neocythereis nigeriensis n. sp.

Pl. 1, Figs. 1—13; Fig. 3

Derivation of name. Nigeria.

Holotype. A male left valve, Af. 82, figured as Pl. 1, Fig. 1. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by a female subquadrate carapace and a male subrectangular carapace, in lateral view. Carapace medium sized; extremities denticulate; occurrence of three more or less continuous dorsal, anterior and ventral marginal ridges, a diagonal ridge which may be broken into a row of tubercles; presence of posteromarginal tubercles; apparently smooth intercostal areas and occurrence of narrow, shallow anterior vestibules in males.

Description

Carapace subrectangular to subquadrate in lateral view, laterally compressed in dorsal view; valves slightly asymmetrical. Dorsal margin slightly arched, highest anterior to median at the anterior cardinal angle, slopes steeply anteriorly and gently posteriorly where the posterior cardinal angle breaks the slope. Anterior margin dorsally oblique, ventrally broadly rounded and bears 8—10 short marginal denticles. Ventral margin acute, slopes steeply dorsally and gently ventrally where it bears 5—6 short, strongly developed marginal denticles (Pl. 1, Figs. 1, 3, 9, 10).

Surface ornament consists of a low dorsal ridge parallel to the dorsal margin, and runs posteriorly to the posterior cardinal angle where it gives off a ventrally running, subventrical ridge. The latter terminates about one-third the way from the ventral margin (Pl. 1, Figs. 1, 3 and 10). A weak posteromarginal ridge is continuous dorsally with the dorsomarginal ridge, and is, especially in females tuberculate, and continues ventrally as a relatively strongly developed, narrow ventral ridge. The ventral ridge gives off at its posterior end a short tuberculate ridge approximately directly ventral to the subvertical posterodorsal ridge, it broadens out anteriorly and is continuous with the "corrugated" anterior submarginal ridge. The

latter ends dorsally at the low eye tubercle situated just anterior to the anterior cardinal angle. Behind the anterior submarginal ridge is a fairly deep groove which is as wide as the anterior submarginal ridge and is parallel to the anterior margin. Medially there is a diagonally running ridge, commonly broken into tubercles, which originates at the posterior cardinal angle and ends at the moderately developed subcentral tubercle. Intercostal areas apparently smooth but covered with fine pits (Pl. 1, Fig. 6). Eye tubercle low, almost inconspicuous; internal ocular socket prominent.

The muscle scar pattern consists of a vertical row of four fairly elongated adductor scars, the dorsal member of which points dorsally and not in close contact with the others; the dorsomedian member is slightly longer than the two ventral scars, a J-shaped frontal muscle scar in front of the upper two adductor scars and two oval mandibular muscle scars (Pl. 1, Figs. 5 and 8). The dorsal group (see Pl. 1, Fig. 8, and Fig. 3) is as described for the genus.

Normal pores are simple, open and countersunk. There are approximately 50 per valve. Some possess supporting calcareous structures for the pore canal (Pl. 1, Fig. 4).

Hinge holoamphidont, as described for the genus. The median ridge of the left valve of some individuals (Pl. 1, Fig. 5) may be non-crenulate. Selvage marginal strongly developed and runs along the anterior, posterior and ventral margins (Pl. 1, Figs. 2 and 9).

Inner lamella anteriorly broad, posteriorly narrow. Line of concrescence and inner margin of duplicature not completely fused, leaving a narrow, shallow crescent-shaped vestibule anteriorly, and a narrow posteroventral vestibule, in males. Females possess no vestibule. Radial pore canals (Pl. 1, Figs. 11—13) are straight, non-branching, sometimes paired and slightly dilating near their distal ends. There are 30—35 anteriorly and 12—14 posteriorly.

Sexual dimorphism is apparent in size; males are longer than females though females are slightly higher (Fig. 4). Females are more strongly ornamented than males and possess finely built marginal denticles and do not have vestibules.

Juveniles of this species not observed.

Material. 44 single valves. 27 are females and 17 are males.

Ecology and distribution. Neocythereis nigeriensis was recorded from a depth of 20 metres on a pale-brown quartzose sand with shell debris and glauconite, at stations GT and A1 in the western Niger Delta (see Tables I and II). Salinity ranges are at the surface between 25.5—31.6 $^0/_{00}$ and at the bottom between 30.3—35.5 $^0/_{00}$. The bottom temperature at station A1 was 25.1°C. It occurs abundantly off Tema Harbour, Ghana.

Dimensions.

	Length	*Height*
Holotype (male left valve)	0.62 mm	0.32 mm
Females (N = 9)	0.51—0.56	0.27—0.32
Males (N = 8)	0.56—0.62	0.30—0.32

Remarks. N. nigeriensis differs from another species of this genus — *N.? simplex* — in size and details of ornament. *N. nigeriensis* is larger than *N.? simplex* (Fig. 4) and has apparently smooth intercostal areas. The intercostal areas of *N.? simplex* are punctate and the valve is less tuberculated. The distribution of both species is different. *N. nigeriensis* is restricted mainly to a sandy substrate while *N.? simplex* is relatively abundant in fine, grey silt substrates (see Tables I and II).

Neocythereis ? simplex n. sp.

Pl. 2, Figs. 1—10; Fig. 5

Holotype. A male left valve, Af. 83, figured as Pl. 2, Fig. 1. Recent. Locality A5, western Niger Delta.

Diagnosis. This species is characterized by a subquadrate shape in lateral view; a strongly developed amphidont hinge; occurrence of large intercostal punctae; fairly large simple normal pores; absence of massive tubercles, and presence of a short anteromedian vestibule.

Description

Carapace subquadrate in lateral view, laterally compressed in dorsal view, with a slight posterior to median swelling in the females. Dorsal margin straight, highest at the anterior cardinal angle and

sloping steeply posteriorly and gently anteriorly. Posterior cardinal angle prominent. Anterior margin broadly rounded, dorsally oblique, and bears 25—28 short, closely packed marginal denticles (Pl. 2, Fig. 2). Ventral margin nearly straight with anterior to median sinuosity, posteriorly upturned where it is truncated to form an arcuate posteroventral margin. Posterior margin acute, steeply sloping dorsally and ventrally pointed. Left valve slightly larger than right valve, overlapping it at the cardinal angles and at the anteroventral and posteroventral margins. Surface ornament consists of low, fairly broad dorsal, anterior, ventral and posterior marginal ridges which are continuous and parallel to all the margins. The inner parts of these ridges are covered with large papillate pits which may be absent in the dorsal and ventromedian parts of the valve. Posterior to the anteromarginal ridge is a fairly broad, shallow submarginal groove with irregular boundaries. A low, weak diagonal ridge arises at the posterior cardinal angle and runs towards the median part of the valve where it ends in a low subcentral muscle tubercle. Intercostal areas mainly smooth, but with sparsely distributed punctae. Ventral to the anterior cardinal angle is a weakly developed eye tubercle; internal ocular socket present.

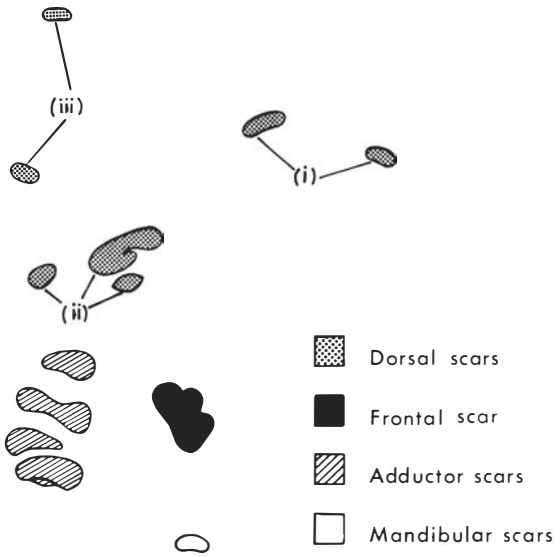


Fig. 6. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Phacorhabdotus hazeli* n. sp.

Normal pores are as far as can be determined simple, open and flushed below valve surface (Pl. 2, Figs. 3, 5, 7). They occur at the bottom of the papillate pits and there are 32—40 per valve.

Muscle scar pattern (Fig. 5) consists of a J-shaped frontal muscle scar; a vertical row of four adductor muscle scars, the lower three of which are in close contact with each other, two oval mandibular scars, present in the ventral part of the valve; and a dorsal muscle scar pattern of two elongated scars in dorsal group (i), an anterior subtriangular and a posterior oval scar in dorsal group (ii), and three triangularly arranged rounded scars in dorsal group (iii).

The hinge is holoamphidont, in the right valve (Pl. 2, Fig. 2) it commences with a high, conical anterior tooth, postadjacent to which is a deep ovate anteromedian socket which is widest and deepest anteriorly and narrows posteriorly, merging with the narrow dorsally serrate posteromedian groove. Posterior tooth smooth, flat-topped, fairly thick and higher at the anterior end. Selvage strongly developed and parallel to the outer margins. Inner lamella well developed, widest anteriorly, narrow ventrally and fairly broad posteriorly. Inner margin and line of concrescence not totally fused anteriorly leaving a short, shallow anteromedian vestibule. Posterior vestibule lacking (Pl. 2, Fig. 6, 9, 10). Radial pore canals straight, unbranching, slightly dilated at their distal ends, between 36 and 40 anteriorly and 14—16 posteriorly. Two to three radial pores may arise from the same points, especially at the anteroventral region.

Sexual dimorphism is only apparent in size (Fig. 4). ?Females are slightly higher and longer than ? males. Juveniles of this species not observed.

Material. Six specimens; four ?female carapaces and two ?male valves.

Ecology and distribution. This species was recorded from depths of 20 and 30 metres respectively at stations GT and A5 in the western Niger Delta (see Tables I and II). Salinity readings are as for *N. nigeriensis.* The bottom temperature at station A5 was 21.3°C. *N.? simplex* occurs on both sandy and silty substrates.

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.410	0.225	—
Females	0.437—0.458	0.240—0.248	0.143—0.150
Males	0.410—0.415	0.225	—

Remarks. This species is doubtfully placed in the genus *Neocythereis* owing to its small size, coarsely punctate surface, and adductor muscle scars. It is however similar in general shape, details of the hinge, presence of a J-shaped frontal muscle scar, and the occurrence of the basic ornamental costae to *N. nigeriensis.*

Genus PHACORHABDOTUS Howe and Laurencich, 1958

Type species *Phacorhabdotus texanus* Howe and Laurencich, 1958

Phacorhabdotus hazeli n. sp.

Pl. 3, Figs. 1—11 and Fig. 6

Derivation of name. In honour of Dr. J. E. Hazel, American Museum Natural History.

Holotype. A left valve, Af. 84, figured as Pl. 3, Fig. 1. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by a distinct eye tubercle; a subrectangular shape in lateral view; a prominent diagonally running median ridge; strongly developed anterior and posterior marginal denticles; occurrence of compound-type normal pores and a large size.

Description

Carapace laterally compressed, medially constricted and widest posterior to median in dorsal view. Left valve slightly larger than right valve and overlaps it at the cardinal angles. Carapace subrectangular in lateral view. Anterior margin broadly rounded and bears 12—15 paddle-like denticles. Dorsal margin straight, gently sloping posteriorly where it seems serrated owing to the perforate posterior part of the dorsomarginal ridge; it is highest at the anterior cardinal angle at the top of which is a strongly developed eye tubercle. Posterior margin laterally compressed, narrowly rounded, medially subangulate and ventrally with 7—9 marginal denticles. Ventral margin slightly convex posteriorly upturned.

The surface ornament consists of three ridges. There is a dorsomarginal ridge which runs from behind the eye tubercle and is posteriorly perforate. It runs posteriorwards to about one-fifth of the way from the posterior cardinal angle before turning vertically for a short distance and continues diagonally as the median diagonal ridge. This latter ridge is strongly developed and runs anteriorwards, with a median discontinuity in some individuals. It ends in a net-like pattern of riblets on a low, weakly developed muscle node. The most prominent of these riblets runs dorsally to the base of the eye tubercle. Between the riblets the valve surface is finely pitted (Pl. 3, Fig. 3). There is a thin ventral ridge which is continuous anteriorly with the anteromarginal ridge but is slightly inwardly turned at its posterior end. Anteriorly there is a thin weakly developed anteromarginal ridge. Intercostal areas smooth. In dorsal aspect, there is an arc-shaped, keel-like structure which continues anteriorly as the anteromarginal ridge and curves inwardly posteriorly as an internal ledge to the dorsal side of the eye tubercle.

Normal pores are of the compound type (Pl. 3, Figs. 5 and 8), few, large and deeply flushed below valve surface. The setal pores are elevated above the sieve plates and there are ?two slightly separated setal pores per plate. The compound normal pores are distributed mainly along the median ridge (Pl. 3, Fig. 11). The muscle scar pattern (Pl. 3, Figs. 4, 7; and Fig. 6) consists of an irregular L- or E-shaped frontal muscle scar, a subvertical row of four fairly elongate adductor scars, the dorsomedian scar being the longest and is slightly constricted, one mandibular scar, a dorsal group of two oval scars in dorsal group (i), a large sickle-shaped scar dorsal to two small rounded scars in dorsal group (ii) and two oval muscle scars in dorsal group (iii). The hinge is holoamphidont; it commences in the left valve (Pl. 3, Fig. 2) with a deep oval anterior socket ventrally bounded by an anteroventral extension of the anteromedian tooth, which is pointed and slightly stepped. The posteromedian hinge element is a narrow finely crenulate ridge, which becomes

relatively broad posteriorly where it ends in the anterior part of the slit-like posterior socket. Hinge in right valve corresponds. Selvage peripheral, weak or sometimes absent.

Inner lamella broad anteriorly and posteriorly. Line of concrescence and inner margin coincident. Vestibule absent. Radial pore canals straight, numerous anteriorly and fewer posteriorly, occur singly or in groups of two or three and are commonly dilated at their distal ends.

Juveniles of this species are identical in most respects to adults. Only the last larval instars were encountered.

Material. 13 specimens; eight adults, three carapaces, two left valves and three right valves, and five juvenile valves.

Ecology and distribution. This species was recorded only from sandy bottoms at stations GT and A1 in the western Niger Delta (see Tables I and II) at a depth of 24 metres. The bottom temperature at station A1 was 25.1°C; the salinity is as recorded for the western Niger Delta. It is rare in the western delta, but has been identified from Recent shallow marine inner neritic samples from off Tema Harbour, Ghana (courtesy of Dr. K. G. McKenzie and Miss P. Cook, British Museum of Natural History, London), and also from pale-brown calcareous sands from off Bandama, Ivory Coast.

Dimensions.

	Length	*Height*	*Width*
Holotype	0.720	0.330	—
Paratypes	0.720—0.735	0.340—0.345	0.23

Remarks. The grouping of this species within *Phacorhabdotus* is based on its close affinity in habitus to species of the genus, rather than to the geologically younger genus *Ambocythere* van den Bold. It can be differentiated from other known species, all fossil, of *Phacorhabdotus* by its strongly developed eye tubercle, presence of strong anterior and posterior marginal denticles; occurrence of compound normal pores, an elongated dorsomedian adductor muscle scar, and a relatively large size. It is however similar in habitus to *P. pokornyi* Hazel and Paulson (1964).

Practically all formerly described species of *Phacorhabdotus* are fossil. The present species possesses the diagnostic characteristics (according to Pokorný (1963) and Hazel and Paulson (1964)) of *Phacorhabdotus.* Benson (1969, p. 477) however has noted "... many specimens of a form very similar to *Phacorhabdotus...*" in Recent sediments from abyssal depths.

The broad similarity between *P. hazeli* n. sp. and *P. pokornyi* Hazel and Paulson (= *Cythere semiplicata* Reuss) is mainly the relatively strong ornament, the marginal denticles and the three lateral ribs. Although only one Recent species has so far been identified, it may seem that the supposed "primitiveness" (Hazel and Paulson 1964, p. 1051) in the strong ornament may need some clarification in the light of this new species. Hazel and Paulson (*op. cit.*) considers *P. pokornyi* as primitive on the grounds that it differs from other examples of *Phacorhabdotus* by possessing "... an eye tubercle and by being denticulate around the marginal rim". *P. hazeli* n. sp. possesses these features. It is highly probably that the polymorphogenic trend in the reduction of ornament and absence of an eye tubercle from older to younger species is due to such ecological factors as depth. Ostracodes living in deep water are known to show loss of the eye tubercles and a reduction of ornament, while their shallow water relatives show strong development of these features. However, a single Recent example, as is this, does not invalidate the hypothesis of an evolving polymorphogenic trend in fossil species of *Phacorhabdotus.*

Genus CARINOCYTHEREIS Ruggieri, 1956

Carinocythereis asterospinosus Omatsola, 1970

Remarks. This species was described by Omatsola (1970 b) from locality GT off Lagos in the western Niger Delta.

It is mostly found to occur on sandy substrates in other parts of the western Niger Delta as recorded for the holotype. Individuals of this species are also found on silty sand rich in shell debris and glauconite, silt, and silty mud. It was recorded from stations GT, A1, A4, J2 and J4 in the western Niger Delta, and is found to be

sparcely distributed on medium to fine-grained sediment substrate in other parts of the delta.

Genus CATIVELLA Coryell and Fields, 1937

Cativella iyemojai n. sp.

Pl. 4, Figs. 1—8

Derivation of name. From *iyemójá* (Yoruba), the goddess of the sea.

Holotype. A male right valve, Af. 85; figured as Pl. 4, Fig. 1. Recent. Locality A5, western Niger Delta.

Diagnosis. This species is characterized by three prominent, non-perforate lateral ridges, connected by short vertical ridges which gives a pseudo-reticulate pattern; a heart-shaped frontal muscle scar and a small size.

Description

Carapace subtriangular in lateral view, ovate in dorsal view, widest posterior to median. Dorsal margin strongly arched owing to the projecting dorsal ridge, highest anteriorly at the anterior cardinal angle, posteriorly steeply sloping. Anterior margin broadly rounded and bears 11—14 sharp-pointing denticles which are concentrated subventrally. Ventral margin straight with a slight anterior to median sinuous. Posterior margin acutely drawnout, ventrally pointing and bears 5—6 strong marginal denticles.

The most prominent surface ornamental features (Pl. 4, Fig. 1) are, a strongly arched dorsomarginal ridge which starts posteriorly and runs along the dorsal margin to just behind the eye tubercle from where it curves strongly inwards and is connected to the dorsal part of the median ridge; a short anterodorsal ridge connects the base of the eye tubercle and the incurved part of the dorsal ridge; a strong, anteromarginal ridge is connected on its innerside to the median and ventromedian ridges and is continuous with the ventromarginal ridge, a bow-shaped median ridge starts posteriorly and runs anteriorly with a slight flexure before reaching the median part of the anteromarginal ridge; a ventromedian ridge runs posteriorly from the ventral part of the anteromarginal ridge and stops about one-fourth way to the posterior margin, and a ventral ridge runs along the posterior half of the ventral margin and is connected posteriorly to the ventromarginal ridge. Intercostal areas are, especially in the dorsal, median and ventral areas, covered by short, vertically running connecting ridges and tubercles which produce a reticulate pattern (Pl. 4, Figs. 1 and 3).

Normal pores are simple, open and elevated. They occur on tubercles (Pl. 4, Figs. 4 and 6) and on the short connecting ridges.

The adductor muscle scars are typical for the genus, and the frontal muscle scar is heart-shaped. There are two fairly rounded muscle scars in each of dorsal groups (i) and (ii), and an unidentifiable number of scars in dorsal group (iii) (see Pl. 4, Fig. 5).

The left valve consists of an oval fairly deep anterior socket, ventrally closed by an anterior extension of the postadjacent anteromedian peg-like tooth which is posteriorly continuous with the crenulated posteromedian ridge. The crenulation of the posteromedian ridge is progressively stronger posteriorly. The posterior hinge element is a ventrally open, shallow C-shaped socket. The right hinge corresponds. Selvage weak and subperipheral.

Inner lamella wide in the anterior and posterior margins. Line of concrescence and inner margin coincide throughout; vestibule absent. Radial pore canals straight to slightly wavy, moderately numerous anteriorly and posteriorly and continuing into the marginal denticles where they become enlarged. Sexual dimorphism distinct; males slightly longer than females and females generally higher than males. Juveniles closely similar to females, but possess a narrow inner lamella, merodont hinge, weakly developed longitudinal ridges and reduced vertical connecting ridges.

Material. 48 specimens, all single valves; 25 of these are adults: 18 females and 7 males.

Ecology and distribution. Cativella iyemojai n. sp. occurs on sandy and silty substrates in which there are abundant fecal pellets, algae, shell debris and glauconite (Table I). It was recorded from stations GT, A1 and A5 with a depth range of 20—30 metres.

It occurs in Recent shallow water sediments from off Bandama (Ivory Coast).

Dimensions.

	Length	*Height*
Holotype (male right valve)	0.540	0.304
Females	0.520—0.525	0.300—0.319
Males	0.530—0.545	0.302—0.315

Remarks. Apart from its cativelline shape and small size, this species is similar morphologically to *Carinocythereis asterospinosus* Omatsola (1970). It differs in possessing a tapering posterior margin, and in the occurrence of strong, short, vertical connecting ridges between the longitudinal ridges.

Subfamily PTERYGOCYTHEREIDINAE Puri, 1957

Genus RUGGIERIA Keij, 1957

Type species *Cythere micheliniana* (Bosquet)

Ruggieria tricostata n. sp.

Pl. 5, Figs. 1—10; Figs. 7 and 8

Derivation of name. After the three prominent longitudinal ridges.

Holotype. A male right valve, Af. 87, figured as Pl. 5, Fig. 1. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by three prominent longitudinal ridges; an elongate to subovate shape in lateral view; few, large, elevated simple normal pores and three to four short, blunt anterior submarginal denticles.

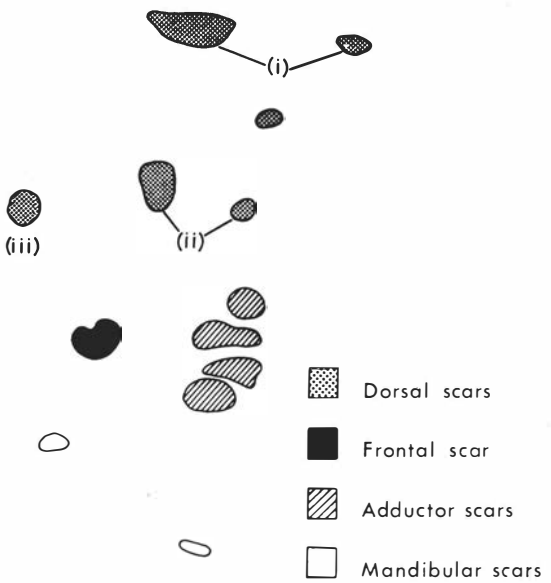


Fig. 7. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars typical for the species of *Ruggieria* studied.

Description

Valves asymmetrical, left valve larger than right; elongate to subovate in lateral view. Dorsal margin straight to slightly arched, uneven, posteriorly gently sloping and marked by a heavy dorsal ridge and highest at the anterior cardinal angle; anterior margin dorsally oblique, ventrally broadly rounded and bears a submarginal row of 3—4 relatively large, blunt denticles and a marginal row of 13—15 small denticles. Ventral margin straight, with an anterior sinuosity, a slight convexity anterior to median and an upturned posterior end; posterior margin obliquely rounded, ventrally truncate and with 4—5 strong marginal denticles.

Surface ornament consists primarily of a broad, strongly arched dorsal ridge, the anterior and posterior ends of which are curved inwards towards the median parts of the valve where they die out before reaching the median ridge; a median ridge that runs, in the males, all the length of the valve (Pl. 5, Fig. 1) and stops in the females at about one-third the way before the anterior margin (Pl. 5, Fig. 3) a strongly developed ventromedian ridge which runs from the anterior margin where it is connected to one of the submarginal denticles, posteriorly forming two posterolateral spines before reaching the posterior margin. A thin ventral ridge runs laterally without reaching the anterior or posterior margins. Eye tubercles weakly developed, internal ocular sinus pronounced. Intercostal areas smooth but seemingly finely tuberculate owing to the elevated simple normal pores.

Normal pores large, simple, open and with elevated ovate rims (Pl. 5, Figs. 5 and 6).

Muscle scars consist of a vertical row of four unequal adductor muscle scars, the dorsomedian

member of which is wedge-shaped, an open U- or heart-shaped frontal scar, two subrounded scars each in dorsal groups (i) and (ii), three muscle scars in dorsal group (iii), and two oval mandibular scars (see Pl. 5, Fig. 7, and Fig. 7).

Hinge holoamphidont, as for the genus (see Pl. 5, Figs. 2, 4, 7 for details). Selvage weak, subperipheral and runs along the anterior, ventral and posterior margins.

Inner lamella moderately broad anteriorly and narrow posteriorly. Line of concrescence and inner margin coincident, vestibule absent. Radial pore canals numerous, commonly straight to slightly wavy, 20—25 anterior and 4—6 posterior.

Sexual dimorphism pronounced, males slenderer, longer and lower than females (Fig. 8). Ornamental dimorphism slight.

Juveniles of the last larval stages are similar in shape to adults but with a weakly developed or absent dorsal ridge and weak submarginal denticles. The early larval stages are only identifiable with great difficulty, and are sometimes practically inseparable from instars of the same age of species such as *R. beninensis* n. sp. and *R. martinssoni* n. sp.

Materials. 258 specimens were studied; 104 of these are adults with a sex ratio of about 1:1.

Ecology and distribution. This species occurs on quartzose sand rich in shell debris and glauconite — stations GT, A1 and J2. A few specimens were also recorded from silty sand (station A10), and from dark-grey silt (station J4) (see Table I and II). Depth ranges between 20 and 75 metres. Bottom temperature ranges between 18.2°C and 25.1°C.

Occurs in Recent shallow marine sediments from off Bandama (Ivory Coast) and off Sierra Leone and Tema Harbour, Ghana.

Dimensions.

	Length	*Height*	*Width*
Holotype (male right valve)	0.600	0.300	—
Females	0.530—0.550	0.285—0.292	0.298—0.303
Males	0.600—0.615	0.300—0.310	0.285—0.293

Remarks. The most distinguishing features of this species are its large, simple normal pores, three prominent longitudinal ridges and smooth intercostal areas.

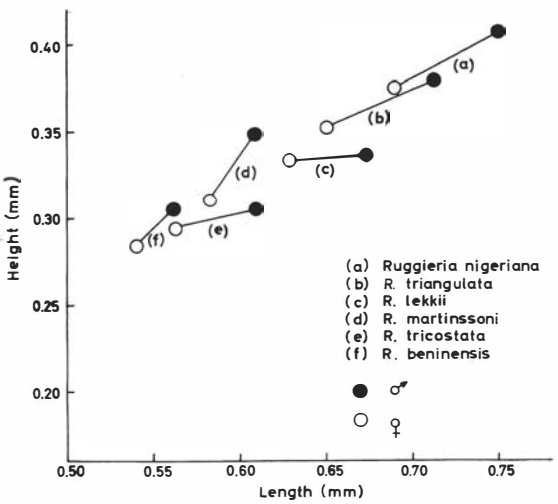


Fig. 8. Dimorphism and size difference in height and length for species of *Ruggieria.* The points plotted are the means for height and length of valves of adult males and females of the various species. The adult dimorphs of each species are connected by a solid line.

Ruggieria lekkii n. sp.

Pl. 6, Figs. 1—11; Fig. 8

Derivation of name. After the coastal town of *Lekki* (Western Nigeria) off which the species was recorded in abundance.

Holotype. A female left valve, Af. 88; figured as Pl. 6, Fig. 1. Recent. Locality J2, western Niger Delta.

Diagnosis. Characterized by an elongate to subtriangular carapace in lateral view; narrow ventromedian and ventral ridges; coarse pseudoreticulate pattern of ridges on the dorsal and dorsomedian parts of the carapace; small anteromarginal denticles interspersed with three to commonly four strong "bifid" denticles, and a prominent eye tubercle.

Description

Valves asymmetrical, elongate to subtriangular in lateral view. Dorsal margin arched in females, straight in males, highest at the anterior cardinal angle. In females, the dorsal margin slopes gently

posteriorwards with a slight median "saddle", and steeply anteriorwards; in males it slopes steeply anterior- and posteriorwards. Eye tubercle and internal ocular socket pronounced. Anterior margin broadly rounded, dorsally oblique and bears 12—13 marginal denticles. Ventral margin straight, dorsally upturned posteriorly, and with an anterior to median sinuosity. Posterior margin obliquely rounded, ventrally directed, broad in females but narrow in males (Pl. 6, Figs. 1, 2 and 3), and bears six variable marginal denticles.

Surface ornament consists of a dorsal and median network of "meandering" ridges giving a pseudoreticulate pattern in the adult (Pl. 6, Fig. 5). This pattern is well developed in the dorsal and anterodorsal regions. Below this is a thin ventrolateral ridge which runs from the posterior towards the anterior and bears a strong backwardly curving spine on its posteroventral part. Anteriorly it ends at about one-third the distance from the anterior margin. Between the ventromedian and ventral ridges an anterior ventrolateral ridge runs posteriorwards and is connected to a posterior ventrolateral ridge in the middle. The ventral ridge begins posteriorly, runs parallel to the ventral margin and continues anteriorly as the anterior submarginal ridge. On its anteroventral part it has four short ribs which are connected to the four strong "bifid" anteromarginal denticles. Normal pores few, simple, open and with narrow rims (Pl. 6, Figs. 7, 8). They are distributed mostly on and between the ridges (Pl. 6, Figs. 5).

Muscle scars are as shown (Fig. 7) for the genus. See Pl. 6, Fig. 4, for details of this species.

Hinge amphidont, as for the genus, (see Pl. 6, Figs. 2, 4 for details). Selvage weak, subperipheral.

Inner lamella moderately wide. Line of concrescence and inner margin coincident. Vestibule absent. Radial pore canals straight to slightly wavy, moderately numerous anteriorly (about 28) and about 8 posteriorly, sometimes running into the marginal denticles where they are enlarged (Pl. 6, Figs. 10, 11). Sexual dimorphism distinct; males longer and almost of the same height as females (Fig. 8). Females are laterally swollen posterior to median and posteriorly rounded, while males are posteriorly pointed. There seems to be sexually dimorphic morphologic differences on the areas surrounding the normal pores of both sexes (Pl. 6, Figs. 7 and 8).

Juveniles of the last three to four larval stages have the same shape, number and type of marginal denticles as males, but possess a more finely reticulated carapace, a small but distinct subcentral tubercle (Pl. 6, Fig. 6), a merodont hinge and a narrow inner lamella. The early larval instars are pitted.

Material. 54 specimens were collected, 20 of which are adults, all single valves: 12 females and eight males.

Ecology and distribution. This species is, as far as can be determined in the area of study, confined to sandy bottoms, quartzose sand rich in shell debris and glauconite (stations GT and A1) and pale-brown silty sand (station J2) (see Tables I and II). Depth ranges between 20 and 30 metres. This species has also been observed from silty sand bottoms in other parts of the Niger Delta.

Dimensions.

	Length	*Height*	*Width*
Holotype (female left valve)	0.630	0.350	—
Females	0.610—0.641	0.323—0.356	—
Males	0.652—0.675	0.320—0.361	—

Remarks. Ruggieria lekkii is different, especially in ornament, from all other species of *Ruggieria* recorded. Its younger instars are easily distinguishable from those of other species here studied, by their shape and ornament which is similar to those of adults. Similarity in the dorsal pattern of ornament is apparent between *R. lekkii*, *R. beninensis*, *R. triangulata* and *R. martinssoni*; specific differences occur in the details of ornament, shape and size (Fig. 8).

Ruggieria beninensis n. sp.

Pl. 7, Figs. 1—13; Figs. 7 and 8

Derivation of name. After the *Benin* River, off which the species was recorded in abundance.

Holotype. A female left valve, Af. 89; figured as Pl. 7, Fig. 1. Recent. Locality A5, western Niger Delta.

Diagnosis. Characterized by a relatively small size; ovate to elongate shape; occurrence of a series of ribs forming a concentric pattern of pseudotriangles; two lateroposterior spines and the strong development of one of the posterior spines.

Description

Carapace elongate in dorsal view and ovate in lateral view; posteriorly laterally compressed. Valves asymmetrical, left valves higher but shorter than right valves (Pl. 7, Figs. 3, 4, 9, 13). Dorsal margin straight, slightly concave medially, highest at the anterior cardinal angle, slopes gently posteriorly and relatively steeply anteriorly. Anterior margin broadly rounded, slightly oblique dorsally and bears between 15 and 19 marginal denticles of unequal length which are concentrated anteroventrally. Ventral margin straight, slightly convex with a slight anterior to median sinuosity and posteriorly upturned. Posterior margin tapering in the right valve but truncate in the left valve, bears six marginal denticles, the fourth from the top strongly developed and upturned. Surface ornament consists dorsally of low, narrow ridges forming a concentric pattern of pseudotriangles. One of the posterodorsal ridges bears a short posterolateral spine. The base of the pseudotriangular pattern of ridges is formed by a long lateral ridge which reaches neither the anterior nor posterior margins. Below this is a mediolateral ridge which is anteriorly connected to the anterior submarginal ridge and is of the same length as the lateral ridge. A ventrolateral ridge commences posteriorly with two broad-based posteriorly pointing spines and runs anteriorly where it is connected to the anterior submarginal ridge. A relatively narrow ventral ridge begins posteriorly just below the spines of the ventrolateral ridge, runs anteriorwards paralleling the ventral margin, continuing dorsalwards as the anterior submarginal ridge. Dorsally, the anterior submarginal ridge forms a lateral branch from which two short ribs run to the base of the eye tubercle (Pl. 7, Fig. 1). Intercostal areas smooth.

Normal pores numerous, simple, open and with broad rims (Pl. 7, Figs. 6, 7, 9, 10). They are distributed on the slopes of the ridges and in the intercostal areas.

Muscle scar pattern (Pl. 7, Figs. 2, 5, 8 and Fig. 7) is as for the genus. The frontal scar is heart- or V-shaped, and there are two scars each in dorsal groups (i) and (ii), one or two scars are present in dorsal group (iii).

Hinge holoamphidont, as for the genus (see Pl. 7, figs. 2, 5, 6 for specific details). Selvage subperipheral, weakly developed or absent.

Inner lamella moderately wide, sometimes narrow (Pl. 7, Fig. 6). Line of concrescence and inner margin coincident. Vestibule absent. Radial pore canals commonly wavy, 20—24 anteriorly and 18 posteriorly. They extend into the anteromarginal denticles where they become enlarged.

Sexual dimorphism distinct; males longer and generally higher than females (Pl. 7, Figs. 3, 7 and Fig. 8); females show a tendency to smoothening of the ridges in the anterior and dorsal regions.

Juveniles similar to females in shape; the lateral ridges are however not strongly developed. The early instars of this species are practically indistinguishable from those of *R. lekkii* and *R. martinssoni.*

Material. 132 specimens of which 32 are adults: 20 males and 12 females.

Ecology and distribution. The most abundant occurrence of *R. beninensis* is from a fine grey silt with abundant fecal pellets, algae and shell debris — station A5. Lesser occurrences are at stations GT, A1 and J2, on quartzose sand rich in shell debris and glauconite (see Tables I and II). Depth range from 20 up to 30 metres. *R. beninensis* has also been observed to occur in other parts of the Niger Delta.

Dimensions.

	Length	*Height*	*Width*
Holotype (female left valve)	0.540	0.280	—
Females	0.540—0.555	0.263—0.298	0.258—0.290
Males	0.555—0.585	0.300—0.315	0.255—0.278

Remarks. R. beninensis is distinguished from other species of *Ruggieria* by its dorsal network of pseudotriangular ridges. It is similar in shape and

ornament to *R. tetraptera tetraptera* (Seguenza) figured by van den Bold (1964, Pl. 1, Fig. 1 a—c), but smaller than the latter.

Ruggieria nigeriana Omatsola, 1970
Pl. 12, Figs. 9—10

1970. *R. nigeriana*, Omatsola, p. 99; Pl. 3, Figs. 1—6; Pl. 4, Figs. 1—7.

Ecology and distribution. This species was reported by Omatsola (1970 b) from station GT off Lagos, Nigeria. Its distribution in the western Niger Delta seems restricted to pale-brown quartzose sand and silty sand with shell debris and glauconite, stations GT, A1 and J2. It appears to be a strictly shallow marine species occuring not deeper than 25 metres. Preliminary observation of samples from other parts of the Niger Delta reveals that it is very rare. I have observed it to be relatively abundant in shallow marine calcareous sands from off Bandama (Ivory Coast) (Reyment's collection May—June 1966).

Its distribution in high-energy turbulent near-shore areas seems correlatable with its greater size (see Fig. 8), thick shell substance and short, strongly developed marginal and lateral spines.

Ruggieria triangulata n. sp.
Pl. 8, Figs. 1—7; Fig. 8

Derivation of name. After its triangular shape.
Holotype. A female right valve; Af. 90; figured as Pl. 8, Fig. 1. Recent. Locality A4, western Niger Delta.
Diagnosis. This species is characterized by a strongly triangular shape in lateral view; a weakly developed fine reticular pattern of ornament on the posterodorsal part of the valve and the occurrence of a short, vertical, anterior submarginal ridge.

Description

Carapace triangular to subtriangular in lateral view; dorsal view torpedo-like and posteriorly compressed. Dorsal margin arched, highest at the anterior cardinal angle, from which it slopes gently anteriorly and steeply posteriorly, anterior margin broadly rounded strongly denticulate, ventral margin straight, slightly convex, with an anterior to median sinuosity, and posteriorly upturned, posterior margin ventrally produced, dorsal and ventral borders narrowing towards each other to a point from which projects a strong upwardly directed spine. Five other marginal spines occur.

Surface ornament consists in the dorsal half, of four to five ridges which are straight in their anterior parts, becoming medially arched, and posteriorly divided into a reticulated network of fine ridges. A strong mediolateral ridge runs the length of the valve and forms a strong posterolateral spine. This ridge and two other median ridges are connected anteriorly by a short ridge from which three short riblets radiate to the outer margin. Ventrally there are lateral ridges which are confined to the median parts of the ventral margin. Eye tubercles low, internal ocular socket prominent.

Normal pores numerous, large, simple, open and narrowly rimmed (Pl. 8, Fig. 6). They occur mainly in the intercostal areas (Pl. 8, Figs. 1 and 3).

Muscle scar pattern (Pl. 8, Figs. 2, 4, 5) consists of two to three scars in dorsal group (i), two fairly rounded scars in dorsal group (ii) and two to three scars in dorsal group (iii). The frontal scar is open V-shaped, and the adductor scars a vertical row of four, the dorsomedian and ventromedian scars are elongated (Pl. 8, Fig. 4). Two mandibular scars are present.

Hinge holoamphidont, as for the genus. Selvage weak or absent. Inner lamella wide. Line of concrescence and inner margin coincident. Vestibule absent. Radial pore canals straight to wavy in the anteroventral and posterior margins (Pl. 8, Fig. 7); there are about 19 anterior and 6 posterior such canals.

Sexual dimorphism distinct (Fig. 8); males longer and slightly higher than females, the posterior margin of females more pointed. Juveniles mostly similar in shape to females. The ornament in the late larval instars is more reticulate and the lateral ridges are not well developed. The triangular shape of the early larval instars distinguishes it from other species of this study.

Material. 44 specimens, 29 adults: 14 males and 15 females.

Ecology and distribution. This species does not show preference for a particular type of substrate (Table I). It occurs on quartzose sand, silty sand, fine grey silt and grey silty clay, respectively at stations GT and A1, A4, A5 and A9. Depth ranges between 20 and 80 metres. The occurrence of 2 and 4 specimens respectively at stations A5 and A9 may be due to the effects of current transportation and displacement of larval instars to the former and adult carapaces to the latter (see Table II).

Specimens have been identified from other parts of the Niger Delta especially from off the Pennington and Brass Rivers at depths of not more than 30 metres.

Dimensions.

	Length	*Height*	*Width*
Holotype (female right valve)	0.630	0.320	—
Females	0.623—0.675	0.320—0.370	0.255—0.288
Males	0.698—0.773	0.360—0.390	0.323—0.339

Remarks. Besides its strongly triangular shape, this species possesses all the hallmarks of the genus *Ruggieria.* Its narrow strongly pointing posterior margin is its most distinctive feature.

Ruggieria martinssoni n. sp.

Pl. 9, Figs. 1—11; Fig. 8

Derivation of name. After Docent A. Martinsson of the Paleobiological Institute, Uppsala, Sweden.

Holotype. A male left valve, Af. 92; figured as Pl. 9, Fig. 1. Recent. Locality A4, western Niger Delta.

Diagnosis. This species is characterized by strong asymmetry of its valves; a saddle-like dorsal margin in the left valve; thick shell substance; a faint network of dorsal ribs and a blunt ventrally produced posterior region.

Description

Carapace angulate-ovate to subtrapezoidal in lateral view; subtriangular to pyriform, and posteriorly compressed in dorsal view. Dorsal margin saddle-like in the left valve, straight in the right valve (Pl. 9, Figs. 1 and 2), highest at the anterior cardinal angle. In the left valve there is an anterior to median depression along the dorsal margin, posterior to which it is arched and from which it slopes gently posteriorly. In the right valve, the dorsal margin is straight, gently sloping up to the raised posterior cardinal angle from which it slopes steeply as the dorsal part of the posterior margin. Anterior margin obliquely rounded, ventrally slightly produced and carries small short marginal denticles interspersed with three to four large blunt denticles. Ventral margin almost straight, medially arched and with a shallow anterior to median sinuosity. Posterior margin acutely rounded, ventrally produced, with five strong ventromarginal denticles.

Surface ornament consists of a stout, low, dorsally convex dorsal submarginal ridge, a strongly developed, ventrally broad anterior submarginal ridge which gives off three to four ribs connected anteriorly to the three to four, strong anteromarginal denticles, a strong ventrolateral ridge which runs the whole length of the carapace, thickens medially and anteriorly, where it is connected to the anterior submarginal ridge; posteriorly it thins out and gives off two posterolateral spines. Medially a network of low Z-shaped ridges runs out anteriorly into four ridges and is posteriorly represented by a low ridge that ends in a short tuberculate spine. A low irregularly shaped tubercle occurs dorsal to the posteromedian part of the ventrolateral ridge. Eye tubercle pronounced, internal ocular socket present.

Normal pores few, large, simple, open and rimmed, slightly dimorphic (Pl. 9, Figs. 7 and 8).

Muscle scars basically as for the genus, not easily identifiable in many specimens due to the rough internal surface of the valves. Frontal muscle scar open V-shaped, adductor muscle scars form a subvertical row of four, the dorsomedian member being the longest (Pl. 9, Fig. 6).

Hinge holoamphidont, as for the genus. Selvage absent.

Inner lamella anteriorly broad and posteriorly

narrow. Line of concrescence and inner margin coincident. Vestibule absent. Radial pores mostly straight but sometimes wavy anteroventrally, between 20 and 24 anteriorly and 7 and 9 posteriorly (Pl. 9, Figs. 9—11).

Sexual dimorphism pronounced, males longer than females (Fig. 8). Females laterally swollen posteriorly and males widest in the posterior to median region (Pl. 9, Figs. 3 and 4). In the posterior region females are more laterally compressed than males and show a general tendency to smoothening. The last larval instars, the only juvenile stage found, are similar to the females, but with a more prominent network of dorsolateral ribs and marginal denticles.

Material. 11 specimens; five of these are adults; three males and two females.

Ecology and distribution. This species was recorded from sandy and silty sand substrates at stations GT, A1 and A4 (see Table I). It seems however, to prefer silty sand bottoms (Tables I and II). Depth range from 20 to 26 metres.

Ruggieria martinssoni was observed to occur in Recent near-shore sediments off Bandama (Ivory Coast) and off the coasts of Ghana and Sierra Leone. Considering its plump shape, thick shell and short, blunt and relatively stout marginal denticles, it is most probably a near-shore inhabitant of turbulent waters.

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.600	0.346	—
Females	0.560—0.585	0.300—0.323	0.180—0.200
Males	0.600—0.615	0.345—0.360	0.210—0.230

Remarks. This species differs from all other *Ruggieria* in possessing a subtriangular to pyriform shape in dorsal view, strong asymmetry between left and right valves, and a tendency to develop tubercles on the ventroposterior part of the valves.

General remarks on Ruggieria

In Keij's (1957, p. 112) original description of the genus *Ruggieria,* based on the species, *Cythere micheliniana* (Bosquet), and an unnamed species (Keij, *op. cit.*, p. 113), he diagnosed the genus as having a surface "... partly or entirely ornamented with reticulation or longitudinal ridges ...". However none of his figures (*op. cit.*, Pl. 20, Figs. 1—3; Pl. 14, Fig. 10) of the type species, nor that of the unnamed species, fit into his diagnosis. His figures (*op. cit.*) indicate that *Ruggieria* is primarily ornamented with costae, and other secondary surface sculpture may be as intercostal pitting or reticulation.

Besides such diagnostic features as shape, marginal denticles, upturned posterior margin, absence of vestibule, arrangement of the frontal and adductor muscle scars, prominent eye tubercle and medium to large size, another ornamental feature which seems to be diagnostic of the genus, is the presence of a short anterior marginal to submarginal ridge (see Keij 1957, Pl. 20, Figs. 1—2, and Pl. 14, Fig. 10), the ventral portion of which is thickened and from which short transverse ribs run anteriorly. This feature seems to occur in almost all species of *Ruggieria* (though not prominently in the type species), except in the strongly reticulate *R. dictyon* van den Bold, from Colon Harbour, Panama. Apart from its strongly reticulated surface ornament and subrectangular shape, *R. dictyon* appears to be congeneric. Van den Bold (1966 a, p. 50) remarked that the proper generic position of this species is not clear, and pointed out its probable identity with *Trachyleberis goujoni* (Brady) of Keij (1954), from the Gulf of Paria.

Fig 7 shows the arrangement of the muscle scars of species of *Ruggieria* of this study. The dorsal group of scars is figured in detail, and consists of an elongated anterior and an ovate posterior scar in dorsal scar group (i), an anterior oval to subtriangular, and a posterior rounded scar in dorsal scar group (ii). Between the dorsal scar groups (i) and (ii) a single scar is commonly found. Three scars are found in dorsal group (iii).

Subfamily BUNTONINAE Apostolescu, 1961
Genus BUNTONIA Howe, 1935

Buntonia olokundudui Reyment and Van Valen, 1969

Pl. 10, Figs. 1—10

1969. *Buntonia olokundudui* Reyment and Van Valen, p. 83, Pl. 2, Figs. 2, 8—9; Pl. 6, Figs. 1—7; Pl. 7, Figs. 1—7.

Reyment and Van Valen (1969) described in detail the anatomy and shell features of this species from off the mouth of the Escravos river in the Niger Delta proper. A close examination of the holotype reveals that it is a penultimate instar. In this study therefore, adult specimens of both sexes have been examined and figured to show the characteristic features of this species.

On plate 10, figures 3 and 7, show an anomalous arrangement of the adductor muscle scars. This is not typical for the species, in which there is commonly a vertical row of four adductor scars. The dorsal muscle field consists of two fairly elongated scars in a dorsal group (i), two rounded scars of unequal size in dorsal group (iii) (Pl. 10, Fig. 7).

Dimensions.

	Length	*Height*	*Width*
Females	0.570—0.600	0.315—0.360	0.300—0.315
Males	0.615—0.675	0.312—0.350	0.285—0.300

Sexual dimorphism is pronounced. Males are longer and lower than females (Pl. 10, Figs. 1—2) and are slightly narrower posteriorly. Juveniles are in all respects similar to adults except in the development of a merodont hinge and a narrow inner lamella.

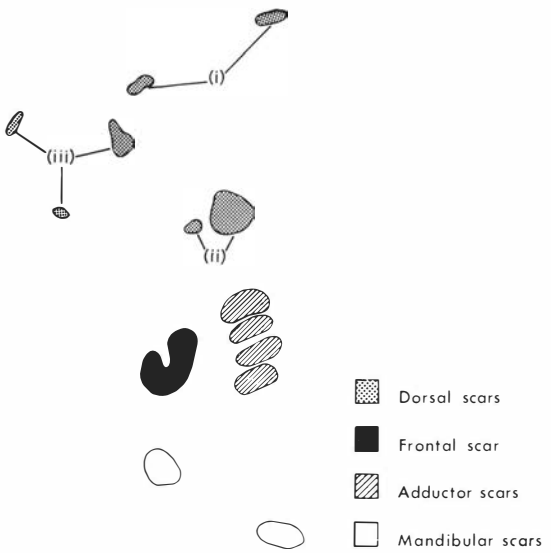


Fig. 9. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Buntonia foliata* n. sp.

Materials. 1851 specimens were seen, 119 of which are adults with a sex ratio of approximately 1:1.

Ecology and distribution. This is the most widespread single ostracode species in the Niger Delta. Its distribution in the western delta is predominantly on fine-grained substrates such as fine grey silt rich in shell debris, fecal pellets and algae (station A5). It is also found in numbers (see Tables I and II) on quartzose sand (stations GT and A1), on pale-brown silty sand rich in shell debris and glauconite (station J2), and to a lesser extent, on clayey substrates (station A3). The depth range within the western delta is between 20 and 35 metres, however specimens have been observed from depths of up to 70 metres in the delta proper. *B. olokundudui* has also been observed in near-shore samples from off Bandama, Ivory Coast.

Buntonia foliata n. sp.

Pl. 11, Figs. 1—11; Fig. 9

Derivation of name. From *folium* (Lat.) leaf, regarding the pattern of ornament on the carapace.

Holotype. A female right valve, Af. 93; figured as Pl. 11, Fig. 1. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by a thin anterior marginal ridge; a faintly denticulate posterior margin; four concentric posterior ridges, and two lateral longitudinal ridges.

Description

Carapace ovoid to pear-shaped in dorsal view; in lateral view, right valve ovate and left valve subtriangular (see Pl. 11, Figs. 2 and 6). Dorsal margin strongly arched, highest medially at the anterior cardinal angle, and gently sloping anteriorly and posteriorly. Anterior margin broadly rounded, ventral margin straight to slightly convex, posteriorly gently upturned and passing into the narrowly rounded, ventrally faintly denticulate posterior margin. Left valve overlaps right valve at the cardinal angles.

Surface ornament consists anteriorly of a narrow, prominent anteromarginal ridge appearing as a

ledge around the anterior margin and continuing anteroventrally to the ventral midpoint. Behind the anteromarginal ridge there is a smooth crescentic area which is lower than the valve surface. The valve surface is ornamented mainly by two laterally notched longitudinal ridges which converge anteriorly and with pitted intercostal areas between. Posteriorly these two ridges are broken by four subvertical concentric ridges which are parallel to the posterior margin. Ventrally, ventrolaterally and anterodorsally, the surface is smooth. In the dorsomedian, dorsoposterior and the anteromedian areas, the surface is covered by coarse pitting which gives a reticulate pattern.

Normal pores are few, small and occur at the bottom of the pits and on the ridges (Pl. 11, Figs. 3, 4, 7).

Muscle scars are typical of the genus. There is a J-shaped frontal scar, a vertical row of equal adductor scars (Pl. 11, Fig. 5), two scars each in dorsal groups (i) and (ii), and three scars in dorsal group (iii) (see Fig. 9).

The right hinge commences with a low "tooth-like" structure, postadjacent to which is a large, laterally pointed and generally rounded anterior tooth which is posteriorly extended below the anteromedian narrow "socket"; a posteromedian anteriorly smooth and posteriorly serrate groove, and a smooth, reniform posterior tooth. The left hinge corresponds. Selvage weak, peripheral anteriorly and subperipheral posteriorly. The hinge shows a high degree of modification.

Inner lamella wide anteriorly and narrow posteriorly. Line of concrescence and inner margin coincident throughout. Vestibule absent. Radial pore canals numerous, straight to slightly wavy; anteriorly about 26 with slight dilations at their distal ends, and about 12 posteriorly.

Sexual dimorphism distinct, males slightly more elongate and narrow posteriorly than females, and females slightly higher and more robust than males.

Three juvenile specimens identified as the last larval instars were seen. They are similar in shape to the males (Pl. 11, Fig. 9) and possess three to four posteromarginal denticles, a dorsally smooth, ventrolaterally finely pitted surface, and two anterior submarginal tubercle-like denticles.

Material. 11 specimens, all single valves; eight of these are adults, five males and three females.

Ecology and distribution. This species is rare in the western delta. It occurs at stations GT, A1, A8 and A9 on sediments ranging from quartzose sand rich in shell debris and glauconite to grey and dark-grey silty clay. An individual containing decomposed soft parts comes from station A8 on a silty clay bottom. Depth range for the species is between 20 and 80 metres (Tables I and II). This is one of the few species recorded in this study that show no preference for a particular substrate and it may also be stenothermal.

Specimens have been observed in deep-water marine samples from off Sierra Leone (courtesy of Dr. M. C. Keen, Geology Dept. Glasgow Univ.), and they are found to show reduced reticulation, absence of the anteromarginal ridge and loss of the fine posteromarginal denticulation.

Dimensions.

	Length	*Height*
Holotype (female right valve)	0.429	0.279
Females	0.428—0.450	0.263—0.279
Males	0.465—0.480	0.263—0.270

Remarks. This species is similar in general ornamental pattern to *Buntonia giesbrechti robusta* (Ruggieri) recorded by van den Bold (1964, p. 165—166; Pl. 3, Fig. 1) from the Neogene N'Tchengué Formation of Gabon, and also from Recent materials from the coast of Angola. It differs from *B. giesbrechti robusta* in its more rounded posterior margin, presence of an anterior submarginal depressed area, occurrence of an anteromedian reticulation, a strong dorsal arching at the anterior cardinal angle and a more ovate shape.

Genus SOUDANELLA Apostolescu, 1961

Soudanella africana n. sp.

Pl. 12, Figs. 1—8

Derivation of name. Africa.

Holotype. A male right valve, Af. 94; figured as

Pl. 12, Fig. 1. Recent. Locality J2, western Niger Delta.

Diagnosis. This species is characterized by a strongly subtriangular shape in lateral view; elongate-ovate in dorsal view; a low eye tubercle and a reticulate pattern of ornament built basically on a subrhomboid pattern of coarse ridges.

Description

Carapace subtriangular in lateral view, elongate-ovate in dorsal view; females laterally more robust than males, posterior extremity slightly compressed and narrowly drawn-out medially. Left valve overlaps right valve slightly at the cardinal angles and the ventromedian region. Dorsal margin angular, highest at the anterior cardinal angle from which it slopes steeply posteriorly with a slight concavity before reaching the posterior margin, and gently anteriorly. It is straight between the cardinal angles. Anterior margin obliquely rounded, ventrally pointing and bears about 15 marginal denticles. Ventral margin straight, slightly sinuous anterior to median, medially gently arched and posteriorly upturned. Posterior margin dorsally oblique, narrow and medially pointed.

Surface ornament consists of three to four closely set subrhomboidal pattern of ridges with a short centrally placed ridge. Intercostal areas coarsely punctate giving rise to a general reticulate pattern. In the anteromedian area, behind the anterior and inner submarginal ridges and the posteromedian part of the valves, the reticulation is strongly developed, and the ridges are subdued. Medially there is a prominent anteriorly flexed ridge which is anteriorly connected at its flexure by a short, posterior, lateroventral ridge. Eye tubercle low, almost imperceptible and occurs on the dorsal end of the inner submarginal ridge. Internal ocular socket prominent.

Normal pores simple, open, moderately numerous and broadly rimmed with relatively small pore openings. The rims may sometimes be extended into broad flap-like structures (Pl. 12, Figs. 6, 8). They are distributed between the pits. Muscle scar patterns are as shown for *S. africana reticularis* n. subsp. (see Fig. 10). There is an open V-shaped frontal scar, a nearvertical row of four adductor scars, the dorsomedian member of which is the longest, two elongate scars in dorsal group (i), two ovate scars in dorsal group (ii), two to three scars in dorsal group (iii), and two oval mandibular scars in the ventral part of the valve (Pl. 12, Fig. 5).

Right hinge consists of an anterior stepped tooth with a conical posterior projection, a postadjacent ventrally closed anterior socket which is posteriorly continuous with a medially narrow strongly serrate median groove, and a reniform posterior tooth. The left hinge corresponds. Selvage weak, peripheral.

Inner lamella broad anteriorly and narrow posteriorly. Line of concrescence and inner margin coincident. Vestibule absent. Radial pore canals numerous anteriorly (about 20) and few posteriorly (about 8), straight to slightly wavy.

Sexual dimorphism in size distinct, males longer, posteriorly strongly tapering and dorsoposteriorly lower than females; females more extended posterior to median and generally more ovate in dorsal view (Pl. 12, Figs. 3 and 4).

Juveniles are similar in shape and basic ornament to males. Their reticulation is more strongly developed than those of adults. The instars of this species are similar to those of *S. africana reticularis* but could be differentiated by the

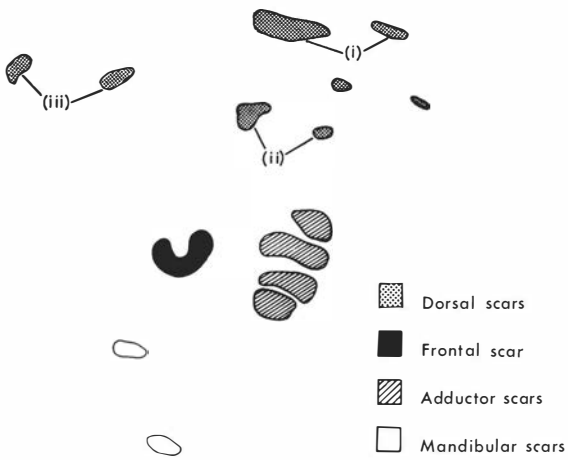


Fig. 10. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Soudanella africana reticularis* n. subsp.

strongly developed narrow posterior margin. The ornament of the larval instars of the species and subspecies is similar and sometimes indistinguishable.

Material. 115 specimens, 89 of these are adults with a sex ratio of 1:1.4 (males: females).

Ecology and distribution. This species is confined in the western delta to sandy substrates rich in shell debris and glauconite (stations GT, A1 and J2) at a depth ranging from 20 to 24 metres (see Table I). Bottom temperature ranges between 20°C and 25.1°C.

A few specimens have been identified from near-shore sand samples from off Bandama, Ivory Coast. So far none has been observed from the Niger Delta proper.

Dimensions.

	Length	*Height*	*Width*
Holotype (male right valve)	0.630	0.285	—
Females	0.558—0.595	0.300—0.315	0.185—0.190
Males	0.607—0.635	0.280—0.300	0.175—0.182

Remarks. This species and the subspecies *S. africana reticularis* n. subsp. have been placed in the genus *Soudanella* on the bases of shape, lateral and dorsal, basic ornament which is costate, arrangement of the frontal and adductor muscle scars and hinge. These species are generally smaller in size than is diagnosed for the genus.

Soudanella africana reticularis n. subsp.

Pl. 13, Figs. 1—11; Fig. 10

Derivation of name. In reference to the finely reticulated ornament.

Holotype. A male left valve, Af. 95; figured as Pl. 13, Fig. 1. Recent. Locality A1, western Niger Delta.

Diagnosis. This subspecies of *S. africana* is characterized by finer reticulation; occurrence of finely built anteromarginal denticles; antero- and posteroventral serration of the inner part of the outer margin; relatively large normal pore openings; a short straight lateromedian ridge; a more obtusely rounded posterior margin and a smaller size.

Description

Carapace subtriangular in lateral view, elongate in dorsal view; females laterally more robust than males, posterior extremity slightly extended medially. Dorsal margin medially straight, gently arched, sloping steeply posteriorly and gently anteriorly. Anterior margin obliquely rounded, bearing about 20 fine marginal denticles. Ventral margin slightly sinuous anteriorly, medially convex and posteriorly upturned. Posterior margin dorsally truncated, slightly produced medially and generally obliquely rounded.

Surface ornament basically identical to that of *S. africana.* The lateral, marginal and submarginal ridges and reticulation are finer than in *S. africana.* Medially there is a straight lateromedian ridge which is in its anterior portion ventrally directed and is here connected to the adjacent lateroventral ridge.

Normal pores moderately numerous, simple, open, broadly rimmed, with a flap-like extension of the rims in some cases, and in others a bow-shaped structure across the relatively large pore openings (Pl. 13, Figs. 3, 5, 6, 8). Eye tubercle as for *S. africana.*

The frontal and adductor muscle scars are as described for *S. africana.* In the dorsal group of scars, there are two elongated scars in dorsal group (i), one triangular and one ovate scar in dorsal group (ii), and two scars in dorsal group (iii). Between dorsal groups (i) and (ii) there are two oval scars (see Fig. 10).

Hinge as described for *S. africana*; selvage peripheral.

Sexual dimorphism slight, males longer than females, and females generally more swollen in the posterior to median parts of the carapace.

Juveniles are similar to males. They are difficult to differentiate from those of *S. africana.*

Material. 25 specimens; 18 adults: 8 females and 10 males.

Ecology and distribution. This species has the same distributional pattern as *S. africana.* It was recorded from stations GT, A1 and J2 (see Tables I and II).

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.585	0.275	—
Females	0.548—0.580	0.270—0.287	0.288
Males	0.585—0.593	0.255—0.265	0.260

Remarks. Soudanella africana reticularis is similar to *S. africana* n. sp. in practically all respects except for a more pronounced obtusely rounded posterior extremity, a straight, short lateromedian ridge, finer reticulation and ridges, and a generally small size.

Genus DAKRIKA n. gen.

Type species *Dakrika robusta* n. sp.

Derivation of name. Dakri (Gr.), tear drop; after the shape of the carapace.

Diagnosis. This monotypic genus of the Buntoninae is characterized by the following properties: medium size; tumid carapace; subtriangular to ovate in lateral view; ellipsoidal in dorsal view. Posterior extremity compressed and denticulate, with alternating large and small denticles in the anterior margin; a pronounced eye tubercle; surface moderately punctate with a weak lateroventral ridge which bears two posterior spines; holoamphidont hinge; a vertical row of four more or less rounded adductor muscle scars; a single U-shaped frontal muscle scar; absence of vestibule and straight to slightly wavy radial pore canals.

Description

Carapace of medium size, subtriangular to ovate in lateral view, elliptical in dorsal view, with a compressed posterior extremity. Left valve overlaps right at the cardinal angles and along the ventral margin. Eye tubercle prominent. Dorsal margin gently arched to slightly undulated, with a thick rim and highest anteriorly. Anterior margin broadly rounded and finely denticulated. Ventral margin convex medially and posteriorly upturned. Posterior margin narrow, medially pointed and with up to eight strong spines.

Central and ventral exterior portions of the valves coarsely punctate. There is a low, wing-like lateroventral ridge which bears two posterior spines and a prominent anterior submarginal ridge. Normal pores simple, open and distributed within and between the punctae. Hinge holoamphidont, with a laterally pointed anterior tooth which in the right valve is followed by a shallow posteromedian groove and a smooth reniform posterior tooth. The hinge in the right valve begins with a shallow oval socket, postadjacent to which is a sharply pointed anteromedian tooth with a curved anterior extension which forms the ventral part of the anterior socket. The posteromedian hinge element is a crenulate ridge with the crenulations becoming progressively stronger posteriorwards, the posterior hinge element is a deep, ventrally open reniform socket.

Inner lamella anteriorly and posteriorly wide; vestibule absent; radial pore canals straight to slightly wavy, numerous anteriorly and few in number posteriorly. Selvage moderately developed, low and peripheral.

Central muscle scars consist of a U-shaped frontal scar, and a subvertical row of four, fairly rounded adductor scars, the median member of which is club-shaped. Dorsal scars consist of two elongated scars in dorsal group (i), a large oval and a small rounded scar in dorsal group (ii), an elongate dorsal, small rounded anterior and a posterior ovate scar in dorsal group (iii). Two large mandibular scars present in the ventral part of the valve.

Sexual dimorphism slight, males usually larger and more elongated than females.

Stratigraphic range. Recent.

Geographic distribution. Niger Delta and possibly along the tropical to subtropical coasts of West Africa.

Ecology. The genus is comparatively rare and seemingly confined to fine-grained substrates, from medium to deep waters. Marine.

Remarks. In habitus this genus shows affinities with genera such as *Brachycythere* Alexander, *Bosquetina* Keij, *Opimocythere* Hazel and *Incongruellina* Ruggieri. It is closely related to the latter genus in general habitus, hinge and the occurrence of marginal denticles. However, *Dakrika* differs in many respects from *Incongruellina. Incongruel-*

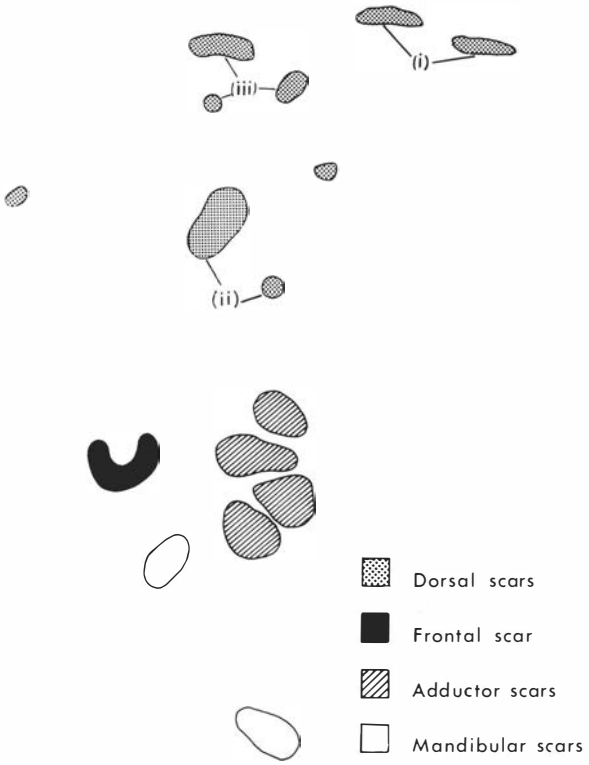


Fig. 11. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Dakrika robusta* n. sp.

lina has strongly asymmetrical valves, a straight dorsal margin, a strongly developed ventrolateral wing-like extension which posteriorly bears a strong spine, a flat venter, a prominent anteromarginal flange, large anterior and posterior vestibules, and a V-shaped frontal muscle scar. Conversely, *Dakrika* has symmetrical valves, a smaller size, no vestibule, a straight to gently arched dorsal margin, a low, weakly developed lateroventral ridge bearing two short posterolateral, backwardly pointing spines, a relatively convex venter, absence of an anterior flange, a U-shaped frontal muscle scar and a carapace shape reminiscent of the Buntoninae.

Dakrika robusta n. sp.

Pl. 14, Figs. 1—10; Fig. 11

Derivation of name. robustus (Lat.), robust after the robust shape of the carapace.

Holotype. A male right valve. Af. 96; figured as Pl. 14, Fig. 1. Recent. Locality A9, western Niger Delta.

Diagnosis. This species is characterized by a subtriangular to ovate shape in lateral view; elliptical in dorsal view with posterior extremity compressed; occurrence of strongly denticulated anterior and posterior margins; a strong eye tubercle; surface medially covered by coarse punctae and a lateroventral ridge which is anteriorly continuous with the strong anteromarginal ridge.

Description

Carapace subtriangular to ovate in lateral view; elliptical in dorsal view; posterior extremity compressed. Left valve slightly larger than right valve and overlapping it at the cardinal angles and along the ventral margins. Dorsal, anterior, ventral and posterior margins as described for the genus. Surface ornament consists of coarse, irregularly arranged punctae occurring only on the central part of the valve, a low fairly stout lateroventral ridge (with two short posterolateral backwardly directed spines) which is anteriorly continuous with a thin, anterior submarginal ridge that ends dorsally below the strongly developed eye tubercle. Below the lateroventral ridge the pattern of pitting is roughly parallel to that ridge and the pitting becomes smaller away from the ridge (Pl. 14, Fig. 1). Normal pores as described for the genus.

Hinge and muscle patterns as described for the genus (see respectively Pl. 14, Figs. 2 and 9; and Pl. 14, Figs. 2, 5; Fig. 11).

Inner lamella wide anteriorly and posteriorly, almost of equal size, but sometimes narrow (Pl. 14, Fig. 9). Radial pores numerous, anteriorly about 30—40, posteriorly about 15—20, and commonly straight to slightly wavy. Sexual dimorphism as described for the genus.

Juveniles of this species were not observed.

Material. 10 specimens, six males and four females.

Ecology and distribution. This species is confined to fine or very fine substrates. It was recorded from stations A5, A7 and A9, with a depth range of between 30 and 80 metres. The bottom temperature for station A5 was 21.3 °C.

Dakrika robusta is not restricted to the western delta. Examination of sediment samples from depths between 25 and 80 metres in the Niger Delta proper shows it to be rare there. A larger species of this genus is reportedly living in deeper waters off the coast of Nigeria (D. Keurs, personal communication 1970). The species has so far not been recorded outside the Niger Delta.

Dimensions.

	Length	*Height*	*Width*
Holotype (male right valve)	0.650	0.398	—
Females	0.630—0.640	0.368—0.375	0.368
Males	0.645—0.660	0.390—0.398	—

Subfamily ECHINOCYTHEREIDINAE Hazel, 1967

Genus CHRYSOCYTHERE Ruggieri, 1962

Chrysocythere foveostriata (Brady)

Pl. 15, Figs. 1—15; Fig. 12, 13, 14, 15

1870. *Cythere foveostriata* (Brady), p. 247; Pl. 32, Figs. 14—17.

Discussion

The species here identified as *Chrysocythere foveostriata* (Brady) is closely similar if not identical in all respects to *C. foveostriata* (Brady) discussed and figured by van den Bold (1964, p. 162; Pl. 2, Fig. 1 a, b; Pl. 5, Fig. 3 a, b), from the Upper to Post-Miocene Formations of Gabon. The Nigerian specimens (as already noted by van den Bold 1964, p. 162), show slight morphologic differences. They have relatively reduced marginal denticles, a lower eye tubercle and heavier lateral ribs.

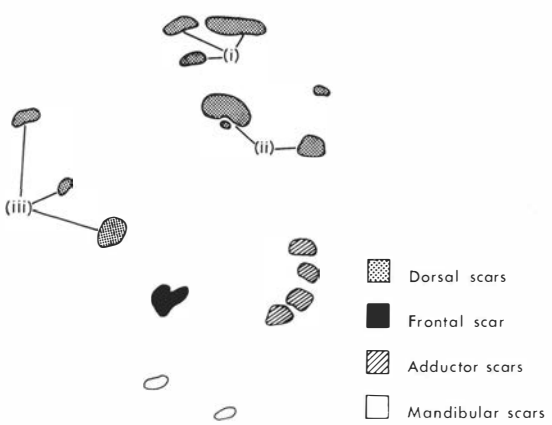


Fig. 12. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Chrysocythere foveostriata* Brady.

Detailed observation of the specimens from the Niger Delta reveals that the frontal muscle scar varies from a V-, J- or U-shaped to two discrete scars (see Pl. 15, Figs. 4, 8, 9—11; and Fig. 13), and the dorsomedian adductor muscle scar is elongate and slightly constricted medially. The dorsal group of muscle scars (Fig. 12) consists of two closely packed elongate scars of unequal size and a reniform scar situated ventral to and below the upper two, in dorsal group (i), a large reniform and a subovate scar in dorsal group (ii), and a subvertical row of three differently shaped scars in dorsal group (iii).

Normal pores simple, open, irregularly shaped, usually rimmed and distributed along the secondary ridges and on the slopes of the primary horizontal ridges.

Juveniles of the last three larval stages were found (see Fig. 14), and are similar in shape and ornament to the females. A few of the penultimate instars are of the same size as the adult females (see Fig. 14), and show most adult characteristics except for their weakly developed hinge, narrow inner lamella and the absence of a vestibule.

Dimorphism strong (see Fig. 15).

Chrysocythere foveostriata (Brady) is the largest of three species of *Chrysocythere* of the Niger Delta (see Fig. 15).

Ecology and distribution. The distributional pattern of *C. foveostriata* seems to indicate that it is substrate-controlled. It was recorded from quartzose sand with shell debris and glauconite (stations GT and A1), and on fine silty sand (stations A10 and J2). No occurrences of this species have been found on finer substrates. The depth ranges between 20 and 25 metres. It is the third most abundant cytheracean ostracode in the Niger Delta, and has also been observed to occur abundantly in shallow marine sediments off Bandama (Ivory Coast), and from off Sierra Leone.

Dimensions.

	Length	*Height*	*Width*
Females	0.555—0.600	0.315—0.335	0.353—0.360
Males	0.615—0.731	0.300—0.330	0.330—0.345

Chrysocythere foveostriata minuta n. subsp.
Pl. 8, Figs. 8—13; Figs. 14 and 15

Derivation of name. Minutus (Lat.), small, after its small size.

Holotype. A female left valve, Af. 91; figured as Pl. 8, Fig. 8. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by five lateral ridges; denticulate margins; a pyriform carapace and a large anterior vestibule typical of *C. foveostriata* (Brady).

Description

Carapace pyriform to subovate in lateral view, ovate in dorsal view, highest at the anterior cardinal angle. Dorsal margin straight to slightly arched due to the strongly arched dorsomarginal ridge, posteriorly gently sloping. Anterior margin broadly rounded, slightly oblique dorsally, and denticulate along two-thirds of its ventral part. Ventral margin sinuous anterior to median, appears convex due to the strongly curved ventromarginal ridge, and is posteriorly upturned. Posterior margin obliquely truncate, and with 4—5 short marginal denticles.

Surface ornament consists of a strongly arched, dorsomarginal ridge which is anteriorly inwardly curved behind the shallow anterior submarginal groove, and posteriorly running down to the dorsoposterior margin; an anterior submarginal ridge which ends dorsally below a low eye tubercle, and is ventrally connected to the anterior end of the ventral ridge. A strongly developed broad dorsolateral ridge which starts posteriorly at a point ventral to the posterior cardinal angle and runs anteriorwards as a dorsally convex ridge, the anterior part of which runs sinuously down to the median part of the valve, and connected at its anterior end to the median part of the anterior submarginal ridge. Behind the dorsolateral and ventrolateral ridges is a short ridge which starts below the anterior submarginal groove and is posteriorly connected to the end of the dorsolateral ridge. A ventrally convex posteroventral

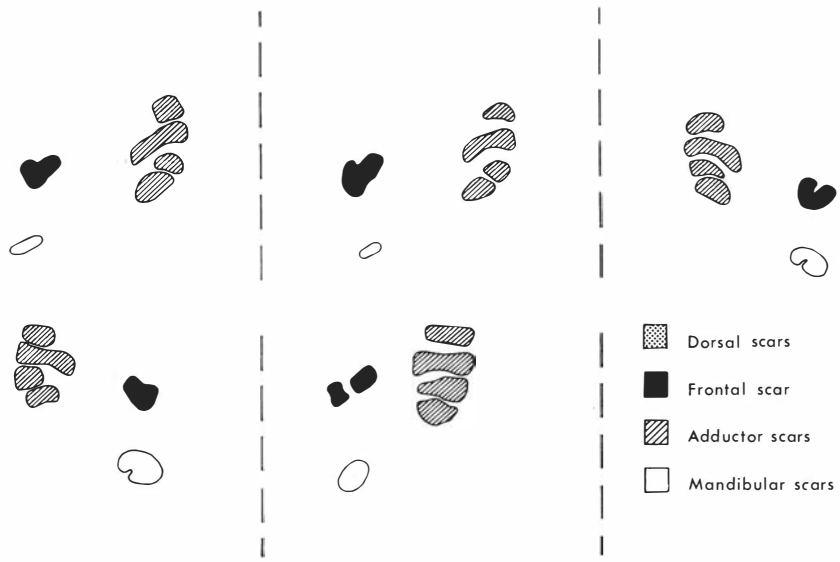


Fig. 13. Arrangement of the frontal adductor and the upper mandibular muscle scars of *Chrysocythere foveostriata* Brady. Note: (i) Occurrence of J-, U-shaped and double frontal scars; (ii) the relatively elongate, medially constricted dorsomedian adductor muscle scar.

ridge runs from the posteroventral margin and is connected to the lower part of the ventrolateral ridge at a point anterior to median. An anteroventral ridge also runs anteriorwards from a point posterior to median along the ventral margin and is connected to the anterior submarginal ridge. Between the five lateral ridges are short connecting ribs which give the surface a coarsely reticulate pattern. Eye tubercles low, internal ocular socket present.

Normal pores are simple, open, rimmed and are distributed in the intercostal areas.

Muscle scar pattern as described for *C. foveostriata* (see Figs. 12 and 13). Frontal muscle scar is, however, J- or U-shaped.

Hinge holoamphidont, as for the genus. See Pl. 15, Fig. 2 for details. Selvage weak and subperipheral.

Inner lamella narrow to moderately wide. Line of concrescence and inner margin incompletely fused, leaving a large anteroventral vestibule. Radial pore canals short, straight to slightly wavy (Pl. 8, Figs. 10—12), medially dilated, 20—25 anteriorly and 6—8 posteriorly.

Sexual dimorphism in size slight, males are slightly larger than females (Fig. 15).

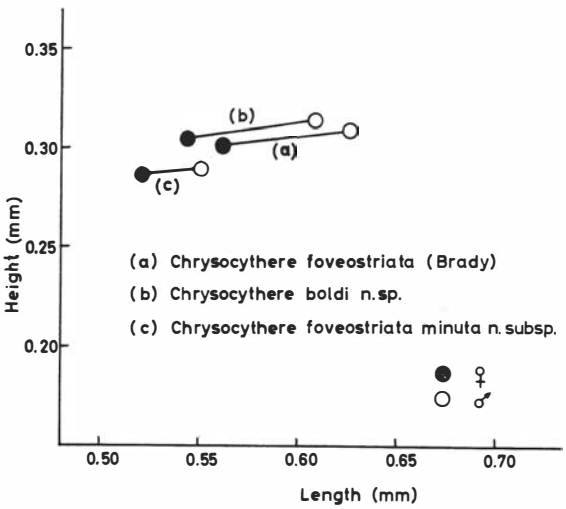


Fig. 14. Dimorphism and size difference in height and length for species and a subspecies of *Chrysocythere*. The points plotted are the means for height and length of right and left valves of adult males and females of the species. Adult dimorphs are connected by a solid line.

A few juvenile specimens were encountered; they are similar in most respects to those of *C. foveostriata.*

Material. 107 specimens; four of these are juveniles, 62 are females and 41 males.

Ecology and distribution. This species was recorded only from quartzose sand rich in shell debris and glauconite at stations GT, A1 and J2 (see Tables I and II). It has the same distribution as *C. foveostriata.*

Dimensions.

	Length	*Height*	*Width*
Holotype (female left valve)	0.533	0.285	—
Females	0.495—0.540	0.270—0.300	0.315—0.330
Males	0.550—0.564	0.285—0.305	0.302—0.312

Remarks. The species is in all respects, except for its small size, identical to *C. foveostriata* (Brady), and it is the smallest species of *Chrysocythere* recorded from the Niger Delta (see Figs. 14 and 15). A comparison of the size of *C. foveostriata* (Brady), and *C. foveostriata minuta* (Fig. 15) shows that the latter is generally of the same size as some females and the penultimate instars of *C. foveostriata.* However a plot of the means of length and height of the adult dimorphs of both species (Fig. 14) shows the distinct differences in size between the two.

Chrysocythere boldi n. sp.

Pl. 16, Figs. 1—10; Figs. 15 and 16

Derivation of name. In honour of Dr. van den Bold, W. A., of Louisiana State University, Louisiana, U.S.A.

Holotype. A male left valve, Af. 97: figured as Pl. 16, Fig. 1. Recent. Locality A5, western Niger Delta.

Diagnosis. This species is characterized by its size; a pyriform to oblong carapace in lateral view, ovate in dorsal view; five thin, prominent lateral ridges; strongly developed, sharply pointing marginal denticles, and a J-shaped frontal muscle scar.

Description

Carapace pyriform to oblong in lateral view, ovate in dorsal view; posterior extremity compressed, and widest posterior to median. Left valve overlaps right at the cardinal angles, and slightly along the ventral margin. Dorsal margin straight to strongly arched, with a sharp anterior to median depression where the dorsomarginal ridge turns inwards and is joined by a short anterodorsal ridge from the eye tubercle; highest at both cardinal angles and slopes steeply posteriorly. Anterior margin obliquely rounded, with a row of three blunt submarginal denticles at its ventral part, and 18—20 strongly developed marginal denticles along three fourths of its ventral part. Ventral margin straight, slightly sinuous anterior to median, posteriorly convex and upturned. Posterior margin dorsally acute, medially truncate with 4—5 strong denticles. Surface ornament consists of a thin bow-shaped dorsal ridge which is anteriorly inturned and branching into smaller ribs; posteriorly it runs up to a point anterior to the posterior cardinal angle from which it turns steeply to the posterior margin. At the anterior margin there is a strong, thin, submarginal ridge which is slightly flexed ventrally where it bears two to three submarginal denticles, and dorsally runs across the low eye tubercle from which it bends inwards to join the anterior part of the dorsomarginal ridge. A posteriorly bow-shaped and anteriorly flexed dorsomedian ridge runs across a shallow submarginal groove and is connected anteriorly to the median part of the anterior submarginal ridge and ends before reaching the posterior margin. Below the dorsal and dorsomedian ridges in the median part of the valve, the vertical connecting ridges meet to form a zig-zag pattern. Below the dorsomedian ridge is a roughly straight ridge which is posteriorly connected to the end of the dorsomedian ridge and anteriorly ends behind the submarginal groove. An almost straight ventromedian ridge runs the length of the valve. Ventrally there is an anterior marginal ridge which ends midway along the ventral margin, and a posterior bow-shaped ridge which is anteriorly connected to the ventral side of the ventrolateral ridge at a point anterior to median. Intercostal areas are commonly covered by short vertically running ridges which give a reticulated pattern. The posterodorsal part of the valve is smooth. The submarginal groove and a median sulcus are represented internally by strong ridges. The ridge corresponding to the median sulcus bears the adductor and frontal muscle scars (Pl. 16, Figs. 2 and 4).

Normal pores small, simple, open, with large circular rims, and distributed over the ridges and riblets (Pl. 16, Figs. 5—8).

The muscle scars are as illustrated for *C. foveostriata* (Brady) (see Figs. 12 and 13); the frontal muscle scar is J- or L-shaped.

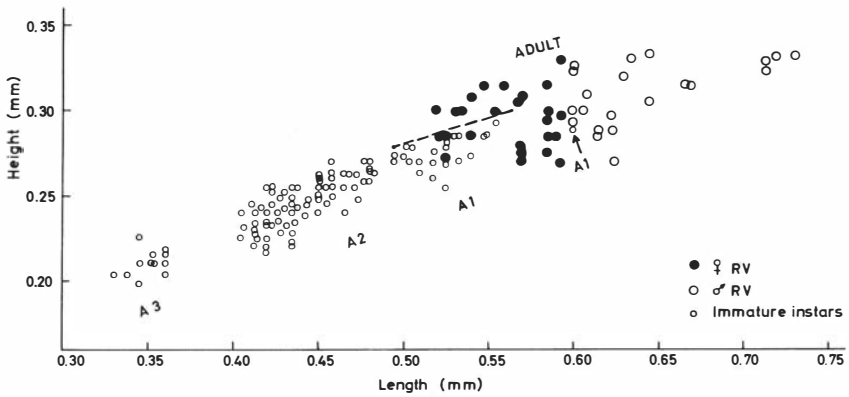


Fig. 15. Scatter diagram of height and length of valves from all localities (right valves only for adults) of *Chrysocythere foveostriata* (Brady). The broken line represents the connection between the highest male (to the right) and the lowest female (to the left) of *Chrysocythere foveostriata minuta* n. subsp.

The hinge is holoamphidont. In the left valve it consists of a small, deep, circular anterior socket, postadjacent to which is a strongly pointed anterior tooth, a narrow, finely crenulated posteromedian ridge and a deep, oval posterior socket. The right hinge corresponds. Selvage moderately developed, peripheral and runs along the free margins.

Inner lamella anteriorly broad and posteriorly narrow. Line of concrescence and inner margin are completely fused, leaving a relatively large anteroventral and narrow posteroventral vestibule. Radial pore canals straight to slightly wavy, 20—25 anteriorly and 8—10 posteriorly. They commonly run into the marginal denticles where they become enlarged.

Sexual dimorphism distinct; males longer than females (see Figs. 15 and 16 A), and females of greater width than males. Most of the female specimens studied show stronger development of the marginal denticles than is found in males (Pl. 16, Figs. 1 and 3).

Juveniles are more abundant than adults (see Tables I and II, and Fig. 16 A). Six larval instars were recognized (see Fig. 16 A, B). The most abundant growth stage is the A4, which represents over one third of the total population of this species.

The last two larval instars are similar in shape and ornament to the adult female. The short vertical connecting ridges become progressively less prominent in the younger instars and are, as well as the longitudinal ridges, absent in the earliest larval instars. The development of the marginal denticles is a progressive process of thickening and subsequent division of a moderately broad anterior and posterior flange. The final adult ornament is built by a step-wise process of coalescence of the fine pits of the earliest larval instars, which in the later stages become accentuated and deepened to form thin, weakly developed longitudinal ridges of stages A3 and A2, and finally developing through A1 into the adult pattern of ornament.

As indicated in Fig. 16 A, a few penultimate instars (A1?) have the same length as the females and a few males, though lower in height. Their ornament is identical to those of adults, but they possess a weakly developed hinge, narrow inner lamella, absence of selvage and thinly calcified valves.

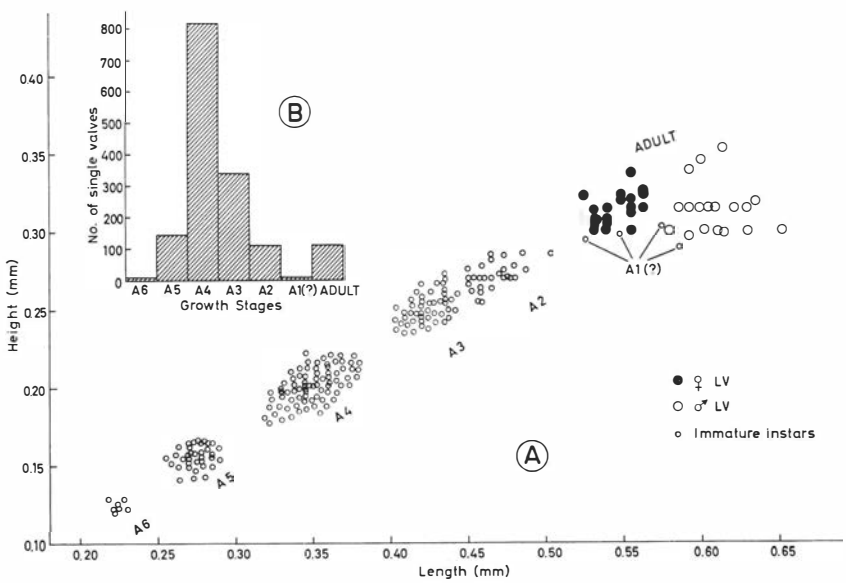


Fig. 16 A. Scatter diagram of height and length of valves (left valves only for adults) of *Chrysocythere boldi* n. sp. from all localities. Note similarity in size between the last larval instar (A1) and the adults. *B.* Histogram showing the population density of the different growth stages of *Chrysocythere boldi* n. sp. from all localities.

Material. 1532 specimens; 60 males and 57 females.
Ecology and distribution. Though *Chrysocythere boldi* is relatively abundant at stations GT, A1 and J2 on a quartzose sand substrate (Table I), it is most common at station A5 on a grey silt substrate with abundant fecal pellets, algae and shell debris. Depth ranges between 20 and 30 metres and may be deeper. The range in bottom temperature is between 21.3°C and 25.1°C. This species has been identified from sediments from other parts of the Niger Delta and also from off Bandama in Ivory Coast.

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.615	0.353	—
Females	0.525—0.565	0.290—0.343	0.351—0.375
Males	0.575—0.650	0.300—0.350	0.312—0.340

Remarks. Chrysocythere boldi n. sp. is similar in habitus to *C. cataphracta* Ruggieri (1962), but has a more rounded shape, thin, high longitudinal ridges, smaller size and possesses an unmistakable vestibule which is absent in *C. cataphracta.* For this latter reason it is similar to *C. foveostriata* (Brady), but has long radial pore canals which run into and are enlarged within the strongly developed marginal denticles. It is higher than *C. foveostriata* (see Fig. 15).

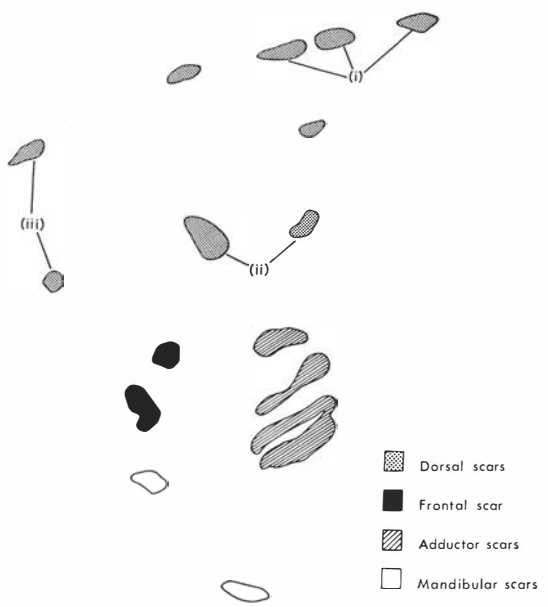


Fig. 17. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Mackenziella lagoensis* n. gen., n. sp.

Family HEMICYTHERIDAE Puri, 1953
Subfamily CAMPYLOCYTHERINAE Puri, 1960
Genus MACKENZIELLA n. gen.
Type species *Mackenziella lagosensis* n. sp.

Derivation of name. In honour of Dr. K. G. McKenzie of the British Museum (Nat. Hist.) London.
Diagnosis. A genus of the subfamily Campylocytherinae with the following characteristics: carapace subrectangular to elongate-ovate in lateral view, inflated-ovate in dorsal view with a compressed posterior margin; widest anterior to median; left valve overlaps right valve at the cardinal angles; posterior and anterior cardinal angles almost of equal height, short, finely built marginal denticles, surface with deep, irregular punctae or foveolate; anterior extremity with prominent marginal rim; ventral and subdorsal ridges present; prominent eye tubercle; anterior and posterior hinge teeth in the right valve smooth, hinge holoamphidont, weakly developed; low, small central muscle node; compound type normal pore; two unequal frontal muscle scars, and a subvertical row of four elongate adductor muscle scars, the lower two always united at their posterior ends.

Description

Carapace subrectangular to elongate-ovate in lateral view; inflated-ovate in dorsal view; posterior extremity compressed and anteromarginal ridge prominent. Dorsal margin straight, highest at the anterior cardinal angle where the prominent eye tubercle is also situated, internal ocular socket prominent. Anterior margin broadly and evenly rounded, may be finely denticulated or smooth. Ventral margin anteriorly concave and posteriorly straight to slightly convex. Posterior margin

dorsally concave, posteriorly and ventrally convex with small denticles. Valves heavily calcified.

Surface foveolate, with fine to moderately coarse, deep, irregularly shaped pits. Behind the strong anteromarginal rim, the ventral and posteroventral margins, the pits are large, and circular in the anterior, but square to rectangular along other margins. Low posterior subdorsal, posterior and ventral submarginal ridges are present.

The normal pores are large, evenly scattered, moderately numerous, of compound type and countersunk deep below valve surface. Setal pores central to marginal.

Muscle scar pattern consists of two frontal muscle scars, a dorsal rounded to subtriangular, and an irregular J-shaped ventral scar; a subvertical row of four elongate adductor muscle scars, the lower two are joined at their posterior ends, two oblong to ovate mandibular scars, three elongated scars in dorsal group (i), an anterior subtriangular and a posterior reniform scar in dorsal group (ii) and three scars, a posterior oblong scar, ventral and anterior to which are two vertically arranged rounded scars in dorsal group (iii).

The hinge is weakly developed; in the right valve it consists of a small triangular anterior tooth, postadjacent to which is a small subrounded anterior socket, a narrow median groove which may be smooth to finely crenulated, and a smooth reniform posterior tooth; in the left valve it begins with a small anterior triangular socket, a small postadjacent anterior tooth, a thin, smooth to finely crenulated posteromedian ridge and a relatively large reniform posterior socket. The selvage is weak and subperipheral.

Inner lamella moderately wide. Line of concrescence and inner margin coincident throughout and parallel to the outer margin. Radial pore canals straight to slightly wavy, numerous anteriorly and few posteriorly.

Sexual dimorphism distinct.

Stratigraphic range. Recent.

Geographic distribution. West Africa.

Ecology. Shallow marine, inner neritic, warm, tropical.

Discussion. Mackenziella is placed in the Hemicytheridae on the following grounds: the double frontal muscle scars, the pattern of the dorsal muscle scars, shape and occurrence of highly complex compound normal pores. It is placed in the Campylocytherinae on the basis of its muscle scar pattern and shape.

Mackenziella shows close affinity in habitus to *Urocythereis* Ruggieri, but differs in possessing four discrete, undivided adductor muscle scars, two frontal muscle scars, a weakly developed holoamphidont hinge, a pronounced eye tubercle, and a low valve. It is similar to *Thaerocythere* Hazel (Thaerocytherinae Hazel, 1967 a) in shape, possession of two frontal muscle scars and undivided adductor muscle scars, but differs from *Thaerocythere* in having a holoamphidont hinge, a more elongate carapace, the absence of a strong ventral ridge and surface reticulation. The genus seems to be closely related to *Urocythereis* Ruggieri which is classified within the Hemicytherinae on the basis of three frontal muscle scars.

Mackenziella lagosensis n. sp.

Pl. 17, Figs. 1—14; Fig. 17

Derivation of name. After the city of Lagos, off which this species was first recorded.

Holotype. A male carapace, Af. 98; figured as Pl. 17, Fig. 4. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by a subrectangular to elongate carapace in lateral view; inflated-ovate in dorsal view; carapace medium to large in size; extremities finely denticulated or smooth; surface foveolate and with a low ridge running along and parallel to the anterior, ventral, posterior and posterior subdorsal areas.

Description

Carapace subrectangular to elongate in lateral view, inflated-ovate in dorsal view. Posterior extremity laterally compressed. There is a strongly developed eye tubercle and a corresponding internal ocular socket. The carapace is anteriorly thickened into a broad anteromarginal rim.

The free margins are as described for the genus. The surface ornament is foveolate, with fine to

moderately coarse, deep, irregular pits. A low ridge runs submarginally along the anterior margin behind a row of coarse, elongate to rectangular anterior pits, and is continuous as a submarginal ridge along the ventral and posterior margins and in the dorsal area, as a posterior subdorsal ridge. Between the posterior subdorsal ridge and the dorsal margin, there is a low dorsally arched ridge which is parallel to the margin and runs to the middle part of the carapace (Pl. 17, Fig. 1). In the anterodorsal half of the valve, a low ridge runs anteriorly from a point posterior to median, towards and below the eye tubercle where it turns ventralwards and is continuous with the anterior submarginal ridge (Pl. 17, Figs. 1 and 4). Normal pores large, numerous, evenly scattered, of compound-type, deeply countersunk below valve surface and showing some degree of adaptation (Pl. 17, Figs. 6, 8, 9, 10—11). The sieve plates of individuals from silty sand bottoms (Pl. 17, Figs. 8, 10—11) are delicately built with fine perforations, whilst the individuals recorded from the sandy, highly turbulent waters (stations GT and A1, see Table I) show strongly buttressed sieve plates (Pl. 17, Figs. 6).

The muscle scar patterns (Fig. 17) and hinge and selvage are as described for the genus.

Inner lamella moderately wide anteriorly and posteriorly. Vestibule absent. Radial pore canals straight to slightly wavy, anteriorly between 20 and 25, and posteriorly between 10 and 12. They are sometimes paired in the anteroventral region.

Sexual dimorphism distinct; males are longer but of the same height as females. Females are commonly finely denticulated at the extremities; this feature is absent or weakly developed in males.

A right valve of a penultimate instar was found. It possesses all the features of the adult male except for a merodont hinge, a narrow duplicature and anterior vestibule (Pl. 17, Fig. 12).

Material. 19 specimens of which 10 are males and 8 are females.

Ecology and distribution. Although few specimens of this species were found, it could be established that it occurs predominantly on medium-grained quartzose sandy substrates (stations GT and A1). A number of specimens were also recorded from silty sand substrates (station A4); see Tables I and II. Slight though important morphologic differences seem to occur between specimens from the sand and the silty sand substrates. Individuals from medium-grained sandy substrates possess tightly arranged pits (Pl. 17, Figs. 1, 2), whereas those from silty sand bottoms show a comparatively "loosely" pitted surface (Pl. 17, Fig. 4). Marginal denticles are also more strongly developed in the latter. As noted the compound normal pores of the two groups of individuals show environmental adaptations.

Specimens referrable to this species have been identified from near-shore sediments off the coast of Ghana, and a probable new species of this genus is living in the shallow waters off the coast of Sierra Leone.

Dimensions.

	Length	*Height*	*Width*
Holotype (male carapace)	0.735	0.390	0.345
Females	0.667—0.700	0.345—0.360	0.345
Males	0.720—0.750	0.365—0.390	—

Remarks. The problem of erecting a monotypic genus is well recognized, but where, as in the present case, the diagnostic characters fit into two widely separate categories, it becomes desirable to erect a new genus.

Genus REYMENTIA Omatsola, 1970

Reymentia ijebuorum Omatsola, 1970

1970. *Reymentia ijebuorum* Omatsola, p. 415; Pl. 3, Figs. 1—14.

This species, the type species of the genus *Reymentia*, was first described (Omatsola 1970 c, p. 415; Pl. 3, Figs. 1—14) from Ikorodu in the western extreme of the Lagos Lagoon, (western Nigeria), a brackish-water oligomesohaline environment.

In the western delta it occurs in the near-shore areas on sand to silty sand substrates (see Tables I and II) at stations GT, A1 and J2. This species also occurs sparsely in other parts of the Niger Delta, and has been observed from near-shore sediments from off Bandama (Ivory Coast).

Morphological differences between the brackish-water individuals and their marine representatives are non-existent. However a slight but significant size difference is apparent (see Fig. 18). The open-marine individuals are slightly higher than those from brackish-water. The marine males are shorter but slightly higher than the brackish-water males, whilst the marine females are higher but of the same length as their brackish-water counterparts.

Material. 164 specimens of which 157 are adults; 53 males and 104 females.

Dimensions.

	Length	*Height*	*Width*
Females	0.392—0.430	0.195—0.218	0.190—0.210
Males	0.410—0.465	0.210—0.239	0.173—0.180

Reymentia microdictyota Omatsola, 1970

Fig. 18

1970. *Reymentia microdictyota* Omatsola, p. 416; Pl. 4, Figs. 1—15.

Reymentia microdictyota was first described from the Lagos Lagoon, western Nigeria (see Omatsola 1970 c, p. 416; Pl. 4, Figs. 1—15).

Its distribution in the Lagos Lagoon is as for *R. ijebuorum* Omatsola, with a salinity range of 0.07 $^0/_{00}$—17.80 $^0/_{00}$. In the western delta, it occurs at stations GT, A1 and J2, on quartzose and silty sand rich in shell debris and glauconite. This species has also been observed from other parts of the Niger Delta on sand or silty sand substrates, and from near-shore sediment samples from off Bandama (Ivory Coast).

A slight size difference occurs between brackish-water and marine individuals (Fig. 18). Brackish-water individuals are generally higher than marine individuals. Their males are longer than both sexes in the marine environment, and are of the same height as the marine females. Brackish-water females are of the same height as the marine females but are higher and also longer than marine males. Marine males are however slightly higher than their females.

Material. 55 specimens of which 53 are adults, 23 males and 30 females.

Dimensions.

	Length	*Height*	*Width*
Females	0.365—0.390	0.180—0.195	0.175—0.186
Males	0.360—0.380	0.185—0.210	0.164—0.172

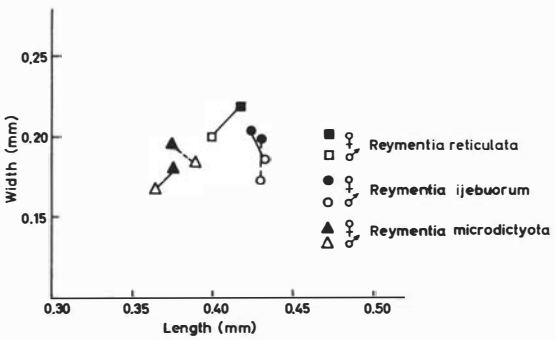


Fig. 18. Diagram showing dimorphism, specific differences in size and size in relation to salinity for height and length of species of *Reymentia.* Plotted points are the means of height and length of carapaces and valves of adults. Adult dimorphs of species recorded from brackish water (Omatsola 1970 c) are connected by a broken line and by a solid line for the same species recorded from a normal marine environment.

Reymentia reticulata n. sp.

Pl. 4, Figs. 9—11; Fig. 18

Derivation of name. After the reticulate surface of the carapace.

Holotype. A male left valve, Af. 86; figured as Pl. 4, Fig. 9. Recent. Locality 1, Ikorodu, Lagos Lagoon, western Nigeria.

Diagnosis. Carapace elongate-ovate in lateral view; elongate to subtriangular in dorsal view; dorsal and ventral margins subparallel; surface coarsely reticulate with a deep anterior submarginal groove; weak eye tubercle; modified holoamphidont hinge and a relatively large size.

Discussion

Omatsola (1970 c, p. 416; Pl. 13, Figs. 5—8) gave a detailed description of this species under open nomenclature — *Reymentia* sp.

Sexual dimorphism is distinct; females are slightly broader than are the males (Fig. 18). Three specimens were recorded from the Lagos Lagoon and were not sexually determined. How-

ever a comparison of their size with those from the open sea, shows that they are smaller than their marine relatives.

Ecology and distribution. This species is, like any others of the genus *Reymentia,* euryhaline. It occurs in the western Niger Delta at stations GT, and A1 on quartzose sand. It is so far only known from the western Niger Delta.

Material. 16 adult specimens; 13 females and 3 males.

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.397	0.195	—
Females	0.405—0.418	0.210—0.233	0.195—0.200
Males	0.397—0.400	0.210	—

Genus BASSLERITES Howe, in Coryell and Fields, 1937

Type species *Basslerella miocenicus* Howe, (1935)

Basslerites elongata n. sp.

Pl. 18, Figs. 1—12; Figs. 19 and 20

Derivation of name. After the elongate shape of the carapace.

Holotype. A female carapace, Af. 99; figured as Pl. 18, Fig. 4. Recent. Locality A5, western Niger Delta.

Diagnosis. This species is characterized by an elongated to subrectangular shape in lateral view, spindle-shaped in dorsal view, an anteriorly pointing V-shaped groove in its posterolateral region, and the frequent occurrence of single irregular to double frontal muscle scars.

Description

Carapace elongate to subrectangular in lateral view; spindle-shaped in dorsal view and widest posteriorly. Dorsal margin straight to gently arched. Anterior margin obtusely rounded and smooth. Ventral margin straight, with a slight median sinuosity. Posterior margin almost vertical, with a median convexity, and ventrally bow-shaped. Shell thin.

The surface is smooth, seemingly pitted owing to the normal pores. In the posteroventral region, the slightly elevated normal pores, which are arranged in a row along the outer margin, give a serrated appearance to this region. At the posteroventral region, in front of the area with a row of normal pores, is a deep, anteriorly pointing V-shaped groove which runs for about one-third of the carapace length (Pl. 18, Figs. 4, 6, 7).

The normal pores are simple, open, slightly elevated in the posteroventral region, but commonly sunk below the surface of the valve (Pl. 18, Figs. 4, 6 ,7). There are about 50 per valve, and they bear flagellate, plumate or pinnate setae (Pl. 18, Figs. 7 and 9). The arrangement of the normal pores is constant within the species.

The muscle scar pattern (Pl. 18, Figs. 5, 8, 10; and Figs. 19C and 20) consists of a single L-shaped or frequently two fairly discrete frontal scars; a vertical row of four equal adductor scars, two mandibular scars of equal size in the ventral part of the valves, and the dorsal groups of muscle scars consisting of three elongate scars in the dorsal group (i), three triangularly arranged scars in dorsal group (ii), and two scars in the dorsal group (iii).

The hinge is typical for the genus (Pl. 18, Figs. 3 and 5). Selvage weak, subperipheral and parallel to the outer margins.

Inner lamella moderately wide anteriorly and narrow posteriorly. Line of concrescence and inner margin incompletely fused, leaving a relatively wide anterior vestibule, and a narrow posteromedian vestibule (Pl. 18, Figs. 10 ,11 ,12).

The radial pore canals are short, straight, 26—28 anteriorly, and 10—12 posteriorly.

Sexual dimorphism is only evident in size. Males are slightly longer than females and females are higher than males.

Juveniles of this species were not observed.

Material. 39 specimens, of which 20 are males and 19 females.

Ecology and distribution. This species shows no preference for a particular type of substrate in the western Niger Delta (Tables I and II). It occurs on quartzose sand, silty sand, fine grey silt and grey clayey silt, respectively, at stations GT-A1, J2, A5 and A3. Depth ranges from 20 to 35 metres, with a bottom temperature range

of 25.1°C—21.3°C. Specimens have been mainly observed from silt and silty muds in other parts of the Niger Delta.

Dimensions.

	Length	*Height*	*Width*
Holotype (female carapace)	0.443	0.213	0.180
Females	0.398—0.445	0.200—0.224	0.171—0.180
Males	0.450—0.470	0.195—0.210	0.159—0.169

Remarks. Basslerites elongata differs from all other species of *Basslerites* by its subrectangular shape and the deep posteroventral anteriorly pointing V-shaped groove. It is with respect to the latter feature similar to *B. argomega* van den Bold (1963), though the groove is of different shape and position in the two species. It is also distinguishable by the occurrence of the L-shaped and two fairly discrete frontal muscle scars.

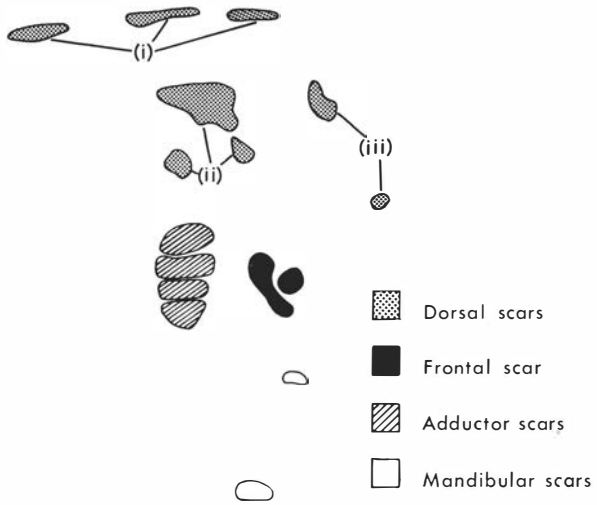


Fig. 20. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Basslerites elongata* n. sp.

Subgenus LOCULICONCHA
Omatsola, 1970
Basslerites (*Loculiconcha*) *ikoroduensis*
Omatsola, 1970
Pl. 19, Figs. 8—9; Figs. 19 and 21

1970. *B.* (*Loculiconcha*) *ikoroduensis* Omatsola, p. 417; Pl. 5, Figs. 1—13.

Discussion

This species, the type species of *B.* (*Loculiconcha*), was first described (Omatsola 1970 c) from the Lagos Lagoon (a brackish-water oligomesohaline environment) in Western Nigeria. It was found in the upper lagoon on a silty sand substrate. In the western Niger Delta it occurs only at station GT on quartzose sand rich in shell debris and glauconite. A few specimens have also been observed from other parts of the Niger Delta on quartzose sand and silty sand substrates.

The muscle scar pattern of the holotype of this species was restudied in the light of the variation noted in the frontal scars of this and

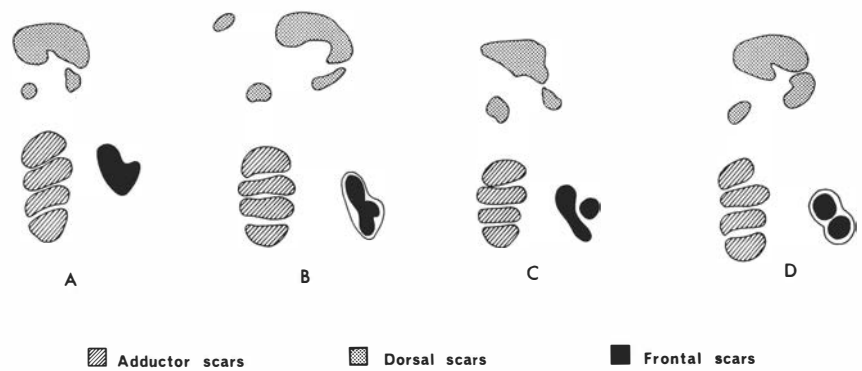


Fig. 19. Arrangement of the frontal, adductor and dorsal (group (ii)) muscle scars of species of the genus *Basslerites* and the subgenus *Basslerites* (*Loculiconcha*) Omatsola. *A* and *B* — *B.* (*Loculiconcha*) *ikoroduensis* Omatsola; *C* — *B. elongata* n. sp.; *D* — *B.* (*Loculiconcha*) *punctata* n. sp. Note: (i) intra-generic and specific variation of the frontal muscle scar patterns, (ii) the close similarity in arrangement and shape of the dorsal muscle scars (group ii)).

a new species *B.* (*Loculiconcha*) *punctata* reported on below. The adductor scars are typical for the genus (Figs. 19 A—B). The frontal scar in the holotype is V-shaped, but in marine individuals between 20—30 % of the specimens show an irregular L- or K-shaped frontal scar (Pl. 19, Figs. 8, 9; Fig. 19 B). The dorsal groups of scars (Fig. 21) consist of three fields: a large oblong, anterior, and two unequal posterior, pear-shaped scars in dorsal group (i), three scars, a large, dorsal crescent-shaped scar, below wich is an elongate scar and posterior to which is a subrounded scar, in dorsal group (ii), and one identifiable rounded scar in dorsal group (iii). There is a suboblong scar behind the large dorsal scar in group (ii).
Material. 11 specimens.

Dimensions.

	Length	*Height*	*Width*
Females (marine)	0.435—0.465	0.219—0.248	0.188—0.203
Females (brackish-water)	0.430	0.230	0.160

Remarks. The indivduals recorded from the normal marine environment are larger in all respects than those reported from the lagoon. So far, only females have been encountered in the marine environment. This is also the case for a new species of this subgenus described below.

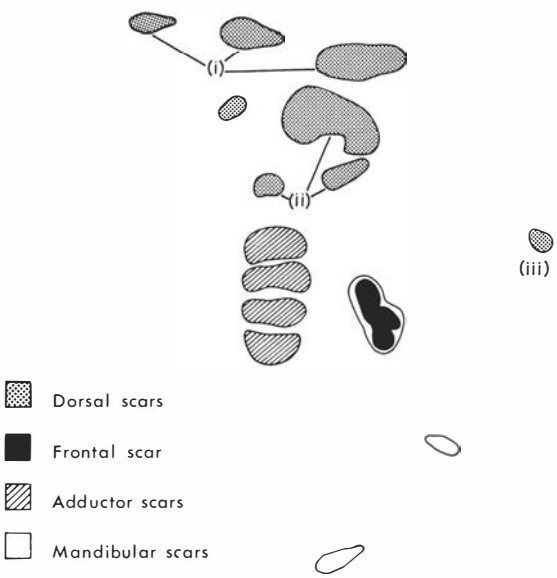


Fig. 21. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Basslerites* (*Loculiconcha*) *ikoroduensis* Omatsola.

Basslerites (*Loculiconcha*) *punctata* n. sp.
Pl. 19, Figs. 1—7; Figs. 19 and 22

Derivation of name. After the fine pits on the carapace.
Holotype. A female right valve, Af. 100; figured as Pl. 19, Fig. 1. Recent. Locality A5, western Niger Delta.
Diagnosis. This species is characterized by an elongate-oblong carapace in lateral view; carapace truncate posteriorly; hinge amphidont or hemi-amphidont; surface covered in the posterior half by regular rows of fine pitting and the frequent occurrence of two discrete closely fitting frontal muscle scars.

Description

Carapace elongated to oblong in lateral view; truncate posteriorly, and ovate in dorsal view. Dorsal margin slightly arched, highest at median to slightly posteromedian, posteriorly angulate and anterior gently sloping. Anterior margin smooth, narrowly rounded, medially slightly pointing. Ventral margin convex with a slight median sinuosity posterior to which it is strongly convex and upturned. Posterior margin dorsally truncated, medially convex and ventrally rounded, and appears to be serrated externally owing to the concentration of rimmed, elevated, simple normal pores on the posteroventral margin. Left valve overlaps the right valve at the cardinal angles.

The surface ornament consists of 18—25 rows of fine pits on the posterior half of the carapace; a shallow posterior groove occurs which becomes posteroventrally enlarged, where the six semi-circularly arranged shallow loculi, typical of the genus, are found (Pl. 19, Figs. 1, 3, 5). Other parts of the valve are smooth, although a patch of finely pitted surface may be found in a position posterior to median (Pl. 19, Fig. 1).

Normal pores moderately numerous, simple,

open and in the posteroventral and posteromedian parts, elevated and rimmed. On the lateral parts of the valve, the normal pore openings are small, slightly sunk below the valve surface and occupy the bottoms of the fine pits.

The muscle scar pattern (Pl. 19, Figs. 2, 4, 6, 12; Figs. 19 D and 22) consists of a vertical row of four, nearly equal, ovate scars, U- and irregularly shaped, and (in up to 15 % of individuals) two discrete, closely located rounded frontal muscle scars (Pl. 19, Figs. 4, 12), two oblong mandibular scars, and in the dorsal muscle scar groups (Fig. 22), of three elongate scars in dorsal scar group (i), one large, dorsal crescentic scar, a smaller anteroventral scar in contact with the latter and a posterior oval scar in the dorsal group (ii), and one scar anterior to group (ii) in the dorsal group (iii). Behind the large dorsal scar of group (ii), there is an elongate, dorsally directed scar.

The hinge in the left valve commences with a cuspate-shaped ventrally closed anterior socket, postadjacent to which is a small rounded anterior tooth, a narrow smooth posteromedian ridge which in some cases is dorsally crenulate at its posterior end (Pl. 19, Figs. 2, 4, 7), and a slit-like anteriorly shallow posterior socket. The right hinge corresponds. Some specimens show a fully developed holoamphidont hinge. Selvage strong, subperipheral and parallel to the anterior and posterior margins.

Inner lamella moderately wide in the anterior and posterior margins. Line of concrescence and inner margin incompletely fused, anteromedially leaving a fairly large vestibule and posteriorly a small vestibule. Radial pore canals short, straight, anteriorly about 25—27 and posteriorly about 10—12.

Sexual dimorphism not observed. All specimens examined possess the subgenetically important semicircular loculi, characteristic of females.

Material. 114 specimens, all provisionally identified as females. Three of these (single valves) are larger than the others (see dimensions), the others, mostly carapaces, are smaller.

Ecology and distribution. This species was recorded from stations GT, A1 and A3 on quartzose sand rich in shell debris and glauconite, station J2 on silty sand, and station A5 on grey silt rich in fecal pellets and shell debris. The most abundant occurrence is however at station A5 (see Tables I and II). It has only been recorded from the western Niger Delta.

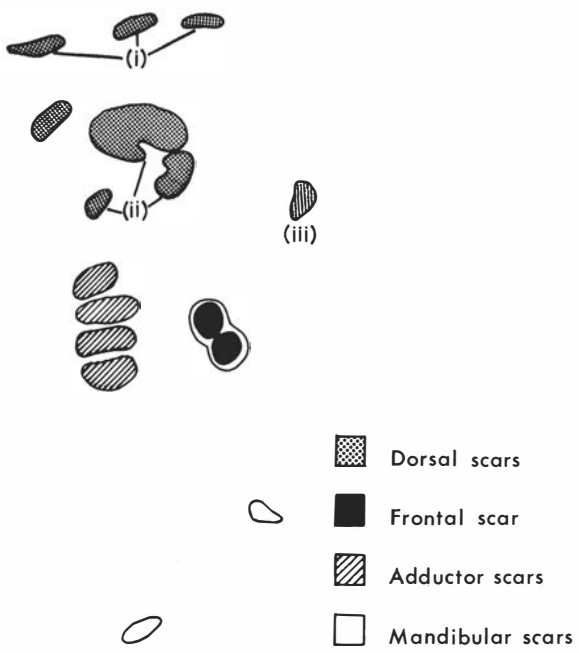


Fig. 22. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Basslerites* (*Loculiconcha*) *punctata* n. sp.

Dimensions.

	Length	*Height*	*Width*
Holotype (female right valve)	0.465	0.210	—
Other large individuals	0.435	0.238	—
Smaller individuals	0.285—0.345	0.144—0.195	0.120—0.143

Remarks. This species differs from *B.* (*Loculiconcha*) *ikoroduensis* Omatsola, 1970 in possessing a more elongate carapace, surface pitting, occurrence of crenulation on the posterior part of the posteromedian hinge element of some individuals and the frequent occurrence of two discrete frontal muscle scars. *B.* (*Loculiconcha*) *ikoroduensis* is euryhaline while *B.* (*Loculiconcha*) *punctata* n. sp. is most probably stenohaline.

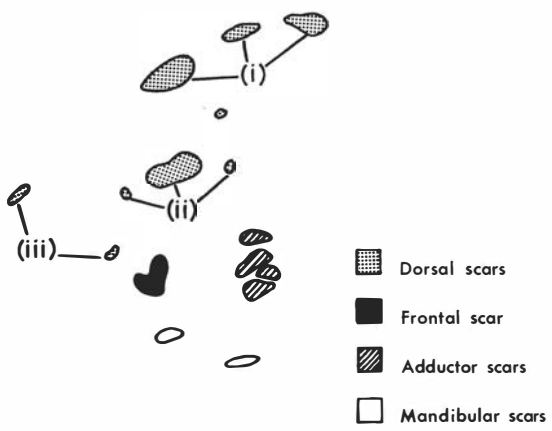


Fig. 23. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Campylocythereis sandbergi* Omatsola.

Most of the specimens of *B. (Loculiconcha) punctata* recorded from station A5 are smaller than a few others found at the same station. They possess the dimorphic posteroventral loculi typical of females. A random examination of these, to ascertain if they are juveniles or adults, reveals that they possess an amphidont or hemiamphidont hinge, relatively wide inner lamella and corresponding vestibules, and the posteroventral loculi. These features indicate that they definitely are adults with possibly stunted growth. They are also identical in ornament to the adults.

Genus CAMPYLOCYTHEREIS Omatsola, 1970
Type species *Campylocythereis sandbergi* Omatsola, 1970

Discussion. A detailed ecologic, taxonomic and systematic study has been carried out (Omatsola, 1970 e) on three species of this genus. The entire muscle scar arrangement of a right valve of the type species, *Campylocythereis sandbergi* (Fig. 23) is included in this study as a base of reference, and for the purpose of comparison with the muscle scar fields of other members of the hemicytherid genera herein described and discussed.

Subfamily THAEROCYTHERINAE Hazel, 1967
Genus HERMANITES Puri, 1955
Type species *Hermania reticulata* Puri, 1953
Hermanites foveolata n. sp.

Pl. 20, Figs. 1—11; Pl. 21, Figs. 1—7; Figs. 24 and 25

Derivation of name. After the foveolate pattern of ornament.

Holotype. A male left valve, Af. 101; figured as Pl. 20, Fig. 1. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by a medium to large carapace; heavily calcified shell, a foveolate, spongy, reticulated type of ornament centred around a large subcentral muscle tubercle; a thin diagonal dorsoposterior ridge, a wide inner lamella, and strong sexual dimorphism.

Description

Carapace large; males are subrectangular and females are subquadrate in lateral view, widest posterior to median and elongate-ovate in dorsal view; extremities fairly compressed. Dorsal and ventral margins subparallel, slightly converging posteriorly. Dorsal margin nearly straight, highest at the anterior cardinal angle and at the dorsoposterior region. Anterior margin broadly rounded and bearing 17—20 fine denticles in some individuals. Ventral margin nearly straight, anteriorly convex, medially slightly concave and posteriorly upturned. Posterior margin subarcuate, dorsally concave, ventrally produced and truncate with 4—5 marginal denticles. Left valve slightly larger than right valve, with a slight overlap behind the posterocardinal angle. Eye tubercle strong, internal ocular socket weakly developed.

Surface ornament consists in the median region of a dense, radiating, spongy, reticulate pattern centred around a strongly developed subcentral muscle tubercle, and a thin marginal dorsoposterior ridge which runs anteriorly from a low dorsoposterior tubercle and turns inwards medially. From the dorsoposterior tubercle, another thin ridge runs vertically for a short distance before turning diagonally towards the subcentral tubercle. A thin anteromarginal ridge is parallel to the anterior margin and continues ventrally and

posteriorly where it widens. Below the anteromarginal ridge there is a fairly broad rim, and posterior to this a chain of large, coarse pits which continue along the anteroventral, posteroventral and ventral margins. Subventrally, a low lateroventral ridge runs from behind the anterior submarginal pits to about one-fourth the way from the posterior margin where it ends in a small posteroventral tubercle.

The normal pores are of two types. There are large, rimmed, scattered elevated simple normal pores (Pl. 20, Fig. 3); and numerus, large, countersunk compound normal pores (Pl. 20, Figs. 4, 6, 7, 8; Pl. 21, Figs. 2, 4, 5—7). The setal pores of the latter are either central or slightly off-centre, and the sieve plates have a honey-comb structure. Compound normal pores from individuals from the high energy inshore areas (Pl. 20, Fig. 9) show strongly calcified radiating structures of the sieve plates (Pl. 20, Fig. 7), while individuals from offshore areas possess finely built sieve plates (Pl. 20, Figs. 4, 8). Internally, the sieve plates are composed of vertically and horizontally running papillate structuress with larger internal openings of the setal pores (Pl. 20, Fig. 6).

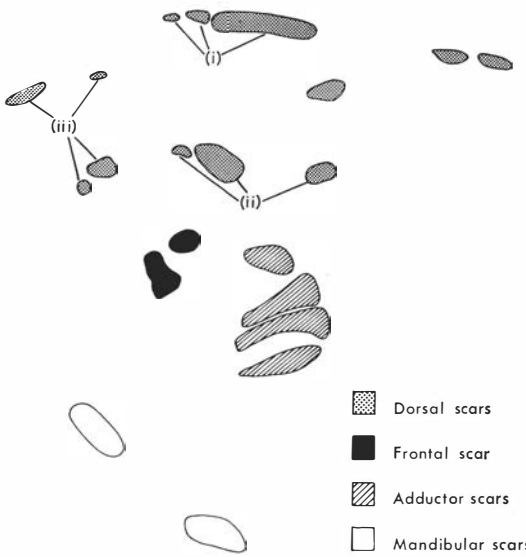


Fig. 24. Detailed arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Hermanites foveolata* n. sp.

The muscle scar pattern (Pl. 20, Fig. 5; Fig. 24) consists of a rounded upper and a subrectangular lower frontal muscle scar, a vertical row of four adductor scars, the dorsal member of which is oblong and the three lower members are elongated, two oblong mandibular scars, a dorsal group consisting of two small, anterior oblong scars and an elongate posterior scar in dorsal group (i), and posterior to which there are two scars, a small anterior reniform scar postadjacent to which is a large, median, oblong scar and a posterior subquadrate scar, in dorsal group (ii), and a set of two unequal dorsal scars and another set of two unequal ventral, closely packed scars in dorsal scar group (iii). A club-shaped scar is present between the dorsal scar groups (i) and (ii).

The hinge in the right valve consists of a high, flat-topped anterior tooth, a postadjacent circular socket which merges into a long narrow dorsally serrate groove, and a flat subquadrate posterior tooth. The left hinge corresponds. Selvage prominent, subperipehral and parallel to the anterior, ventral and posterior margins.

Inner lamella anteriorly wide, ventromedially narrow and posteriorly fairly wide. Line of concrescence and inner margin coincident throughout. Radial pore canals moderately numerous, straight, slightly dilated medially, 30—32 anteriorly and 12—14 posteriorly, where they may be in bundles of twos and threes.

Sexual dimorphism strong; males longer and wider posterior to median than females. Ornamental dimorphism is also evident. Males have minute regular pitting along thin costae forming the reticulated patterns (Pl. 21, Fig. 2) while in females the areas between the punctae are smooth (Pl. 21, Fig. 4). The compound normal pores also show sexual differentiation. Male compound normal pores (Pl. 20, Figs. 4, 8 and Pl. 21, Fig. 5) have coarsely perforated sieve plates with strongly radiating structures whilst those of females (Pl. 21, Figs. 6, 7) show delicate, finely perforated sieve plates.

Juveniles not observed.

Material. 15 specimens; six males and nine females.

Ecology and distribution. Hermanites foveolata occurs on quartzose sand, silty sand and grey

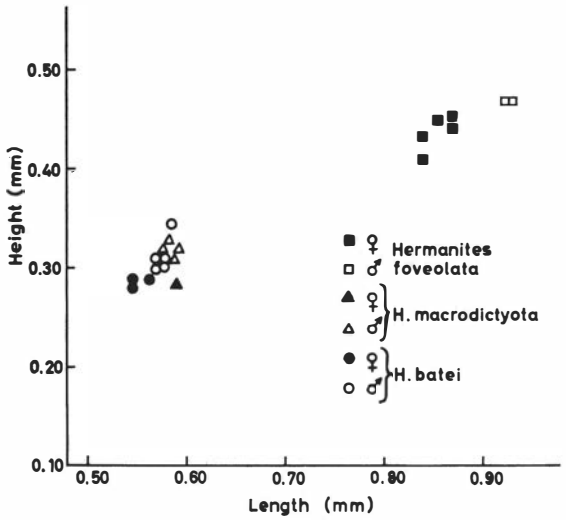


Fig. 25. Scatter diagram for height and length of carapaces and valves of species of *Hermanites* from all localities.

clayey silt respectively at stations GT, A4 and A3. Depth ranges between 20 and 35 metres, and the known temperature range is from 25.1°C to 25.8°C and possibly lower (see Tables I and II).

Specimens have been observed to occur in shallow nearshore samples from off Tema, Ghana, and off Bandama, Ivory Coast, from depths of about 44 metres.

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.930	0.465	—
Females	0.840—0.870	0.413	0.435
Males	0.930—0.938	0.465	0.480

Remarks. The species can be distinguished from other *Hermanites* by its foveolate to spongy, radiating pattern of reticulation, a moderately robust carapace, a fairly large size and a strong ornamental and normal pore dimorphism. It lacks the strong lateroventral and dorsal ridges found in many species of the genus.

Hermanites batei n. sp.

Pl. 22, Figs. 1—14; Figs. 25 and 26

Derivation of name. In honour of Dr. R. H. Bate, British Museum (Nat. Hist.) London.

Holotype. A male left valve, Af. 102; figured as Pl. 22, Fig. 12. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by coarse surface pitting; notched dorsolateral, anteromarginal, ventrolateral and dorsoposterior ridges.

Description

Carapace subrectangular in lateral view, arrow-shaped in ventral view, widest anterior to median and extremities compressed. Dorsal and ventral margins subparallel, posteriorly converging. The ventral margin is anteriorly and posteriorly denticulated. Anterior margin broadly rounded and finely denticulated. Posterior margin subarcuate, dorsally concave, ventrally produced and bearing four to five marginal denticles.

Surface coarsely punctate with a concentric pattern centred around the pronounced subcentral muscle tubercle. There is a laterally notched anteromarginal ridge, a pronounced, notched ventrolateral ridge which runs anteriorly and is connected to the lower part of the anteromarginal ridge, and ends submarginally at a strong posteromarginal tubercle. Anterior to the posterior cardinal angle, a broad, notched ridge runs vertic-

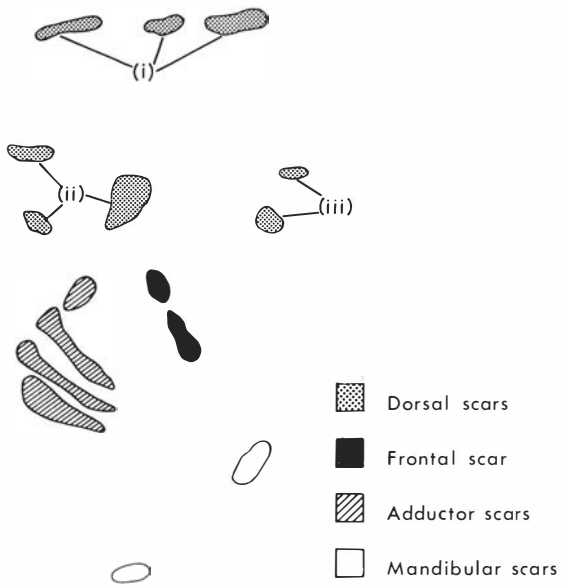


Fig. 26. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Hermanites batei* n. sp.

ally downwards and stops about one-third of the distance from the dorsal margin. Another thin notched ridge runs anteriorly along the dorsal margin and then slightly inwards to a point just below the eye tubercle.

Normal pores are of open, simple and compound types and moderately numerous. The simple normal pores are large, rimmed and slightly elevated, while the compound normal pores deeply sunk below the valve surface, and with slightly off-centre setal pores (Pl. 22, Figs. 8, 9). There are about 46 normal pores per valve.

The muscle scars consist of two frontal scars, an ovate dorsal and a ventral elongate dorsally pointing scar, a subvertical row of four adductor scars, (the top two scars are fairly rounded and the lower scars are elongate), two ovate mandibular scars, and a dorsal group consisting of three fairly elongated scars in dorsal group (i), three scars, two vertically subreniform and a posterior subtriangular scar in dorsal scar group (ii), and two rounded muscle scars in dorsal group (iii) (Pl. 22, Figs. 7, 11; Fig. 26).

The hinge is as for the genus. The median hinge element of the left valve is smooth to finely crenulate. The selvage is strong, narrow and peripheral.

Inner lamella wide anteriorly and posteriorly, and ventromedially narrow. Line of concrescence and inner margin coincident throughout. Vestibule absent. Radial pore canals numerous anteriorly and few posteriorly, straight, and dilated near the outer margin. There are 30—35 anterior and 12—18 posteroventral canals (Pl. 22, Figs. 13, 14).

Sexual dimorphism is pronounced. Males are slightly longer and higher than females. Male reticulations are stronger and females tend to smoothen out the finer ornamental structures (see Pl. 22, Figs. 1, 2, 4, 6, 12 and Fig. 25).

Two specimens of the penultimate instars were found and are closely similar to the adult females. They have thin valves, a merodont hinge, strongly developed reticulations but weak costae.

Material. 14 specimens; five of these are females and seven are males.

Ecology and distribution. This species was recorded from quartzose sand at station A1 and grey clayey silt at station A3. Depth ranges between 20 and 35 metres.

Specimens of this species have been identified in samples from other parts of the Niger Delta. The author has also observed specimens from off Ghana, Ivory Coast and Sierra Leone (West Africa).

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.578	0.310	—
Females	0.555—0.563	0.285—0.293	0.285
Males	0.570—0.585	0.300—0.345	0.300—0.330

Remarks. Hermanites batei is similar in habitus to *H. hydropleura* Hazel (1968), though differences occur. *H. batei* is smaller, possesses perforate lateral and marginal ridges, and a less reticulate surface. The posteromedian vertical ridge in *H. hydropleura* is represented in *H. batei* by a short, perforate, dorsoposterior ridge.

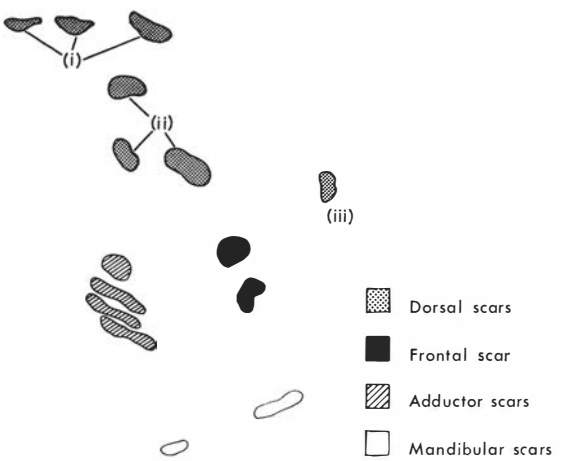


Fig. 27. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Hermanites macrodictyota* n. sp.

Hermanites macrodictyota n. sp.
Pl. 23, Figs. 1—15; Figs. 25 and 27

Derivation of name. Macrodictyon (Gr.) — large netted; after the coarse reticulation on the carapace.

Holotype. A right valve, Af. 103; figured as Pl.

23, Fig. 1. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by strong coarse pitting in a web-like form; perforate anterior and ventral ridges; low eye tubercles; low subcentral muscle tubercle, and a strong, ventrally produced posterior margin.

Description

Carapace subrectangular in lateral view, strongly produced posteroventrally, dorsal and ventral margins subparallel, posteriorly converging. Ventral margin sinuous medially and finely denticulate. Anterior margin broadly rounded, smooth or finely denticulate. Posterior margin truncate, dorsally concave, ventrally produced and denticulate. Left valve overlaps the right valve at the cardinal angles and along the ventral margin. Surface ornament consists of a web-like, coarse, reticulate pattern built around a low subcentral muscle tubercle; perforate anteromarginal and latero-ventral ridges, a short dorsoposterior tuberculate ridge and a weakly developed dorsolateral ridge. Eye tubercle low, internal ocular socket pronounced.

Normal pores are numerous and are of simple, open and compound types. The simple normal pores are distributed along the ribs, and the compound pores are feebly rimmed and occur in or on the margin of the pits (Pl. 23, Figs. 3, 4, 6—8). A number of the compound normal pores bear flagellate or club-like setae (Pl. 23, Figs. 6, 7, 8) whilst others possess a probably organic lip at the setal pore openings. The latter structure is not a tactile organ. The micropores of the sieve plates are either circular or polygonal in shape. The internal structure of a compound normal pore (Pl. 23, Fig. 9) shows a complex honey-comb structure. There are about 60—65 normal pores per valve.

The muscle scar pattern consists of two frontal scars, a vertical row of four adductor scars, the dorsal member of which is ovate and the lower three elongate, two elongated mandibular scars, and in the dorsal groups, of three unequal, elongated scars in dorsal group (i), a dorsal reniform and two unequal oblong scars in dorsal group (ii), and one scar in dorsal group (iii) (see Fig. 27).

The hinge is typical for the genus. The posteromedian hinge element of the left valve may be smooth to slightly crenulate. The selvage is weak and peripheral.

The inner lamella is moderately wide anteriorly and posteriorly. Line of concrescence and inner margin coincide throughout. Vestibule absent. Radial pore canals anteriorly numerous (35—39) and posteriorly few (12—16). They are straight, dilated close to their distal ends and sometimes grouped in pairs in the posteroventral region.

Sexual dimorphism not known with certainty. Juveniles not observed.

Material. 15 specimens.

Ecology and distribution. This species occurs on quartzose sand, silty sand and on grey silt, respectively at stations A1, A4 and A5. Depth ranges from 20—30 metres, and bottom temperatures are between 25.1°C and 21.3°C (see Table I). It is relatively more abundant on sand substrates (see Table II).

Specimens have been observed in beach sand from Gongué Beach, Gabon.

Dimensions.

	Length	*Height*
Holotype	0.570	0.380
Paratypes	0.570—0.593	0.285—0.330

Remarks. Individuals of *H. macrodictyota* recorded from quartzose sand in a nearshore high energy area (Pl. 23, Fig. 10) show slight ornamental modification. The reticulate pattern of these individuals is coarse, the anteromarginal, ventromarginal and dorsal ridges are more pronounced, the perforation of ridges is reduced or absent, the anteromarginal and ventromarginal denticulations are absent and the posteroventral region is reduced and submedially pointed. These modifications are possibly adaptive mechanisms for surviving the highly turbulent near-shore environment.

This species differs from other species of *Hermanites* in possessing a low subcentral muscle tubercle and subdued lateral ridges.

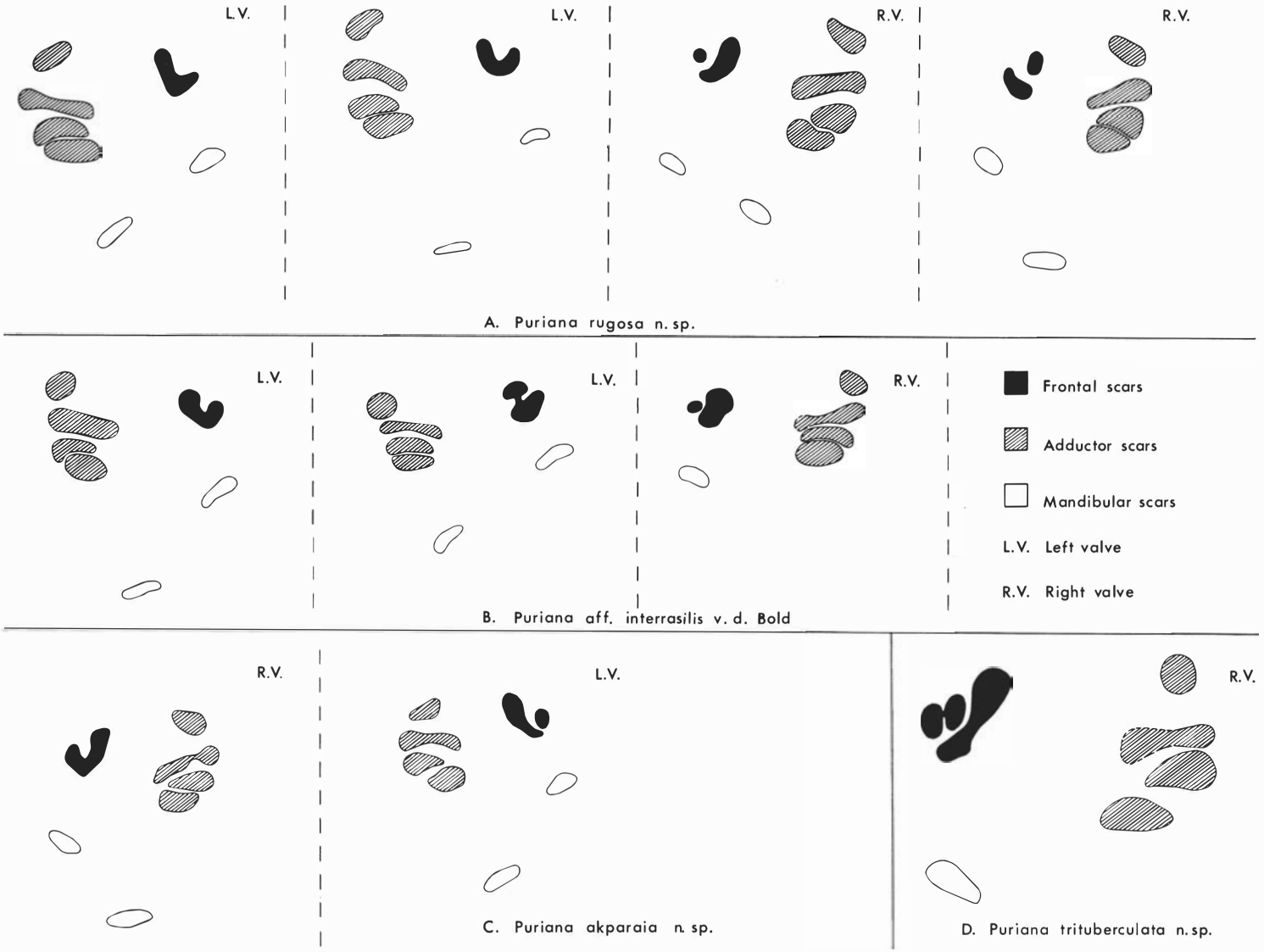


Fig. 28. Arrangement of the frontal, adductor and mandibular muscle scars of *A.* — *Puriana rugosa* n. sp.; *B.* — *P.* aff. *Puriana interrasilis* van den Bold; *C.* — *P. akparaia* n. sp., and *D.* — *P. trituberculata* n. sp. Note: (i) intraspecific variation of the frontal muscle scars and (ii), the elongated, medially constricted dorsomedian adductor muscle scar.

Genus PURIANA Coryell and Fields, 1953
in Puri, 1953)
Type species *Favella puella* Coryell and Fields, 1937
Puriana rugosa n. sp.
Pl. 24, Figs. 1—13; Figs. 28 and 29

Derivation of name. Rugosus (Lat.) — wrinkled, after the pattern of surface ornament.
Holotype. A female right valve, Af. 104; figured as Pl. 24, Fig. 1. Recent. Locality GT, western Niger Delta.
Diagnosis. This species is characterized by four anterior concentric ridges, and the division of the median and posterior ridges into irregular lines of small to moderately large tubercles.

Description

Carapace of medium size, with thick shell substance, elongate-subrectangular in lateral view, and highest at the anterior cardinal angle. Dorsal margin straight, gently sloping posteriorly and steeply anteriorly. Anterior margin broadly rounded and may be denticulated. Ventral margin straight, with a sinuosity anterior to median and anteriorly slightly convex. Posterior margin medially slightly produced, strongly denticulated and rounded in female, dorsally slightly truncate with few denticles in males.

The surface ornament consists in the anterior part of the shell of four concentric anterior ridges parallel to the anterior margin, and in other parts of the valve of irregularly shaped vertical ridges which are, on their median and ventral ends, broken into irregular lines of small tubercles as in *P. rugipunctata* Ulrich and Bassler. The second anterior concentric ridge continues ventrally as a strong ventral ridge. Eye tubercle low, located at the dorsal end of the second anterior concentric ridge, internal ocular socket prominent.

Normal pores are fairly numerous, relatively large, simple, open, and distributed on and between the ridges (Pl. 24, Figs. 5, 6).

The muscle scar pattern (Pl. 24, Figs. 8—10; Fig. 28 A) consists of L-, U-shaped or two discrete frontal scars, a vertical to slightly oblique row of four scars, two oval mandibular scars, an anterior elongate and two posterior subrounded scars in dorsal scar group (i), an elongated dorsal scar, a small scar ventral and in close contact with the latter, and a rounded posterior scar, in dorsal group (ii), and three scars of various sizes in dorsal group (iii). There is a strongly developed fulcral point (see Pl. 24, Fig. 8).

The hinge is weak; in the right valve it consists of a subtriangular, smooth anterior tooth, a narrow slit-like postadjacent anterior socket which continues posteriorly as a narrow, dorsally crenulated posteromedian groove, and a reniform, smooth posterior tooth. The hinge in the left valve corresponds (Pl. 24, Figs. 2 and 4). The selvage is strongly developed, subperipheral and parallel to the free margins.

Inner lamella moderately wide. Line of concrescence and inner margin coincident. Vestibule absent. The radial pore canals are fairly numerous, straight to slightly wavy, and may be paired at the posterior margin. There are between 18 and 22 anteriorly and 8 and 10 posteriorly (Pl. 24, Figs. 11—13).

Sexual dimorphism is evident in size (see Fig. 29). Males are slightly longer and higher than females. Females possess stronger marginal denticles, which are absent in some males (Pl. 24, Fig. 3).

Juveniles of this species are ornamentally different from the adults. Instead of the tubercles and ridges of adults, they possess a fine, mesh-like reticulate pattern which is centred around a weak subcentral tubercle. They also possess prominent marginal denticles, narrow duplicature and a merodont hinge.
Material. 181 specimens, all single valves. 151 of these are adults, 61 females and 90 males.
Ecology and distribution. This species is confined to quartzose sand rich in shell debris and glauconite. It was recorded from stations GT and A1, at a depth of 20 metres. Bottom temperature 25.1°C (see Tables I and II). Specimens have been observed from off Bandama, Ivory Coast.

Dimensions.

	Length	*Height*
Holotype (female right valve)	0.570	0.300
Females	0.555—0.570	0.270—0.300
Males	0.578—0.600	0.285—0.308

Remarks. The closest known species to *P. rugosa* n. sp. is *P. rugipunctata* (Ulrich and Bassler), which has a similar pattern of ridges and tubercles on the ventrolateral parts of the valves.

Puriana aff. *interrasilis* van den Bold, 1966
Pl. 25, Figs. 1—11; Figs. 28 and 29

1966. *Puriana ? interrasilis* van den Bold, p. 163; Pl. 3, Fig. 5 a, d; Pl. 5, Figs. 5 c.

Discussion. Van den Bold (1966) described this species from the post-Miocene N'Tchengué Formation of Gabon and doubtfully placed it in the genus *Puriana.* The present investigation reveals that van den Bold's (1966, p. 163) assignment is correct, the possible discrepancy being the strongly arched dorsal margin of this species. All other features fall within the range of the genus. Van den Bold's figure (van den Bold, *op. cit.*, Pl. 3, Fig. 5 a) of a right valve does not seem conspecific with his figure 5 c of plate 3. The former is reminiscent of a new species described below as *P. akparaia.*

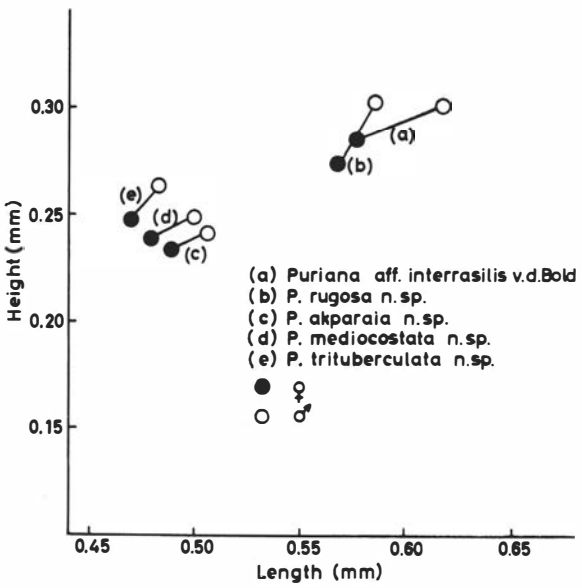


Fig. 29. Dimorphism and size differences in height and length of valves and carapaces of species of *Puriana.* Plotted points are the means of height and length of adults of the various species. The adult dimorphs are connected by a solid line. Pooled samples from all localities.

The muscle scar pattern (Pl. 25, Figs. 4, 6—8; Fig. 28 B) is identical, with slight specific differences, to those of other species of the genus studied here. The frontal muscle scar varies intraspecifically from a U-shaped to two discrete scars (see Fig. 28 B). An anterior vestibule is present in some individuals but absent in others (Pl. 25, Fig. 11).

Sexual dimorphism is strong (see Pl. 25, Figs. 2, 3 and Fig. 29). The Nigerian specimens are generally larger than those from Gabon.

Ecology and distribution. In the western delta *P.* aff. *interrasilis* is found to occur in near-shore quartzose sand substrates at stations GT and A1. It has the same distribution as all other species of *Puriana* of the western delta. Specimens have also been observed from off Bandama (Ivory Coast) and off the coast of Sierra Leone.

Dimensions.

	Length	*Height*
Females	0.563—0.608	0.270—0.293
Males	0.623—0.645	0.300—0.315

Puriana akparaia n. sp.
Pl. 26, Figs. 1—11; Figs. 28 and 29

Derivation of name. Âkpãrà (Itsekiri), the deity of thunder.

Holotype. A male left valve, Af. 105; figured as Pl. 26, Fig. 1. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by an elongate-ovate shape in lateral view; small to medium size; surface ornament with strongly tuberculate lateral and ventral regions, and a prominent submarginal groove.

Description

Carapace elongate-ovate in lateral view, oblong in dorsal view, slightly robust and widest posterior to median. Dorsal margin straight to slightly undulate, highest at the anterior cardinal angle. Anterior margin broadly rounded, dorsally slightly oblique with fine denticles (between 10—13) along two-thirds of its ventral part. Ventral margin more or less straight, subparallel to the dorsal

margin, and with an anterior to median sinuosity. Posterior margin obtusely rounded, slightly produced medially and bears 4 to 6 strong marginal denticles.

Surface ornament basically tuberculate. There is a prominent anterior submarginal groove which runs from below the low eye tubercle and stops ventrally about one-sixth distance from the ventral margin. Anterior to this, the surface is punctate to reticulate. On the dorsolateral part, the surface in males is covered by irregular, closely packed short ridges which form a pseudoreticulate pattern; in the females it is covered sparsely by punctae. Below the submarginal groove, there are two fairly prominent anteriorly convex ridges which starts subdorsally and runs to the ventral margin. Behind these ridges the surface is covered by coarse tubercles which diverge from a shallow lateral "corridor" (see Pl. 26, Figs. 1 and 3). Dorsoposteriorly, there is a strong oblique groove running from behind the posterior cardinal angle to the posteroventral part of the valve. Eye tubercle low, internal ocular socket prominent.

Normal pores are numerous, simple, open and distributed on and between the ridges and tubercles (Pl. 26, Fig. 11). There are about 50 per valve. Muscle scar pattern (Pl. 26, Figs. 2, 4, 5, 6, 8 and Fig. 28 C) are basically as described for *P. rugosa.* The frontal muscle scars vary from a J-shaped to two discrete scars, the latter consisting of a small rounded anterior and an elongate ventrally narrow and pointed, postadjacent scar (see Fig. 28 C).

The hinge is as described for *P. rugosa*, but with smaller hinge elements in both valves (Pl. 26, Figs. 2 ,4). The selvage is strong, peripheral and parallel to the free margins. A narrow postadjacent groove, possibly for the selvage of the right valve, may be found in the left valve.

Inner lamella moderately wide. Line of concrescence and inner margin slightly separated anterior ly, leaving a narrow irregular vestibule; posteriorly completely fused (Pl. 26, Figs. 9, 10). Radial pore canals few, commonly branching anteriorly and straight posteriorly. There are 15—18 anterior and 8—11 posterior. Sexual dimorphism distinct, males slightly larger than females (Fig. 29) and are more strongly ornamented than females (Pl. 26, Figs. 1, 3). Females show a tendency to smoothening of the surface ornament.

Juveniles not observed.

Material. 37 specimens; 25 females and 12 males.

Ecology and distribution. This species was recorded from stations GT and A1, on quartzose sand rich shell debris and glauconite (see Tables I and II).

Dimensions.

	Length	*Height*	*Weight*
Holotype (male left valve)	0.503	0.255	—
Females	0.470—0.488	0.230—0.240	0.225
Males	0.495—0.503	0.245—0.255	—

Remarks. Puriana akparaia can be distinguished from other species of *Puriana* by the presence of a relatively deep anterior submarginal groove, and a shallow "corridor" between the lateral and ventrolateral tuberculations.

Puriana mediocostata n. sp.

Pl. 27, Figs. 1—10; Fig. 28

Derivation of name. After the prominent mediolateral ridge.

Holotype. A female right valve, Af. 106; figured as Pl. 27, Fig. 1. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by a strongly developed dorsal, median and anterior ridges, and a prominent eye tubercle.

Description

Carapace subrectangular to elongate in lateral view and of small size. Dorsal margin straight seemingly posteriorly arched, owing to the strongly arched dorsal ridge, highest at the anterior cardinal angle from which it slopes gently posteriorly and slightly steeply anteriorly. Anterior margin narrowly rounded, fine to coarsely denticulated. Ventral margin more or less straight, slightly sinuous anterior to median and anteriorly convex upwards. Posterior margin acutely rounded, dorsally truncated and ventrally rounded and slightly produced medially.

The surface ornament consists mainly of scalloped ridges. There is a strongly bow-shaped dorsal ridge which is anteriorly curved inwards behind the eye tubercle and runs ventrally, parallelling the anterior margin as the anterior submarginal ridge. Medially, there is a straight and strongly developed ridge which is irregular at its anterior end behind the anterior submarginal ridge, and is posteriorly connected by a short vertical rib to the incurved posterior end of the dorsal ridge. Along the venter, there is a line of 5—6 large anteriorly convex tubercles. Originating anteriorly from the dorsal part of the eye tubercle is a narrow ridge which runs obliquely towards the median part of the anterior margin. A detailed examination of the ridges reveals that they are ornamented by fine, consistent lines of pitting identical in both sexes (Pl. 27, Figs. 5, 8). Intercostal areas are smooth in males, but in females are covered by fine pustules, and sparsely tuberculated in the dorsal and lateral regions (Pl. 27, Figs. 5, 8). The eye tubercle strongly developed and spherical internal ocular socket prominent.

Normal pores are fairly large, moderately numerous — 35 to 40 per valve — simple open and mainly located on the tubercles (Pl. 27, Figs. 5, 6, 8).

The muscle scar pattern (Pl. 27, Fig. 7) is identical with that of *P. akparaia*, but the frontal scar is J- or L-shaped.

The right hinge (Pl. 27, Fig. 4) consists of a stepped laterally pointing anterior tooth, postadjacent to which is an anteroventrally closed but posteroventrally open, shallow anterior socket, a narrow serrated groove and a subrounded to reniform posterior tooth. The hinge in the left valve corresponds. The selvage is strong and peripheral along the dorsal and ventral parts of the anterior margin and subperipheral along the ventral and posterior margins.

The inner lamella is moderately wide. Line of concrescence and inner margin completely fused. Vestibule absent. Radial pore canals few; about 20 straight, anterior ones, and about 10 slightly wavy posterior ones, where they are sometimes paired.

Sexual dimorphism slight; males slightly larger than females (Fig. 29). Females possess stronger ornament and finely granular intercostal areas. Juveniles not observed.

Material. 14 specimens; 8 females and 6 males.

Ecology and distribution. This species has the same distributional pattern as other species of *Puriana* encountered in this study. See Tables I and II.

Dimensions.

	Length	*Heigth*	*Width*
Holotype (female right valve)	0.488	0.225	—
Females	0.480—0.497	0.225—0.240	—
Males	0.503—0	0.245—0.255	0.225

Remarks. The species can be distinguished from other species of *Puriana* by its strong scalloped dorsal, median and anterior ridges.

Puriana trituberculata n. sp.

Pl. 28, Figs. 1—10; Figs. 28 and 29

Derivation of name. After the three prominent tubercles typical for this species.

Holotype. A male left valve, Af. 107; figured as Pl. 28, Fig. 1. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by a strong subcentral muscle tubercle; ventroposterior and dorsoposterior tubercles; a fairly deep anterior submarginal groove, and surface ornament of narrow ridges arranged in a convolute pattern.

Description

Carapace subrectangular to ovate in lateral view, the left valve overlaps the right valve at the cardinal angles and along the ventral margin. Dorsal margin straight, highest at the anterior cardinal angle and sloping gently posteriorly where it is slightly arched. Anterior margin obliquely rounded, ventrally produced and finely denticulate. Ventral margin anteriorly convex, sinuous anterior to median and straight posteriorly. Posterior margin dorsally truncate, ventrally slightly produced and denticulate.

The surface ornament consists of a strongly developed subcentral muscle tubercle, a postero-

ventral tubercle and a less prominent dorsoposterior tubercle. A deep anterior submarginal groove runs from below the eye tubercle, parallelling the anterior margin and stopping just anterior to the ventral sinuosity. Between this groove and the anterior margin, the surface is covered by a reticulate pattern of low ridges which are bounded on the inside by a narrow submarginal ridge. Behind the anterior submarginal groove, the rest of the valve is ornamented by a differently orientated pattern of tubercles and short low convolutions (see Pl. 28, Figs. 1, 3, 5, 6). The eye tubercle is low and the internal ocular socket prominent.

Normal pores numerous (45—50 per valve), simple, open and distributed on the costae, tubercles and in the intercostal areas.

Muscle scar pattern (Pl. 28, Figs. 2, 4, 7) as described for *P. rugosa* and other species of *Puriana* here studied. The frontal muscle scar pattern varies intraspecifically between two and three scars (Pl. 28, Figs. 4, 7 and Fig. 28).

Hinge typical for the genus. The selvage is prominent, subperipheral and parallel to the free margins.

The inner lamella is moderately wide. The line of concrescence and inner margin are slightly separated anteriorly but completely fused posteriorly. The anterior vestibule is narrow, crescent-shaped and median in position. Radial pore canals numerous, 28—33 anterior and 15—19 posterior. In the anterodorsal and posteromedian regions they are branched.

Sexual dimorphism pronounced. Males are larger than females (Fig. 29). Ornamental dimorphism is slight but distinct; male costae and tubercules are larger and wider than in females in which the tubercles are relatively reduced (Pl. 28, Figs. 1, 3, 5, 6).

Juveniles belonging to the penultimate instar are in all respects similar to the adult females but with finer ornament and a merodont hinge.

Material. 5 specimens; 3 adults and 2 juveniles.

Ecology and distribution. This species was recorded only from station GT, on quartzose sand, rich in shell debris and glauconite. Depth 20 metres, and bottom temperature was 25.1°C. So far it has only been found in the western Niger Delta.

Dimension.

	Length	*Height*
Holotype (male right valve)	0.488	0.270
Females	0.465—0.473	0.248—0.255

Remarks. P. trituberculata n.sp. is the shortest of all species of *Puriana* recorded from the Niger Delta. It is however higher than *P. akparaia* and *P. mediocostata* (see Fig. 29). It can distinguished from other species of *Puriana* by the three prominent tubercles and the ornament of convolutions.

Subfamily HEMICYTHERINAE Puri, 1953
Genus AURILA Pokorný, 1955
Type species *Cythere convexa* Baird, 1850

Aurila punctoreticulata n. sp.
Pl. 29, Figs. 1—12; Figs. 30 and 31

Derivation of name. After the reticulate pattern of pitting on the anterior and posteroventral regions of the valves.

Holotype. A female right valve, Af. 108; figured as Pl. 29, Fig. 1. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by its medium size, coarsely punctate surface with the pits forming a reticulate pattern in the anterior, ventral and posteroventral regions, and a thin ventral submarginal ridge.

Description

Carapace strongly asymmetrical, almond-shaped in lateral view, with a strongly produced posterior region. Dorsal view elongate-ovate and widest posterior to median. The left valve overlaps the right valve along the dorsal and ventral margins. Dorsal margin strongly convex, highest at the anterior cardinal angle, gently sloping posteriorly and anteriorly. Anterior margin broadly rounded, dorsally slightly oblique. Ventral margin medially convex with a slight anterior to median sinuosity. Posterior margin strongly pointing, dorsally concave and with a short upturned caudal process.

The surface ornament is basically punctate. The coarse pits are arranged in the median part of the valve in a concentric pattern with fewer pits in the middle. In the anterior and posteroventral

parts of the carapace, the pits are superimposed by short horizontal ridges which give a punctoreticulate pattern. Just posterior to the anterior margin is a low anterior submarginal ridge which begins from below the eye tubercle, parallel to the anterior margin and runs along the ventral margin, before ending at the posteroventral corner. The pits are coarse at the anterior, ventral and posteroventral regions of the valve. The interpunctal areas are finely pitted or smooth. The eye tubercle is large and low; an internal ocular socket is present but small.

Normal pores are of simple and compound types, moderately numerous and scattered. The sieve plates of the compound normal pores are finely perforated and possess small, centrally placed setal pores (Pl. 29, Fig. 7). They occur mostly on the slopes of the pits (see Pl. 29, Figs. 1, 3).

The muscle scar pattern is typical for the genus (Pl. 29, Figs. 5, 8, 9; Fig. 30). The third adductor muscle scar from the top is divided in some specimens but is single in most. The dorsal muscle scars consist of three ovate to subtriangular scars in the dorsal scar group (i), a large, dorsal ovate scar, a subrounded postadjacent scar and a small ventral scar in dorsal scar group (ii), and two vertically arranged scars in dorsal scar group (iii).

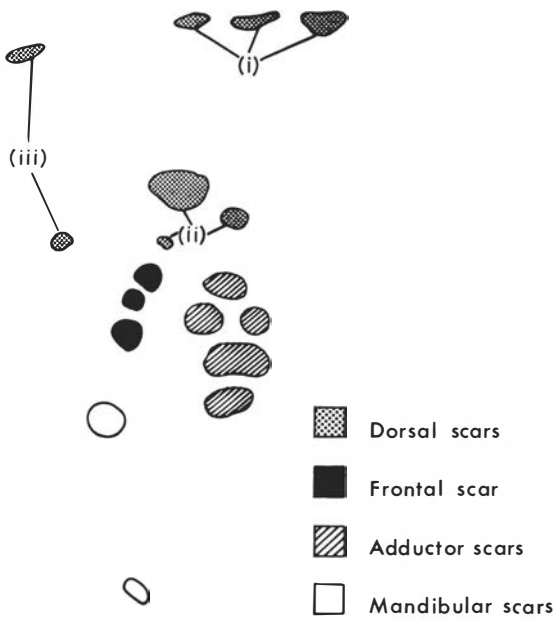


Fig. 30. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Aurila punctoreticulata* n. sp.

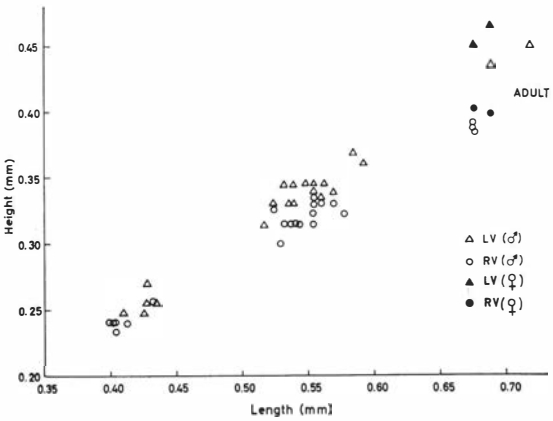


Fig. 31. Scatter diagram of height and length of valves of *Aurila punctoreticulata* n. sp. from all localities. Note the strong asymmetry in height and length of left and right valves of adults and in the larval instars.

The hinge in the right valve consists of a stepped, flat-topped anterior tooth, a postadjacent socket, a weak, serrated median groove and a reniform, strongly incised posterior tooth (Pl. 29, Fig. 2). The hinge in the left valve corresponds (Pl. 29, Fig. 4). A narrow but deep accommodation groove is present dorsal to the median hinge element of the left valve (Pl. 29, Fig. 4).

The selvage is weak and subperipheral.

Inner lamella wide anteriorly and narrow posteriorly. The line of concrescence and inner margin are coincident throughout. The radial pore canals are straight; there are 43 anterior ones and about 20 posterior ones. Slight sexual dimorphism in size. Males are longer but lower than females (Fig. 31).

Juveniles of at least two larval stages were encountered. They are similar in ornament to the adults but have strong merodont hinge and are with or without a narrow duplicature. In the late larval instars, the left and right valves are not as strongly asymmetrical as in the adults, and the early instars seem to show no distinct asymmetry of left and right valves (see Fig. 31).

Material. 72 specimens; 16 adults, 9 males and 7 females.

Ecology and distribution. This species was recorded at stations GT and A1 on quartzose sand rich in shell debris and glauconite, at a depth of 20 metres. The bottom temperature was 25.1°C (see Tables I and II). Specimens have been observed in clean sand from Gongué Beach in Gabon and also from calcareous sands off Bandama (Ivory Coast). I have also noted its occurrence from off the coast of Sierra Leone.

Dimensions.

	Length	*Height*	*Width*
Holotype (female right valve)	0.675	0.383	—
Females	0.670—0.680	0.385—0.401	—
Males	0.690—0.720	0.435—0.450	0.390

Remarks. The closest species to *A. punctoreticulata* n. sp. is *A. punctata* (v. Münster) recorded from the N'Tchengué Formation of Gabon by van den Bold (1964, p. 169; Pl. 3, Fig. 3). *A. punctoreticulata* possesses a more elongate carapace, stronger reticulation on the anterior and posteroventral margins, and a slightly less prominent caudal process.

Genus MUTILUS Neviani, 1928

Type species *Cythereis laticancellata* Neviani, 1928

Mutilus nigeriana n. sp.

Pl. 30, Figs. 1—13; Fig. 32

Derivation of name. Nigeria.

Holotype. A female right valve, Af. 109; figured as Pl. 30, Fig. 1. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by coarsely reticulate valves; a strongly developed eye tubercle: an upturned caudal process in right valve but blunt in left valve, and the occurrence of narrow anterior and ventral vestibules.

Description

Carapace subquadrate to subovate in lateral view, ovoid in dorsal view, widest at median and with compressed marginal extremities. The valves are strongly asymmetrical; left valve subovate with short, blunt medially placed caudal process; right valve with strongly upturned caudal process. Dorsal margin strongly arched, highest posterior to the anterior cardinal angle, posteriorly gently sloping and steeply anteriorly. Anterior margin broadly rounded and dorsally slightly oblique in the right valve. Ventral margin generally convex, medially sinuous and posteriorly upturned. Posterior margin truncate in the left valve, but produced in the right valve into a short, prominent, dorsally pointing caudal process and dorsally concave. The surface ornament consists of a coarse, heavily reticulated pattern of thin, high ridges which form a web-like pattern, the median ridge of which is well developed. Along the anterior margin, a submarginal ridge runs from behind the eye tubercle towards the anteroventral region. Dorsally this ridge continues across the eye tubercle as the dorsomarginal ridge, which at its posterior end is inturned and forms part of the posterodorsal reticulate pattern. Ventrally there is a narrow submarginal ridge which begins at the anteroventral corner and runs posteriorly where it is upturned to form part of the posteroventral reticulate pattern. The pits between the ridges are deepest medially and shallow along the margins. A strongly developed eye tubercle is present anterior to the cardinal angle and the internal ocular socket is small.

The normal pores are small, of simple, open and compound types, and numerous. There are about 80 per valve. The simple normal pores occur on the ridges, and the compound normal pores at the bottom of the pits (Pl. 30, Figs. 6 (female) and 9 (male)). The setal pores are marginal and the sieve plates are finely perforate in both sexes.

The muscle scar pattern is as for the genus (see Fig. 32). There are three frontal scars (Pl. 30, Figs. 2, 5 and Fig. 32). The third adductor scar from the top is single and elongated in some individuals but commonly double in others (Pl. 30, Figs. 5, 8). The dorsal scars comprise three elongate scars in dorsal group (i), a large subtriangular to ovate anterior scar, a small postadjacent scar and a fairly elongate dorsal scar in

dorsal group (ii), and one or two scars in dorsal group (iii).

The hinge is as for the genus (Pl. 30, Fig. 8). The median hinge groove of the right valve is dorsally serrate. The selvage is strong, peripheral and parallel to the free margins.

The inner lamella is moderately wide in the anterior and posterior regions and ventromedially narrow. The line of concrescence and inner margin are not completely fused anteriorly leaving a narrow anterior and a posteroventral crescentic vestibule. The radial pore canals are numerous, straight to slightly wavy; they are commonly paired in the anterior margin and several may arise posteriorly from the same point (Pl. 30, Figs. 11, 12 and 13).

Sexual dimorphism is apparent. Males are longer and narrower than females (Pl. 30, Figs. 4, 7). The surface of the ridges in females is smoother than those of males. Normal pores show slight sexual differentiation (Pl. 30, Figs. 6, 9).

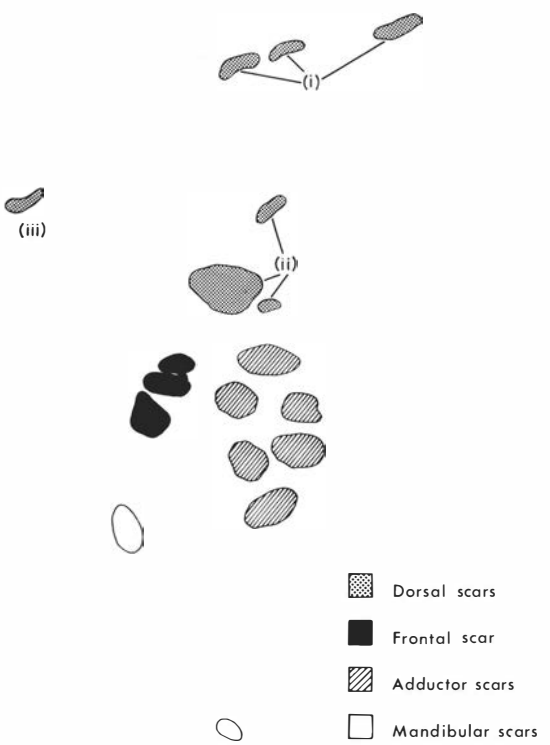


Fig. 32. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Mutilus nigeriana* n. sp.

One juvenile instar was encountered. It is similar in most respects to adult males but with the absence of an inner lamella and presence of a merodont hinge.

Material. 24 specimens: five of these are males and eighteen females.

Ecology and distribution. This species was recorded at stations GT and A1 on quartzose sand rich in shell debris and glauconite (see Tables I and II). Specimens have been observed in sand from Gongué Beach, Gabon and from calcareous sand from off Bandama, Ivory Coast.

Dimensions.

	Length	*Height*	*Width*
Holotype (female right valve)	0.437	0.308	—
Females	0.455—0.476	0.285—0.310	0.280—0.291
Males	0.480—0.510	0.320—0.338	0.255—0.270

Remarks. Mutilus nigeriana n.sp. is similar in ornament to *M.* sp. aff. *M. convolutus* (Brady), discussed and figured by van den Bold (1964, p. 169; Pl. 2, Fig. 3) from the N'Tchengué Formation of Gabon. Brady (1868) first described the latter species (*Cythere convoluta Brady*, p. 182; Pl. 12, Figs. 3, 4) from Mauritius. I examined Brady's (1868) collections and noted some specific differences between his species and *M. nigeriana.* The posterior margin of *M. nigeriana* is strongly produced in the right valve whilst that of *M.* sp. aff. *M. convolutus* is medially slightly produced and truncate. The dorsal margin of *M. nigeriana* is more strongly arched and the reticulations are less coarse than in *M.* aff. *convolutus.*

Further comparison of this species with those of the genus *Radimella* Pokorný (1968) indicates that *M. nigeriana* shows strong affinities with these and may be conspecific.

The main systems of meshes, ridges and areas as designated by Pokorný (1968, Fig. 1) can to a considerable degree be identified in *Mutilus nigeriana.*

In terms of Pokorný's (1969, p. 331) grouping, *M. nigeriana* may be assigned to the *Radimella pondosera*-type of ornament.

The adductor muscle scar pattern of *M. nigeriana* (Fig. 32) is in general similar to that of

Radimella, though the ventromedian group occurs sometimes as a single scar in *M. nigeriana.*

For the time being, *nigeriana* is retained in *Mutilus* until a more detailed investigation involving a larger number of specimens becomes available.

Genus CAUDITES Coryell and Fields, 1937
Type species *Caudites medialis* Coryell and Fields, 1937
Caudites africana n. sp.
Pl. 31, Figs. 1—14; Fig. 33 A—B

Derivation of name. Africa.

Holotype. A male carapace, Af. 110; figured as Pl. 31, Fig. 1. Recent. Locality GT, western Niger Delta.

Diagnosis. This species is characterized by a dorsoposterior ridge; nearly vertical posterolateral and ventrolateral diagonal ridges, and thickened free margins.

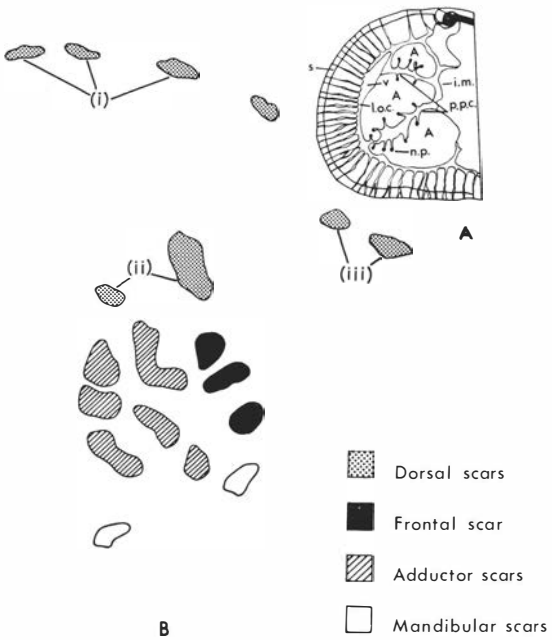


Fig. 33. Caudites africana n. sp. *A.* Anterior half of a right valve showing radial pores and secondary fusion of the inner lamella. (A = attached areas; n.p. = normal pores; p.p.c. = pseudomarginal pore canals; i.m. = inner margin; l.o.c. = line of concrescence; s = selvage). *B.* Arrangement of the dorsal, frontal, adductor and mandibular muscle scars.

Description

Carapace subtriangular to elongate in lateral view, of medium size, arrow-shaped in dorsal view, greatest width anterior to median at the low subcentral muscle tubercle. Dorsal margin slightly bow-shaped, highest at the anterior cardinal angle from which it slopes gently posteriorly up to the posterior cardinal angle, then steeply to form the posterodorsal part of the posterior margin. Anterior margin narrowly rounded, slightly oblique dorsally and ventrally directed. Ventral margin sinuous, medially concave, and anteriorly and posteriorly convex. Posterior margin acute, ventrally pointed and dorsally concave with a short rounded caudal process.

The surface ornament consists of a dorsoposterior ridge which thins out anteriorly, a relatively strong subvertical ridge dorsally connected to the posterior part of the dorsoposterior ridge and is ventrally connected to a short posteroventral ridge. A strong lateral diagonal ridge is connected posteriorly to the inner part of the posterior subvertical ridge, and runs towards the anteroventral margin where it stops short of the ventral margin. The carapace is thickened around the free margins to form a narrow marginal rim. Intercostal areas apparently smooth but are finely pitted in places especially around the simple normal pores thus giving a false sieve plate appearance (Pl. 31, Figs. 4, 7, 10). Eye tubercle low, internal ocular socket deep.

Normal pores numerous, occurring only in the parts of the valve behind the secondarily fused inner lamella. There are simple and compound types. The simple pores are rimmed and occur in shallow depressions (Pl. 31, Figs. 4, 7, 10), some of which are surrounded by a radiating pattern of pitting that gives a false sieve-plate appearance. Others possess concentric arrangements of pits around the pore openings thus giving the appearance of compound normal pores (Pl. 31, Figs. 8, 10). The true compound pores are sunk deep below the valve surface and possess radiating structures (Pl. 31, Figs. 4, 5, 9) on their sieve plates.

The muscle pattern is as shown in Fig. 33 B.

(See also Pl. 31, Fig. 6). There are three fairly elongated muscle scars in dorsal group (i), a large ventrally pointing irregularly shaped scar and a small posterior ovate scar in dorsal group (ii) and two subtriangular scars in dorsal group (iii). There are three frontal muscle scars, six variously shaped adductor scars and two subtriangular mandibular scars.

The hinge in the left valve consists of a deep anterior socket, a strongly built, rounded anterior tooth, a faintly crenulated posteromedian bar and a slitlike posterior socket. The selvage is strong and subperipheral.

The inner lamella is wide anteriorly and narrow posteriorly (Pl. 31, Fig. 2). Line of concrescence and inner margin of primary part of the duplicature incompletely fused anteriorly, where a narrow irregularly shaped vesibule is formed (Pl. 31, Figs. 12, 13, 14; and Fig. 33 A). The inner margin of the secondarily fused inner lamella is irregular (Pl. 31, Fig. 2) and runs ventral to the internal ocular socket. True radial pores are numerous, about 40 anteriorly and 19 posteriorly; they are broad at their origin, straight to slightly wavy, medially dilate and sometimes branching (Fig. 33 A). There are three large, anterior pseudomarginal pore canals.

Sexual dimorphism slight, males are slightly larger than females, dorsally strongly arched and with a less concave posterodorsal margin.

Juveniles were not observed.

Material. 8 specimens.

Ecology and distribution. The species is rare in the Niger Delta. It was recorded only from station GT (see Tables I and II).

Dimensions.

	Length	*Height*	*Width*
Holotype (male carapace)	0.510	0.278	0.173
Females	0.483—0.495	0.233—0.240	0.165
Males	0.510—0.519	0.270—0.278	—

Remarks. C. africana is similar to *C. rectangularis* (Brady) in habitus but it is more dorsally arched, possesses a fairly robust caudal process and a ventral diagonal ridge.

Subfamily UNCERTAIN
Genus NEOCAUDITES Puri, 1960
Type species *Neocaudites neviani* Puri, 1960

Discussion

Puri (1960, p. 127) in his original description, classified *Neocaudites* Puri, under the subfamily Trachyleberidinae of the Trachyleberididae. He did not give his reasons for this grouping. Thereafter several authors, van den Bold (1963, p. 389), Morales (1966, p. 84), Holden (1967, p. 43) and Hazel (1967 a, p. 31), also placed *Neocaudites* within the Trachyleberidinae. Their classification is probably based on the morphology and the V-shaped frontal muscle scar of species of this genus.

Puri and Dickau (1969, p. 366) however grouped *Neocaudites* within the family Hemicytheridae, probably on the grounds of the occurrence of compound normal pores (type C of Puri and Dickau, 1969) reported for *Neocaudites neviani* Puri. Compound normal pores are characteristic of the three new species treated in this study.

Puri (1960, p. 127) and van den Bold (1963, p. 389) mentioned the presence a row of three adductor muscle scars in their respective studies of *N. neviani* (Puri) and *N. triplistriatus* (Edwards). Puri (*op. cit.*) also noted two frontal muscle scars for *N. neviani,* while van den Bold (*op. cit.*) mentioned a V-shaped frontal muscle scar for *N. triplistriatus.* Such an interspecific occurrence of V-shaped and two discrete frontal muscle scars is not uncommon in the Trachyleberididae—Hemicytheridae group. However, the occurrence of three adductor muscle scars, though peculiar as indicated by van den Bold (1963, p. 389), is easily understandable under closer observation. It is commonly found in species of *Neocaudites* investigated in this study (see Pl. 32, Fig. 5 and Fig. 34 for *N. purii*; Fig. 36 for *N. tuberculata*, and especially Pl. 33, Fig. 5, for *N. rectangularis*), that the middle pair or lower two of the adductor muscle scars are almost always in close contact, and may, under lower magnification, seem to be a single scar.

Regarding the frontal muscle scar, Puri's (*op. cit.*) diagnosis of two scars for the type species

is so far the only known occurrence of a double frontal scar for the genus. There are also U- and C-shaped frontal muscle scars.

For the present, I should tentatively group the genus *Neocaudites* Puri, within the Hemicytheridae, subfamily "Uncertain". This is based on the shape, the occurrence of both single U-, V- or irregulariy-shaped and double frontal muscle scars, the presence of three elongate muscle scars in dorsal scar group (i), three differently arranged muscle scars in dorsal scar group (ii), and the occurrence of highly complex compound normal pores, which so far as this study reveals, are typical (with one exception) of the Hemicytherinae. The present placing however awaits confirmation from the study of soft parts.

Neocaudites purii n. sp.

Pl. 32, Figs. 1—14; Figs. 34 and 35

Derivation of name. In honour of Dr. Harbans S. Puri, Tallahassee, Florida, U.S.A.

Holotype. A male left valve, Af. 111; figured as Pl. 32, Fig. 1. Recent. Locality A5, western Niger Delta.

Diagnosis. This species is characterized by a subrectangular carapace a strongly arched dorsal ridge, a prominent dorsoposterior tubercle, pronounced marginal ridges, a large anterior vestibule and numerous large, compound normal pores.

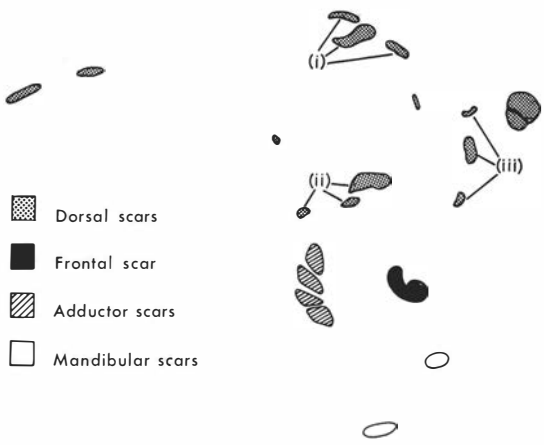


Fig. 34. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Neocaudites purii* n. sp.

Description

Carapace subrectangular in lateral view, laterally compressed in dorsal view, and widest anterior to median. Dorsal margin almost straight, medially convex due to the strongly arched dorsal ridge, highest at the anterior cardinal angle from which it slopes gently anteriorly and posteriorly. Anterior margin broadly rounded with 12—15 marginal denticles and with a thin anteroventral frill. Ventral margin anteriorly and posteriorly convex, denticulate and medially with a shallow sinuosity. Posterior margin obtuse and denticulate, dorsally and ventrally sloping towards each other and slightly produced medially. Surface ornament consisting in the dorsal area of a strongly arched dorsal ridge which begins anteriorly below the eye tubercle, is medially arched and runs along the margin to the dorsal side of the prominent dorsoposterior tubercle. From this tubercle, an almost imperceptible ridge runs diagonally to the slightly raised subcentral muscle node. Along the anterior, ventral and posterior margins a broad marginal ridge runs continuously along the margins, and narrows slightly at the ventromedian margin where it produces three short dorsal ribs. Dorsomedially, a shallow, weak narrow sulcus, internally represented by a low ridge, runs vertically to about two-thirds the distance from the dorsal margin. A shallow submarginal groove is present on the inner side of the marginal ridge except along the ventromedian margin. The intercostal areas are generally smooth but may be finely pitted along the median diagonal ridge (Pl. 32, Fig. 3). The eye tubercle is low, internal ocular socket is small but distinct.

Normal pores (Pl. 32, Figs. 6—8, 9, 13) are numerous, large, and of the compound type, countersunk below valve surface and with a ring around their external openings.

The setal pores are central or slightly off-centre and rimmed. The sieve plates show structural differences in relation to the sexes. Sieve plates of females (Pl. 32, Figs. 8, 13) are finely perforated with off-centre setal pore openings, while those of males (Pl. 32, Figs. 6, 7) are coarsely perforated and with central pore openings.

The muscle scar pattern (Pl. 32, Fig. 5; Fig. 34) consists of a C-shaped frontal muscle scar, an oblique row of four adductor scars, the two lower members being in close contact, two oval mandibular scars, and a dorsal group of scars consisting of three elongate diagonally arranged scars in dorsal group (i), three small scars in dorsal group (ii) and three vertically arranged scars in dorsal group (iii).

The hinge is holoamphidont. In the left valve, it begins with a shallow anterior socket, a strong pointed ventrally curved anteromedian tooth, a narrow, smooth posteromedian ridge and an oval posterior socket. The right hinge corresponds. Selvage strong, narrow and peripheral.

The inner lamella is moderately wide anteriorly and narrow posteriorly. The line of concrescence and inner margin incompletely fused anteriorly where an irregular anteromedian vestibule is present. Radial pore canals, fairly numerous anteriorly (about 33) and few posteriorly (about 15). They are generally straight, but may be wavy especially along the anteroventral region, dilated at their ends and sometimes branching. In some cases they extend into the marginal denticles where they are enlarged (Pl. 32, Figs. 11, 12, 14).

Sexual dimorphism distinct; males larger than females (Fig. 35) and more stoutly ornamented.

Juveniles not observed.

Material. 8 specimens; 5 males and 3 females.

Ecology and distribution. Neocaudites purii was recorded from fine grey silt with abundant faecal pellets, algae and shell debris Station A5), and from quartzose sand (station A2). It is comparatively abundant on fine-grained substrates (Tables I and II). Depth ranges from 20 to 30 metres, and bottom temperature from 25.1°C to 21.3°C. A single specimen has been observed from off Tema Harbour (Ghana) and a few from off Bandama (Ivory Coast).

Dimensions.

	Length	*Height*	*Width*
Holotype (male left valve)	0.500	0.270	—
Females	0.480—0.490	0.233—0.240	—
Males	0.500—0.510	0.255—0.270	0.150

Remarks. N. purii differs from other species of the genus in possessing a strongly arched dorsal ridge, and numerous, large, compound normal pores. It is similar to *N. terryi* Holden (1967) in shape and ornament. *N. terryi* has a gently arched dorsal ridge, a strongly developed diagonal ridge, a concave dorsoposterior margin and it is larger.

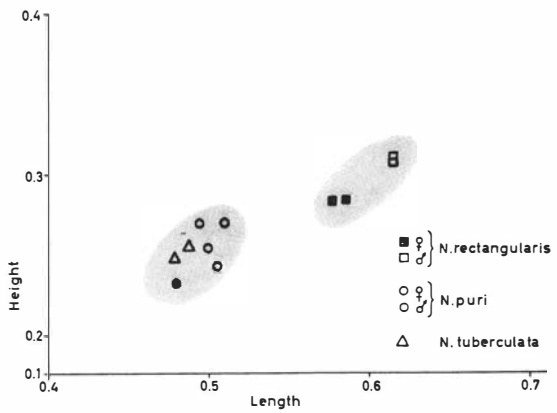


Fig. 35. Scatter diagram of length and height of *Neocaudites rectangularis* n. sp., *N. purii* n. sp. and *N. tuberculata* n. sp. from all localities. Note: (i) Specific differences in size and (ii), relationship between size to substrate. *N. rectangularis* is restricted to medium-grained quartzose sand while *N. purii* and *N. tuberculata* are commonly found in silt and muddy silt (see Table 1).

Neocaudites rectangularis n. sp.

Pl. 33, Figs. 1—14; Fig. 35

Derivation of name. After the rectangular shape of the carapace.

Holotype. A male right valve, Af. 112; figured as Pl. 33, Fig. 1. Recent. Locality A1, western Niger Delta.

Diagnosis. This species is characterized by a rectangular carapace in lateral view, strong marginal denticles, a prominent eye tubercle and a strong ornamental and normal pore dimorphism.

Description

Carapace rectangular to elongated in lateral view, laterally compressed in dorsal view, greatest width at the slightly swollen subcentral muscle tubercle.

Left valve overlaps the right valve at the cardinal angles. Dorsal margin straight, slightly irregular at the points where the dorsal ridge is tuberculate, higher at the anterior cardinal angle, slightly convex posteriorly and with a prominent posterior cardinal angle. Anterior margin broadly rounded and with up to 13 paddle-like denticles and a corresponding marginal row of rosette-like tubercles in males (Pl. 33, Figs. 1, 4), but small, blunt marginal denticles in females (Pl. 33, Figs. 6, 9). The ventral margin is anteriorly convex, medially sinuous and posteriorly upturned. Posterior margin broadly rounded, slightly concave at the dorsal margin and with six striated paddle-like ventral denticles in males (Pl. 33, Figs. 1, 3) and small blunt denticles in females (Pl. 33, Fig. 6).

The surface ornament consists in the dorsal region of a relatively thin and weakly developed, irregularly tuberculate dorsal ridge which is anteriorly connected to the posterior part of the strongly developed eye tubercle. Anteriorly there is a broad, smooth and prominent submarginal ridge which parallels the anterior margin, is dorsally connected to the eye tubercle and ventrally joined to an irregular, dorsally convex ventral submarginal ridge. A smooth, broad, postero-marginal ridge is connected ventrally to the posterior end of the ventral ridge. Laterally, a prominent diagonal ridge runs anteriorly at an angle of 45° from the dorsoposterior corner as a gradually broadening diagonal ridge which ends near the anteroventral margin. A short posterolateral ridge runs from the origin of the diagonal ridge at about an angle of 60° towards the posterior margin. Intercostal areas are covered by (i) irregularly shaped pits and grooves, concentrated on the anterior, posteroventral, ventral and dorsal areas, (ii) tubercles which are commonly rounded in males but usually triangular in females, and (iii) fine pits which occur at the origin of the diagonal ridge and are scattered in patches on the other parts of the carapace. The eye tubercle strongly developed, internal ocular socket small.

Normal pores (Pl. 33, Figs. 8, 10—12) are few, large, of simple and compound types and concentrated in the middle parts of the valve. Most of the simple normal pores run through tubercles, but they are also found on other parts of the valve. The compound normal pores are countersunk below the valve surface, possess central to slightly marginal, rimmed setal pores and show strong dimorphic differences. The male sieve plates comprise coarse, radiating and branching structures which give a net-like pattern (Pl. 33, Figs. 8, 11), while the female sieve plates are finely perforated and with a radiating pattern (Pl. 33, Figs. 10, 12).

The muscle scar pattern consists of a U-shaped frontal scar, a slightly oblique row of four adductor scars with an elongated dorsomedian member and two lower scars in close contact (Pl. 33, Figs. 2, 5), two ovate to subrounded mandibular scars, and a dorsal group scars consisting of three scars in dorsal groups (i) and (ii) (see Pl. 33, Figs. 2, 5).

The hinge is holoamphidont, and as described for *N. purii* (see Pl. 33, Fig. 2).

Selvage narrow and peripheral.

Inner lamella anteriorly broad, posteriorly narrow and ventromedially absent. The anterior duplicature is sometimes ornamented by a marginal row of short, fine crenulations. Line of concrescence and inner margin coincident throughout, vestibule absent. Radial pore canals are numerous anteriorly, few posteriorly and straight to slightly wavy. There are 44 anterior and 16 posterior, medially dilate canals with few bifurcations.

Sexual dimorphism strong, distinct, apparent in size, detail of ornamental differences and in the compound normal pores (see Pl. 33, Figs. 1 and 6; 4 and 9; 8 and 11; 10, 12 and Fig. 35).

Juveniles were not observed.

Material. 4 specimens; 2 females and 2 males.

Ecology and distribution. This species was recorded from quartzose sand rich in shell debris and glauconite at stations GT and A1 at a depth of 20 metres; the bottom temperature at station A1 was 25.1°C (see Tables I and II). *N. rectangularis* has only been found in the western Niger Delta.

Dimensions.

	Length	*Height*
Holotype (male right valve)	0.615	0.308
Females	0.578—0.585	0.285
Male (L.V.)	0.615	0.312

Remarks. N. rectangularis is the largest species of *Neocaudites* recorded from the Niger Delta. It differs from other species of the genus by its strong ornamental and normal pore dimorphism, strongly developed eye tubercles, and the broadly rounded posterior margin.

Neocaudites tuberculata n. sp.
Pl. 34, Figs. 1—9; Figs. 35 and 36

Derivation of name. After its strongly tuberculate valves.

Holotype. A right valve, Af. 113, figured as Pl. 34. Fig. 1. Recent. Locality A5, western Niger Delta.

Diagnosis. This species is characterized by strong dorsoposterior and ventral tubercles, a feebly developed diagonal ridge and a pointed posterior margin.

Description

Carapace subtriangular to subquadrate in lateral view. Dorsal margin saddle-shaped and uneven, highest at the anterior cardinal angle and posteriorly elevated at the posterior cardinal angle. Anterior margin broadly rounded with 8—10 short, blunt marginal denticles. Ventral margin straight, slightly sinuous medially and posteriorly upturned. Posterior margin dorsally acute, ventrally obtuse and medially produced, with short, heavy denticles on the posteroventral region.

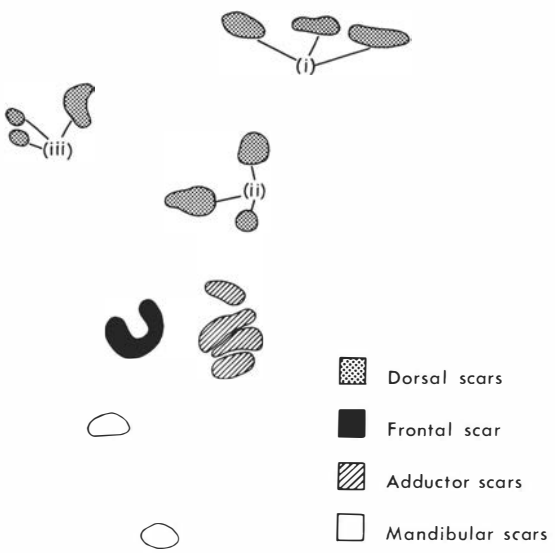


Fig. 36. Arrangement of the dorsal, frontal, adductor and mandibular muscle scars of *Neocaudites tuberculata* n. sp.

The surface ornament consists of a prominent, smooth, strongly curved anterior submarginal ridge, a narrow, tuberculate dorsal ridge, a large dorsoposterior tubercle from the ventral part of which a short, low distally curved ridge runs towards the posteromedian region, a low, faintly discernible diagonal ridge which ends at the slightly raised subcentral muscle tubercle, a prominent, smooth posteromarginal ridge and a large ventroposterior tubercle from which an irregular ridge runs anteriorly to be connected to the ventral tip of the anterior submarginal ridge. The intercostal areas are smooth, and sparsely punctate to tuberculate in places. Eye tubercle low, internal ocular socket present.

Normal pores are, as far as can be determined, of both simple and compound types and relatively few. The simple normal pores run mostly through tubercles and are few (Pl. 34, Figs. 3, 5), and the compound normal pores are flushed below the surface and possess centrally placed setal pores (Pl. 34, Figs. 5, 6).

The muscle scar pattern (Pl. 34, Figs. 2, 4 and Fig. 36) consists of a U-shaped frontal scar, a vertical row of four elongate to subrounded adductor scars, two subovate mandibular scars, and dorsal scars which consist of three elongate scars in dorsal group (i), three triangularly arranged scars in dorsal group (ii) and three scars in dorsal group (iii) (see Fig. 36).

The hinge in the right valve consists of a strong, rounded anterior tooth, a ventrally deep and dorsally shallow anteromedian socket which narrows and is continuous with a narrow, dorsally crenulate median groove and a rounded posterior tooth. The selvage is narrow and peripheral.

The inner lamella is anteriorly and posteriorly wide and ventromedially absent. Line of concrescence and inner margin completely fused. Radial pore canals numerous anteriorly and few posteriorly, straight to slightly wavy.

Material. 3 specimens.

Ecology and distribution. This species was recorded from station A5 on a fine grey silt with abundant fecal pellets, algae and shell debris. The depth is 30 metres and bottom temperature was at the moment of collection 21.3°C (see Tables I and II). It is rare in the Niger Delta.

Dimensions.

	Length	*Height*	*Width*
Holotype	0.488	0.255	—
Paratypes	0.480—0.485	0.248	—

Remarks. The species can easily be distinguished by its smaller size, and strongly tuberculated posterior.

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PLATES

Plate 1

Neocythereis nigeriensis n. gen., n. sp.

Figs. 1—10 are scanning electron micrographs; figs. 11—13 are transmitted light micrographs.

1. External view of a male left valve. Holotype Af. 82. × 80.
2. Internal view of a male right valve. Note the weakly crenulate median hinge element. Paratype Af. 82:1. × 80.
3. External view of a female right valve. Paratype Af. 82:2. × 80.
4. A sunken simple normal pore from the dorsomedian part of a male (same as in fig. 1). Note the lateral supporting framework. × 4,000.
5. Internal view of the median part of a male right valve (same as in fig. 2) showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 160.
6. Surface of a male left valve (same as in fig. 1) showing details of surface sculpture and distribution of simple normal pores. × 400.
7. An infilled slightly countersunk simple normal pore of a male left valve (same as in fig. 1). × 4,000.
8. Detail arrangement of the frontal, adductor and upper mandibular muscle scars of a right valve (same as in figs. 2 and 5). × 400.
9. Internal view of a male left valve. Note the practically smooth median hinge bar, and presence of a strong selvage. Paratype Af. 82:4. × 87.
10. External view of the posterior of a female right valve (same as in fig. 3). × 160.
11—12. Posterior and anterior marginal areas respectively, of a male left valve (holotype) showing radial pores and crescentic vestibule. × 134.
13. Anterior marginal area of a female right valve (same as in fig. 3). Note absence of vestibule. × 134.

Plate 2

Neocythereis ? simplex n. gen., n. sp.

Figs. 1—5, and 7 are scanning electron micrographs; 6, 8—10 are transmitted light micrographs.

1. External view of a left valve. Holotype Af. 83. × 127.
2. Internal view of a right valve. Paratype Af. 83:1. × 127.
3. Detail of surface ornament of a left valve (same as in fig. 1) showing large papillate pits and distribution of flushed simple normal pores. × 318.
4. Interior of the median part of a right valve (same as in fig. 2) showing the arrangement of the muscle scars, and the details of the anterior elements of the right hinge. × 318.
5. A sunken simple normal pore. × 6,332.
6. Anterior marginal area of a left valve showing radial pores and an anteroventral vestibule. × 134.
7. A countersunk normal pore and details of the surrounding area. × 3,180.
8. A left valve showing radial pores, vestibule and distribution of normal pores. × 67.
9—10. Anterior and posterior marginal areas of a right valve (same as in fig. 2) showing radial pores and vestibule. × 134.

Plate 3

Phacorhabdotus hazeli n. sp.

Figs. 1—7 are scanning electron micrographs; figs. 8—11 are transmitted light micrographs.

1. External view of a right valve. Holotype Af. 84. × 80.
2. Internal view of a left valve. Paratype Af. 84:1. × 87.
3. Details of the anterior end of the diagonally running lateromedian ridge of the right valve in fig. 1, showing surface sculpture and distribution of normal pores. × 387.
4. Internal view of the anterior half of a left valve (same as in fig. 2) showing arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 173.
5, 8. Compound normal pores from different parts of the holotype (fig. 1). × 7,867.
6. Dorsal view of an adult carapace. Paratype Af. 84:2. × 87.
7. Internal view of a left valve (same as in fig. 4) showing the detailed arrangement of the dorsal (group (ii)), frontal and adductor muscle scars. × 373.
9—10. Posterior and anterior marginal areas respectively, of a left valve (same as in fig. 2) showing the inner lamella and radial pores. × 134.
11. A left valve (same as in fig. 2) showing radial pores and distribution of normal pores. × 67.

Plate 4

Figs. 1—8. *Cativella iyemojai* n. sp.

Figs. 1—6 are scanning electron micrographs; figs. 7—8 are transmitted light micrographs.

1. External view of a female right valve. Holotype Af. 85. × 80.
2. Internal view of a female left valve. Paratype Af. 85:1. × 80.
3. External view of a male right valve. Paratype Af. 85:2. × 80.
4. A simple normal pore with an elevated rim. × 4,000.
5. Internal view of a left valve (same as in fig. 2) showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 160.
6. Detail of the surface sculpture between the median and the ventral ridges of a female right valve (same as in fig. 1) showing the disribution of simple normal pores. × 400.

7—8. Posterior and anterior marginal areas respectively of a left valve (same as in fig. 2) showing the radial pores. × 134.

Figs. 9—11. *Reymentia reticulata* n. sp.

All figures are scanning electron micrographs.

9. External view of a male left valve. Holotype Af. 86. × 147.
10. External view of a female right valve. Paratype Af. 86:1. × 147.
11. Internal view of a female left valve. Paratype Af. 86:2. × 134.

Plate 5

Ruggieria tricostata n. sp.

Figs. 1—7 are scanning electron micrographs; figs. 8—10 are transmitted light micrographs.

1. External view of a male right valve. Holotype Af. 87. × 80.
2. Internal view of a male left valve. Paratype Af. 87:1. × 80.
3. External view of a female left valve. Paratype Af. 87:2. ×:80.
4. Internal view of a female right valve. Paratype Af. 87:3. × 80.

5—6. Simple normal pores with elevated rims, respectively from a male (fig. 1), and a female (fig. 3). Note the slight difference in the surface sculpture. × 4,000.

7. Internal view of a right valve (same as in fig. 4) showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 160.
8. A right valve (same as in fig. 1). × 67.

9—10. Anterior and posterior marginal areas respectively of a right valve (same as in figs. 1 and 8) showing the radial pores. × 134.

Plate 6

Ruggieria lekkii n. sp.

Figs. 1—8 are scanning electron micrographs; figs. 9—11 are transmitted light micrographs.

1. External view of a female left valve. Holotype Af. 88. × 77.
2. Internal view of a female right valve. Paratype Af. 88:1. × 77.
3. External view of a male right valve. Paratype Af. 88:2. × 77.
4. Internal view of a right valve (same as in fig. 2) showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 153.
5. Surface ornament of a female left valve (same as in fig. 1). Note the distribution of the simple normal pores. × 373.
6. External view of the left valve of a pre-adult larval instar. Note: (i) occurrence of low subcentral tubercle; absent in the adult, (ii) distribution of normal pores identical to those of the adult. × 87.
7. A rimmed simple normal pore from the female in fig. 1. × 3,733.
8. A rimmed simple normal pore from the male in fig. 3. × 7,467.
9. A right valve female (same as in fig. 2) showing the radial pores. × 67.

10—11. Anterior and posterior marginal areas respectively, of a right valve (same as in figs. 2 and 9) showing details of the radial pores. × 134.

Plate 7

Ruggieria beninensis n. sp.

Figs. 1—8, 10 are scanning electron micrographs; figs. 9, 11—13 are transmitted light micrographs.

1. External view of a male left valve. Holotype Af. 89. × 80.
2. Internal view of a male right valve. Paratype Af. 89:1. × 80.
3. Dorsal view of a male. Note strong asymmetry between left and right valves. Paratype Af. 89:2. × 83.
4. Dorsal view of a female. Note asymmetry of the valves, and tendency to smoothing of the costae in

the anterior part of the carapace. Paratype Af. 89:3. × 83.

5. Internal view of the anterior part of a male right valve (same as in fig. 2) showing the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 160.

6. Internal view of a male left valve. Paratype Af. 89:4. × 80.

7, 10. Rimmed simple normal pores respectively of a female and a male. × 4,000.

8. Details of the arrangement of the frontal, adductor and dorsal (group (ii)) muscle scars of a left valve (same as in fig. 6). × 400.

9, 13. Left and right valves respectively showing radial pores. Note the assymetry in shape and size of both valves. × 67.

11, 12. Anterior and posterior marginal areas respectively of a right valve (same as in fig. 13) showing details of the radial pores. × 134.

Plate 8

Figs. 1—7. *Ruggieria triangulata* n. sp.

Figs. 1—6 are scanning electron micrographs; fig. 7, a transmitted light micrograph.

1. External view of a male right valve. Holotype Af. 90. × 80.

2. Internal view of a male left valve. Paratype Af. 90:1. × 80.

3. External surface of a right valve (same as in fig. 1) showing the ornament and the distribution of simple normal pores. × 160.

4. Details of the dorsal (group (ii)), frontal and adductor muscle scars of a right valve (same as in fig. 1). × 400.

5. Internal view of a right valve (same as in fig. 2) showing arrangement of the dorsal, frontal, adductor and mandibular muscle scars. × 160.

6. Rimmed simple normal pore of a male right valve (same as in fig. 1). × 4,000.

7. A right valve male (same as in fig. 2) showing the radial pores. × 67.

Figs. 8—13. *Chrysocythere foveostriata minuta* n. subsp.

Figs. 8, 9, 13, are scanning electron micrographs, and figs. 10—12 are transmitted light micrographs.

8. External view of a left valve. Holotype Af. 91. × 80.

9. Internal view of a right valve. Paratype Af. 91:1. × 80.

10—11. Posterior and anterior marginal areas respectively, of the holotype showing radial pores and a large anterior crescent-shaped vestibule. × 134.

12. Anterior marginal area of a right valve (same as in fig. 9) showing a relatively narrow vestibule, and radial pores. × 134.

13. An infilled, rimmed simple normal pore. × 4,000.

Plate 9

Ruggieria martinssoni n. sp.

Figs. 1—8 are scanning electron micrographs; figs. 9—11 are transmitted light micrographs.

1. External view of a female left valve. Holotype Af. 92. × 80.

2. External view of a female right valve. Paratype Af. 92:1. × 80.

3. Dorsal view of a female carapace. Note strong asymmetry between left and right valves. Also compare figs. 1 and 2. Paratype Af. 92:2. × 83.

4. Dorsal view of a male carapace. Paratype Af. 92:3. × 80.

5. Internal view of a male left valve. Paratype Af. 92:4. × 80.

6. Detail of the frontal and adductor scars of a left valve (same as in fig. 5). × 400.

7—8. Rimmed simple normal pores respectively of a male (fig. 4) and a female (fig. 3). × 4,000.

9—10. Anterior and posterior marginal areas respectively, of a right valve showing radial pores. × 134.

11. Anterior marginal area of a left valve showing radial pores. × 134.

Plate 10

Buntonia olokundudui Reyment and Van Valen

Figs. 1—7 are scanning electron micrographs; figs. 8—10 are transmitted light micrographs.

1. External view of a female left valve. × 77.

2. External view of a male right valve. × 77.

3. Arrangement of the frontal, adductor and mandibular muscle scars of a right valve (same as in fig. 7). Note anomalous arrangement of the two upper adductor scars. × 380.

4. Internal view of a male right valve. × 77.

5—6. Rimmed simple normal pores. Note the bottle-neck shape of the sunken pore opening in fig. 5. × 3,800.

7. Internal view of part of a right valve (same as in fig. 4) showing arrangement of all muscle fields. × 153.

8—9. Anterior and posterior marginal areas of a right valve showing the radial pores. × 134.

10. A right valve, male. × 67.

Plate 11

Buntonia foliata n. sp.

Figs. 1—7, 9 are scanning electron micrographs; figs. 8, 10—11 are transmitted light micrographs.

1. External view of a female right valve. Holotype Af. 93. × 117.
2. Internal view of a female left valve. Paratype Af. 93:1. × 117.
3. Surface ornament of a female right valve (same as in fig. 1). Note the distribution of simple normal pores. × 670.
4, 7. Simple normal pores from a female right valve (same as in fig. 1). × 3,180.
5. Arrangement of the frontal and adductor muscle scars of a right valve (same as in fig. 2). × 367.
6. Internal view of a male left valve. Paratype Af. 93:2. × 134.
8. A right valve of a female. × 67.
9. External view of the left valve of a juvenile instar. Note finely pitted surface and the development of marginal denticles. × 153.
10—11. Anterior and posterior marginal areas of a right valve (same as in figs. 2 and 8) showing radial pores. × 134.

Plate 12

Figs. 1—8. *Soudanella africana* n. sp.

Figs. 1—6 and 8—10 are scanning electron micrographs; fig. 7 is a transmitted light micrograph.

1. External view of a male right valve. Holotype Af. 94. × 90.
2. Internal view of a male left valve. Paratype Af. 94:1. × 90.
3. Dorsal view of a male carapace. Paratype Af. 94:2. × 97.
4. Dorsal view of a female carapace. Paratype Af. 94:3. × 97.
5. Internal view of a right valve (same as in fig. 2) showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 180.
6. Surface sculpture and distribution of simple normal pores of a right valve (same as in fig. 1). × 900.
7. Anterior marginal area of a right valve showing the radial pores. × 134.
8. A broad-rimmed simple normal pore. × 4,500.
Figs. 9—10. *Ruggieria nigeriana* Omatsola (1970).
9. External view of a male right valve. × 77.
10. Internal view of a male left valve. × 77.

Plate 13

Soudanella africana reticularis n. subsp.

Figs. 1—8 are scanning electron micrographs; figs. 9—11 are transmitted light micrographs.

1. External view of a male left valve. Holotype Af. 95. × 87.
2. Internal view of a male right valve. Paratype Af. 95:1. × 87.
3. Surface sculpture of a male left valve (same as in fig. 1) showing shallow pits and the distribution of different types of simple normal pores. × 870.
4. Internal view of a male right valve (same as in fig. 2) showing the arrangement of the dorsal, frontal, adductor and mandibular muscle scars. × 173.
5, 6, 8. Details of three rimmed simple normal pores. × 4,267.
7. Arrangement of the frontal, adductor and upper mandibular muscle scars of a right valve (same as in figs. 2 and 4). × 427.
9. A right valve male showing radial pores. × 67.
10—11. Anterior and posterior marginal areas respectively, of a right valve showing the radial pores. × 134.

Plate 14

Dakrika robusta n. gen., n. sp.

Figs. 1—6, 9 are scanning electron micrographs; figs. 7—8, 10 are transmitted light micrographs.

1. External view of a male right valve. Holotype Af. 96. × 80.
2. Internal view of a male right valve. Paratype Af. 96:1. × 80.
3. Surface ornament of a male right valve (same as in fig. 1). Note the distribution of the simple normal pores. × 400.
4. Dorsal view of a female carapace. Paratype Af. 96:2. × 80.
5. Internal view of a right valve (same as in fig. 2) showing the arrangement of the dorsal (group (ii)), frontal and adductor muscle scars. × 400.
6. Lateral external view of a female carapace (same as in fig. 4). × 67.
7—8. Posterior and anterior marginal areas respectively, of a left valve (same as in fig. 10) showing the radial pores. × 134.
9. Internal view of a female left valve. Paratype Af. 96:3. × 80.
10. A left valve showing the radial pores. Note the distribution of the normal pores. × 67.

Plate 15

Chryscythere foveostriata (Brady)

Figs. 1—11 are scanning electron micrographs; figs. 12—15 are transmitted light micrographs.

1. External view of a male left valve. × 80.
2. Internal view of a male right valve. × 80.
3. External view of a female right valve. × 80.
4. Internal view of the anterior half of a right valve (same as in fig. 2) showing the arrangement of the dorsal, frontal, adductor and mandibular muscle scars. Note rimmed internal openings of simple normal pores in the area below the anteromedian hinge element. × 153.

5—7. Irregularly shaped simple normal pores. × 3,750.

8. Arrangement of the frontal and adductor muscle scars of a right valve (same as in fig. 2). × 383.

9—11. Arrangement of the frontal and adductor muscle scars of respectively two right valves and a left valve. Note the variation in shape of the frontal muscle scars. × 383.

12. A right valve showing an anterior vestibule and radial pores. × 67.

13—14. Anterior marginal areas of two right valves showing crescent-shaped vestibules and wavy, sometimes medially dilating radial pores. × 134.

15. Posterior marginal area of a right valve (same as in fig. 14) showing radial pores. × 134.

Plate 16

Chrysocythere boldi n. sp.

Figs. 1—8 are scanning electron micrographs; figs. 9—10 are transmitted light micrographs.

1. External view of a male left valve. Holotype Af. 97. × 80.
2. Internal view of a male left valve. Paratype Af. 97:1. × 80.
3. External view of a female left valve. Paratype Af. 97:2. × 80.
4. Arrangement of the frontal and adductor muscle scars of a male left valve (same as in fig. 2). × 387.
5. Surface sculpture of a male left valve (same as in fig. 1) showing the distribution of the simple normal pores. × 800.

6—7. Simple normal pores piercing through the ridges of a male left valve (same as in figs. 1 and 5). Respectively × 3,870; × 1,587.

8. A simple normal pore (same as that in the right hand corner of fig. 5). × 1,593.

9—10. Posterior and anterior marginal areas respectively, of a left valve showing the radial pores and vestibules. × 134.

Plate 17

Mackenziella lagosensis n. gen., n. sp.

Figs. 1—11 are scanning electron micrographs; figs. 12—14 are transmitted light micrographs.

1. External view of a male right valve. Paratype Af. 98:1. × 77.
2. Internal view of a female right valve. Paratype Af. 98:2. × 77.
3. Surface sculpture of the lateromedian part of the male right valve in fig. 1 showing the shapes of the pits and the distribution of compound normal pores. × 383.
4. Dorsal view of a female carapace. Holotype Af. 98. × 80.
5. Internal view of a right valve (same as in fig. 2) showing the arrangement of the muscle scar fields. × 153.
6. A strongly "buttressed" compound normal pore from the lateral part of fig. 1. × 7,333.
7. Arrangement of the frontal and adductor muscle scars of a right valve (same as in figs. 2 and 5). × 383.

8, 10, 11. Compound normal pores from various parts of the holotype (fig. 4). Note the honey-comb structure of the broken part of the pore in fig. 8. × 3,830.

9. Internal view of a male left valve. Paratype 98:3. × 77.
12. A pre-adult right valve showing radial pores. Note occurrence of a narrow but discernible anterior vestibule. × 67.

13—14. Anterior and posterior marginal areas of a right valve (same as in fig. 2) showing radial pores. Note the absence of vestibule. × 134.

Plate 18

Basslerites elongata n. sp.

Figs. 1—9 are scanning electron micrographs; figs. 10—12 are transmitted light micrographs.

1. External view of a male left valve (slightly damaged). Paratype Af. 99:1. × 80.
2. A simple normal pore from the posteroventral part of the male in fig. 6. × 4,867.
3. Internal view of a female left valve. Paratype Af. 99:2. × 83.
4. Right lateral view of a female carapace. Holotype Af. 99. × 100.
5. Internal view of a left valve (same as in fig. 3) showing the arrangement of the muscle scar fields. × 163.
6. Right lateral view of a male carapace. Paratype Af. 99:3. × 100.

7. Details of the posterior part of a male carapace (same as in fig. 6) showing the non-setae and setae-bearing simple normal pores. Note the occurrence of flagellate and pinnate sensory setae. × 420.
8. Arrangement of the frontal and adductor muscle scars of a left valve (same as in fig. 3). Note the presence of two discrete frontal scars. × 920.
9. A simple normal pore from the lateral side of a male carapace (same as in fig. 6) showing a projecting feather-like sensory seta. × 4,167.
10. A left valve showing radial pores, anterior and posterior vestibules and distribution of the normal pores. × 67.
11—12. Posterior and anterior marginal areas respectively, showing vestibules and radial pores. × 134.

Plate 19

Basslerites (*Loculiconcha*) *punctata* n. sp. Figs. 1—7, 10—12.

Figs. 1—7, 10 are scanning electron micrographs; figs. 11—12 are transmitted light micrographs.

1. External view of a female right valve. Holotype Af. 100. × 107.
2. Internal view of a female left valve. Paratype Af. 100:1. × 105.
3. Posteroventral part of the holotype (fig. 1) showing the distribution of elevated simple normal pores, six semicircularly arranged loculi and surface punctation. × 300.
4. Internal view of the dorsal half of a female left valve (same as in fig. 2). Note the faint crenulation of the posterior extremity of the median hinge element and the arrangement of the muscle scar fields. × 163.
5. Extreme posterior part of a right valve (same as in figs. 1 and 3) showing the detailed arrangement of the normal pores and the loculi. × 333.
6. Detail of the arrangement of the dorsal (group (ii)), frontal and adductor muscle scars of a left valve (same as in figs. 2 and 4). × 407.
7. Internal view of the posterior part of a right valve. Note crenulation of the posteromedian hinge element. × 163.
10. Normal pores from the posterior part of a right valve (same as in fig. 1). × 670.
11—12. Posterior and anterior marginal areas respectively, of a left valve (same as in fig. 2) showing radial pores and vestibules. Note the two discrete frontal muscle scars. × 134.

Basslerites (*Loculiconcha*) *ikoroduensis* Omatsola Figs. 8—9.

All figures are scanning electron micrographs.

8. Arrangement of the frontal and adductor muscle scars of a left valve (same as in fig. 9). × 453.
9. Internal view of a female left valve. × 107.

Plate 20

Hermanites foveolata n. sp.

Figs. 1—9 are scanning electron micrographs; figs. 10—11 are transmitted light micrographs.

1. External view of a male left valve. Holotype Af. 101. × 70.
2. Internal view of a male right valve. Paratype Af. 101:1. × 67.
3. Surface sculpture of the posteromedian part of the holotype (fig. 1) showing the distribution of simple (elevated) and compound (sunken) normal pores. × 700.
4, 6—8. Compound normal pores. 4, 6 and 8 are from a male left valve (same as in fig. 1). Note (i) the honey-comb structures of the sieve plates in fig. 4. × 7,000; (ii) and fig. 8. × 3,500; the complicated pillar-like structure of the damaged sieve plate in fig. 6. × 3,500; 7 is from the male left valve in fig. 9. Note the heavy calcification and buttressing of the sieve plate. × 8,667.
5. Arrangement of the frontal, adductor and upper mandibular muscle scars of a male right valve (same as in fig. 2). × 300.
9. External view of a male left valve. Paratype Af. 101:2. × 50.
10—11. Anterior and posterior marginal areas respectively, of a male right valve (same as in fig. 2) showing radial pores. × 134.

Plate 21

Hermanites foveolata n. sp.

All figures are scanning electron micrographs.

1. Dorsal view of a male carapace. Paratype Af. 101:3. × 63.
2. Detail of the surface sculpture of the male in fig. 1. × 700.
3. Dorsal view of a female carapace. Paratype Af. 101:4. × 63.
4. Detail of the surface sculpture of the female in fig. 3. Note absence of coarse surface ornament, and the distribution of compound normal pores. × 630.
5—7. Compound normal pores of a male (fig. 5), and a female (figs. 6 and 7). Note the distinct structural dimorphism between the normal pores belonging to the different sexes. × 3,180.

Plate 22

Hermanites batei n. sp.

Figs. 1—12 are scanning electron micrographs; figs. 13—14 are transmitted light micrographs.

1. Left external view of a female carapace. Paratype Af. 102:1. × 80.
2. Dorsal view of a male carapace. Paratype Af. 102:2. × 80.
3. Internal view of a male left valve. Paratype Af. 102:3. × 80.
4. Surface sculpture of the posterolateral side of a female carapace (same as in fig. 1) showing the distribution of simple and compound normal pores. × 400.
5. Internal view of a male right valve. Paratype Af. 102:4. × 80.
6. Dorsal view of a female carapace. Paratype Af. 102:5. × 80.
7. Internal view of the anterior half of a left valve (same as in fig. 3) showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 160.

8—9. Compound normal pores of the female in fig. 1. × 4,333.

10. Ventral view of a male carapace (same as in fig. 2). × 80.
11. Detail arrangement of the frontal, adductor and upper mandibular muscle scars of a left valve (same as in figs. 3 and 7). × 400.
12. External view of male left valve. Holotype Af. 102. × 87.

13—14. Posterior and anterior marginal areas respectively, of a left valve showing the radial pores. × 134.

Plate 23

Hermanites macrodictyota n. sp.

Figs. 1—10 are scanning electron micrographs; figs. 11—15 are transmitted light micrographs.

1. External view of a male right valve. Holotype Af. 103. × 97.
2. Internal view of a male left valve. Paratype Af. 103:1. × 97.
3. Surface sculpture from the lateromedian part of the male right valve in fig. 1, showing the distribution of setae-bearing and non setae-bearing compound normal pores. × 467.
4. A non setae-bearing compound normal pore with a probably organic structure emerging through the setal pore. × 7,667.
5. Arrangement of the frontal and adductor muscle scar (not visible due to algal encrustation) of a left valve (same as in fig. 2). × 467.

6—9. Compound normal pores; 6—8 are setae-bearing compound normal pores from the holotype (fig. 1). × 4,670. Note the finger-like branching at the tip of the setae in figs. 6 and 7. Fig. 9 is a partly damaged compound normal pore from the right valve in fig. 10. Note the internal structure. × 7,000.

10. External view of a right valve. Paratype Af. 103:2. × 73.
11. A left valve (same as in fig. 2) showing radial pores. × 67.

12—13. Anterior and posterior marginal areas respectively, of a right valve (same as in fig. 10) showing the radial pores. × 134.

14—15. Posterior and anterior marginal areas respectively, of a left valve (same as in figs. 2 and 11) showing the radial pores. × 134.

Plate 24

Puriana rugosa n. sp.

Figs. 1—10 are scanning electron micrographs; figs. 11—13 are transmitted light micrographs.

1. External view of a female right valve. Holotype Af. 104. × 87.
2. Internal view of a female left valve. Note distribution of normal pores. Paratype Af. 104:1. × 87.
3. External view of a male left valve. Paratype Af. 104:2. × 87.
4. Internal view of a male right valve. Paratype Af. 104:3. × 87.
5. Surface sculpture of a male left valve (same as in fig. 3) showing the distribution of simple normal pores. × 300.
6. Details of a simple normal pore from fig. 5. Note: the wall around the pore has been damaged exposing the "corrugated" tube of a normal pore. × 3,867.
7. Internal view of a female left valve. Note arrangement of the frontal, adductor and mandibular muscle scars. × 77.

8—10. Internal views of a right (fig. 8), left (fig. 9) and right (fig. 10) valves respectively, showing arrangement of dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 167.

11. A right valve showing the radial pores. × 67.

12—13. Anterior and posterior marginal areas respectively, of a right valve (same as in fig. 11) showing the radial pores. × 134.

Plate 25

Puriana aff. *interrasilis* van den Bold

Figs. 1—4, 6—7 and 9 are scanning electron micrographs; figs. 5, 8, 10—11 are transmitted light micrographs.

1. External view of a male right valve. × 87.
2. Internal view of a female right valve. × 87.
3. Internal view of a male left valve. × 87.
4. Arrangement of the dorsal (group (ii)), frontal and mandibular muscle scars of a right valve (same as in fig. 2). × 427.
5. A female right valve (same as in fig. 2) showing radial pores and vestibules. × 67.
6—7. Internal views of left valves showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 433.
8. Arrangement of the frontal, adductor and mandibular muscle scars of a left valve. × 267.
9. Surface sculpture of a male right valve (same as in fig. 1). Note distribution of simple normal pores. × 173.
10—11. Posterior and anterior marginal areas respectively, showing radial pores and vestibules. × 134.

Plate 26

Puriana akparaia n. sp.

Figs. 1—6, 8, 11, are scanning electron micrographs; figs. 7, 9—10 are transmitted light micrographs.

1. External view of a male left valve. Holotype Af. 105. × 90.
2. Internal view of a male right valve. Paratype Af. 105:1. × 90.
3. External view of a female left valve. Paratype Af. 105:2. × 90.
4. Internal view of a female left valve. Paratype Af. 105:3. × 90.
5. Detail arrangement of the frontal, adductor and mandibular muscle scars of a right valve (same as in fig. 2). × 433.
6. Arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars of a right valve (same as in figs. 2 and 5). × 180.
7. A right valve showing radial pores. × 67.
8. Internal view of the median part of a left valve (same as in fig. 4) showing the arrangement of the dorsal, frontal, adductor and mandibular muscle scars. × 180.
9—10. Anterior and posterior marginal areas respectively, of a right valve (same as in fig. 7) showing radial pores and an anterior vestibule. × 134.
11. Surface ornament of a female left valve (same as in fig. 3) showing the distribution of simple normal pores. × 900.

Plate 27

Puriana mediocostata n. sp.

Figs. 1—8 are scanning electron micrographs; figs. 9—10 are transmitted light micrographs.

1. External view of a female right valve. Holotype Af. 106. × 90.
2. Internal view a female left valve. Paratype Af. 106:1. × 90.
3. External view of a male left valve. Paratype Af. 106:2. × 90.
4. Internal view of a male right valve. Paratype Af. 106:3. × 90.
5. Surface sculpture of the female in fig. 1, showing details of the intercostal ornament and the distribution of simple normal pores. × 446.
6. A simple normal pore from the lateral side of the male in fig. 3 (same as shown in fig. 8). × 1,800.
7. Internal view of a male right valve (same as in fig. 4) showing the arrangement of the dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 446.
8. Surface sculpture of the male in fig. 3 showing details of intercostal areas and the distribution of simple normal pores. × 446.
9—10. Anterior and posterior marginal areas respectively of a male right valve (same as in fig. 4) showing the radial pores. × 134.

Plate 28

Puriana trituberculata n. sp.

Figs. 1—7 are scanning electron micrographs; figs. 8—10 are transmitted light micrographs.

1. External view of a male left valve. Holotype Af. 107. × 90.
2. Internal view of a male right valve. Paratype Af. 107:1. × 90.
3. External view of a female left valve. Paratype Af. 107:2. × 90.
4. Internal view of the anterior half of a right valve (same as in fig. 2) showing the arrangement of dorsal (D), frontal (F), adductor (A) and mandibular (M) muscle scars. × 446.
5—6. Surface sculpture of the anterior parts of respectively a male and a female, showing slight ornamental dimorphism. × 180.
7. Detail arrangement of the dorsal (group (ii)), frontal and adductor muscle scars of the right valve in fig. 2. × 446.
8. A left valve male (same as in fig. 1) showing radial pores. × 67.
9—10. Posterior and anterior marginal areas respectively, of a male left valve (holotype) showing radial pores and an anterior vestibule. × 134.

Plate 29

Aurila punctoreticulata n. sp.

Figs. 1—9 are scanning electron micrographs; figs. 10—12 are transmitted light micrographs.

1. External view of a female right valve. Holotype Af. 108. × 100.
2. Internal view of a male right valve (slightly tilted). Paratype Af. 108:1. × 83.
3. Surface sculpture of a female right valve (same as in fig. 1) showing the ornament and distribution of the normal pores. × 167.
4. Internal view of the dorsal half of a left valve. Note the deep accommodation groove. Paratype Af. 108:2. × 83.
5. Internal view of a male right valve (same as in fig. 6) showing the arrangement of the muscle scar fields. × 183.
6. Internal view of a male right valve. Paratype Af. 108:3. × 67.
7. Surface sculpture of a female right valve (same as in fig. 1) showing a compound normal pore. × 3,330.
8. Internal view of a male right valve (same as in fig. 6) showing the arrangement of the frontal, adductor and mandibular muscle scars. × 300.
9. Detail arrangement of the frontal and adductor muscle scars of a right valve (same as in fig. 2). × 383.
10. A female right valve showing radial pores. × 67.
11—12. Anterior and posterior marginal areas respectively, of a right valve (same as in fig. 10) showing radial pores. × 134.

Plate 30

Mutilus nigeriana n. sp.

Figs. 1—8 are scanning electron micrographs; figs. 9—13 are transmitted light micrographs.

1. External view of a female right valve. Holotype Af. 109. × 100.
2. Internal view of a male left valve. Note the distribution of the normal pores. Paratype Af. 109:1. × 97.
3. Surface sculpture from the dorsolateral part of a female carapace (same as in fig. 4) showing the distribution of compound normal pores. × 787.
4. Dorsal view of a female carapace. Paratype Af. 109:2. × 100.
5. Internal view of a male left valve (same as in fig. 2) showing the arrangement of the dorsal (group (ii)), frontal and adductor muscle scars. × 480.
6, 9. Compound normal pores from a female (figs. 3 and 4) and a male (fig. 7). × 3,867.
7. Dorsal view of a male carapace. Paratype Af. 109:3. × 100.
8. Internal view of a male right valve (tilted to show the dorsolateral aspect of the hinge). Paratype Af. 109:4. × 83.
10—11. Left and right valves respectively, showing the radial pores. Note asymmetry in shape and size between the left and right valves). × 67.
12—13. Anterior and posterior marginal areas respectively, of a right valve (same as in fig. 11) showing details of the radial pores. × 134.

Plate 31

Caudites africana n. sp.

Figs. 1—11 are scanning electron micrographs; figs. 12—14 are transmitted light micrographs.

1. Left external view of a male carpace. Holotype Af. 110. × 77.
2. Internal view of a damaged left valve showing the secondary fused inner lamella. × 140.
3. Internal view of a female left valve (slightly damaged). Note the distribution of the normal pores. Paratype Af. 110:1. × 80.
4. Surface sculpture of a male carapace (same as in fig. 1) showing fine pitting and distribution of normal pores. × 383.
5. A countersunk slightly damaged compound normal pore. × 8,433.
6. Internal view of a female left valve (same as in fig. 3) showing the arrangement of the dorsal (group (ii)), frontal and adductor muscle scars. × 383.
7. Detail of a simple normal pore and the surrounding surface ornament. × 1,533.
8. A "false" compound normal pore from the male carapace in fig. 1. × 3,330.
9. A countersunk compound normal pore from the holotype. × 10,667.
10. Surface pitting and distribution of normal pores of a male carapace (same as in fig. 1). × 767.
11. Right external view of a female carapace. Paratype Af. 110:2. × 80.
12. A male right valve showing true and false radial pores. × 67.
13—14. Anterior and posterior marginal areas respectively, of a left valve showing radial pores and vestibules. × 134.

Plate 32

Neocaudites purii n. sp.

Figs. 1—3, 5—10, 13 are scanning electron micro-

graphs; figs. 4, 11—12 are transmitted light micrographs.

1. External view of a male left valve. Holotype. Af. 111. × 90.
2. Internal view of a male left valve. Paratype 111:1. × 90.
3. Surface sculpture of a male left valve (same as in fig. 1) from the medioposterior part of the left valve in fig. 1. Note the distribution of the countersunk compound normal pores. × 300.
4. Anterior marginal area of a male left valve showing the radial pores and vestibule. × 134.
5. Internal view of a male left valve (same as in fig. 10) showing the arrangement of the dorsal (group (ii)), frontal, adductor and mandibular muscle scars. × 420.
6—7. Compound normal pores of a male left valve (same as in figs. 1 and 3). × 4,167.
8, 13. Compound normal pores of a female right valve (same as in fig. 9). Note the occurrence of a flap-like "organic matrix" on the opening of the setal pore of fig. 13; and the dimorphic differences between the compound normal pores of males and females. × 4,267.
9. External view of a female right valve. Paratype Af. 111:2. × 87.
10. Internal view of a female left valve. Paratype Af. 111:3. × 87.
11—12. Posterior and anterior marginal areas respectively, of a left valve. × 136.
14. Anterior marginal area of a left valve (same as in fig. 12) showing details of the radial pores and the anterior vestibule. × 267.

Plate 33

Neocaudites rectangularis n. sp.

Figs. 1—12 are scanning electron micrographs; figs. 13—14 are transmitted light micrographs.

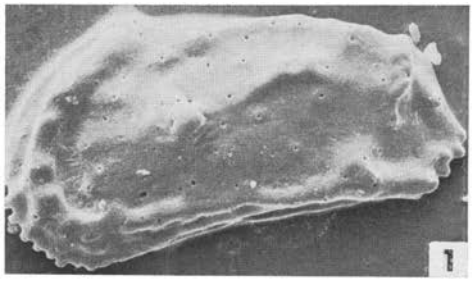
1. External view of a male right valve. Holotype Af. 112. × 87.
2. Internal view of a male left valve. Paratype Af. 112:1. × 87.
3—4. Posterior and anterior valves respectively of a right valve (same as in fig. 1). Note the strongly developed paddle-like denticles of the posteroventral margin (fig. 3), and the "flower-like" tightly arranged denticles of the anterior margin (fig. 4). × 167.
5. Internal view of a male left valve (same as in fig. 2) showing arrangement of the frontal, adductor and upper mandibular muscle scars. × 427.
6. External view of a female left valve. Paratype Af. 112:2. × 90.
7. An infilled simple normal pore. × 1,733.
8, 11. Countersunk compound normal pores of a male right valve (same as in fig. 1). × 4,267.
9. External view of the anterior half of a female left valve (same as in fig. 6). × 180.
10, 12. Countersunk compound normal pores of a female left valve (same as in fig. 6). × 4,200.
13—14. Posterior and anterior marginal areas respectively, of a male right valve (same as in fig. 2) showing the radial pores. × 134.

Plate 34

Neocaudites tuberculata n. sp.

Figs. 1—6 are scanning electron micrographs; figs. 7—9 are transmitted light micrographs.

1. External view of a right valve. Holotype Af. 113. × 80.
2. Internal view of a right valve. Paratype Af. 113:1. × 90.
3. External posterior view of a right valve (same as in fig. 1) showing surface sculpture and distribution of normal pores. × 160.
4. Internal view of a right valve (same as in fig. 2) showing arrangement of the frontal, adductor and mandibular muscle scars. × 446.
5. Detail of surface ornament of the posterodorsal part of the right valve in fig. 1. × 400.
6. A compound normal pore (infilled). The elevated rim of the pore is visible. × 4,000.
7. A right valve (holotype). × 67.
8—9. Anterior and posterior marginal areas respectively, of the right valve in fig. 7 showing the radial pores. × 134.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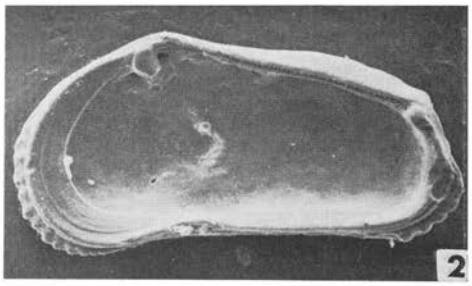
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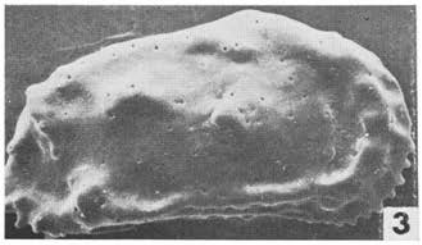
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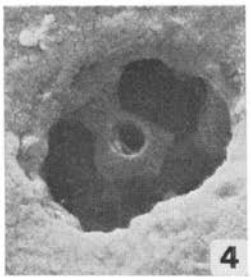
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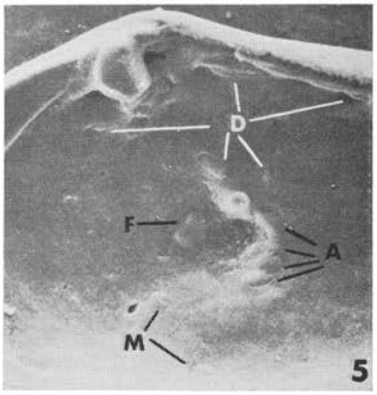

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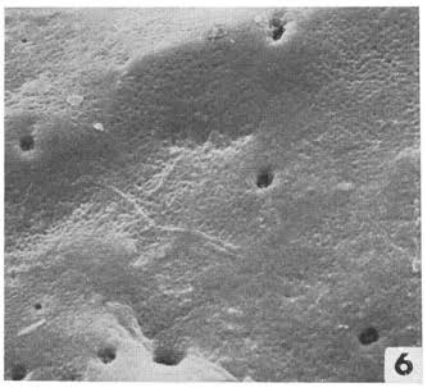
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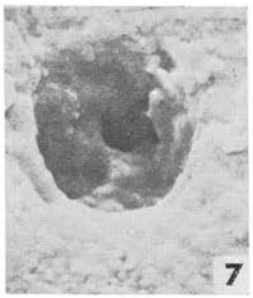
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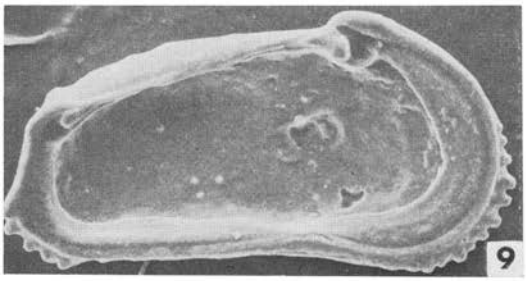
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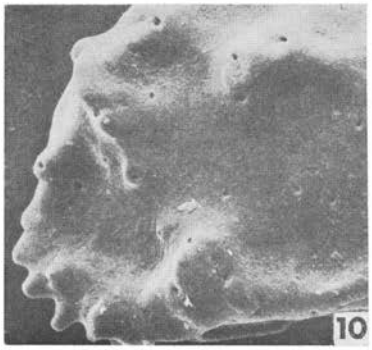
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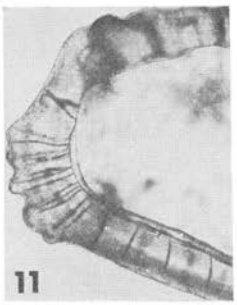
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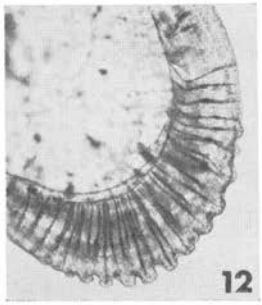
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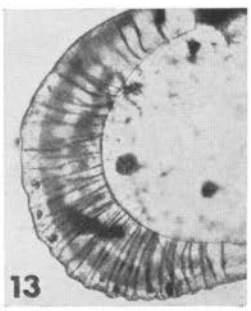
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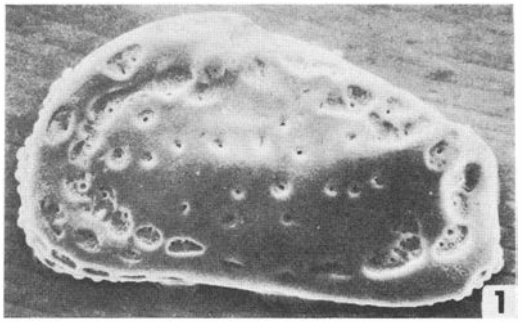
Plate II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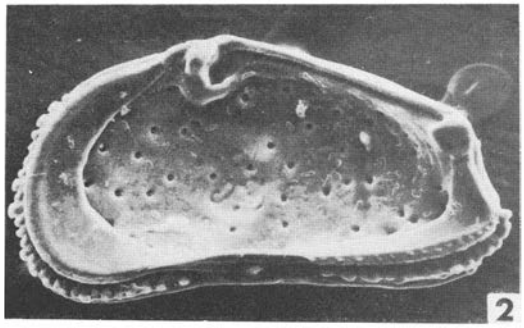
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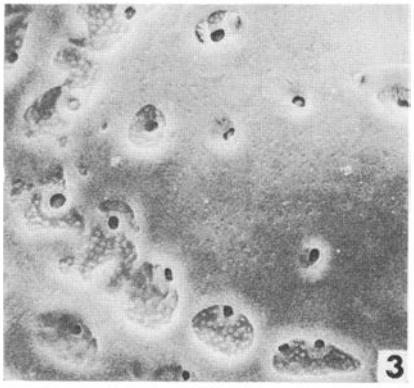
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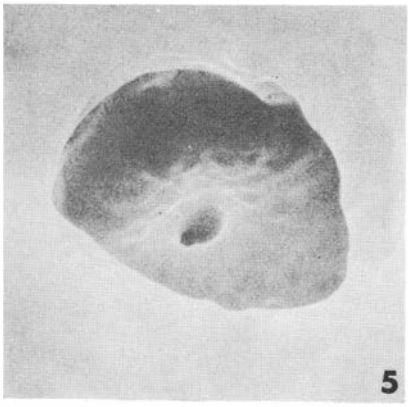
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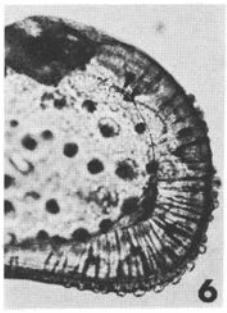
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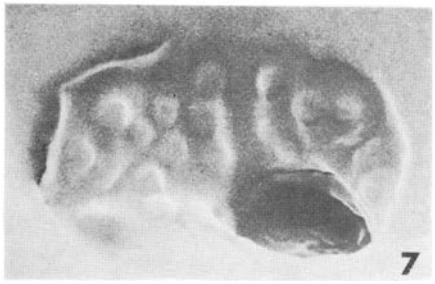
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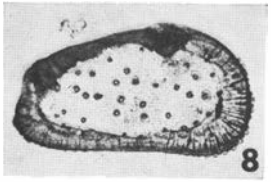
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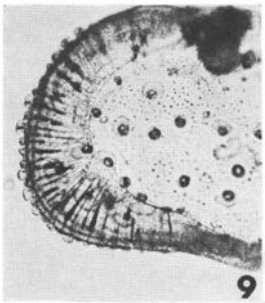
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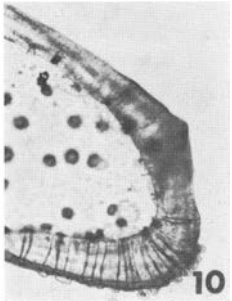
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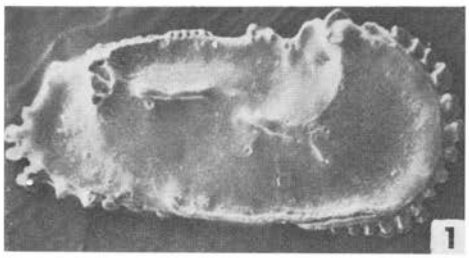
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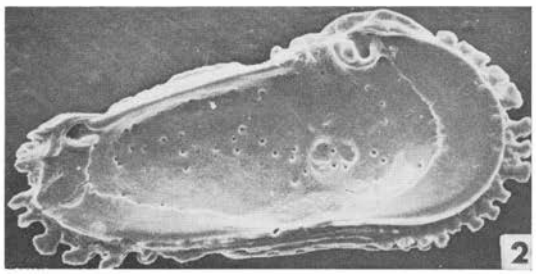
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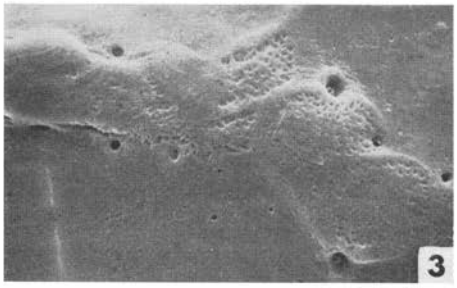
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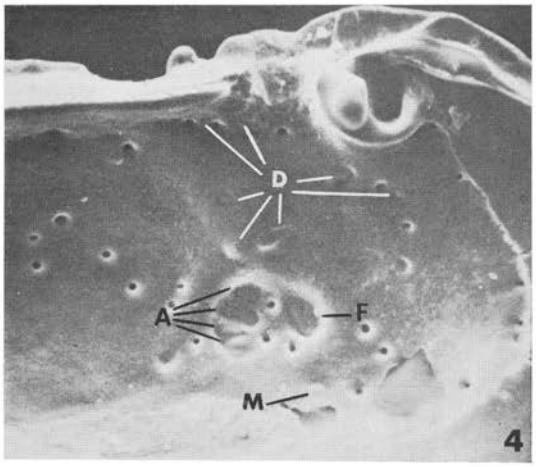

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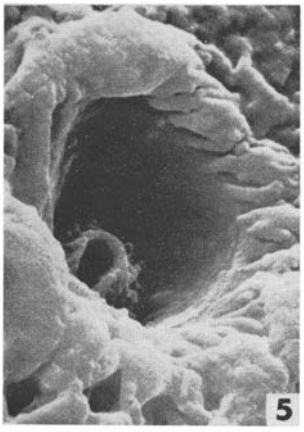
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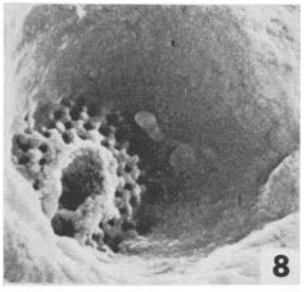
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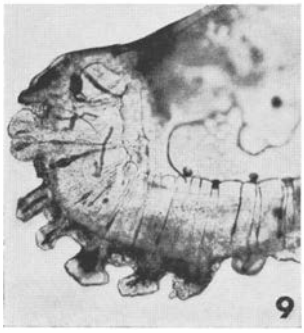
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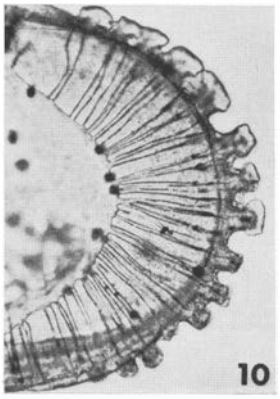
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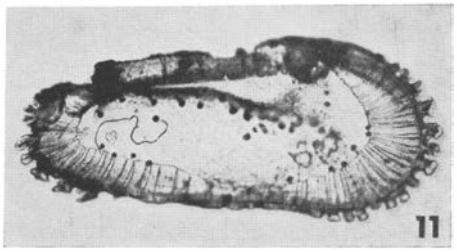
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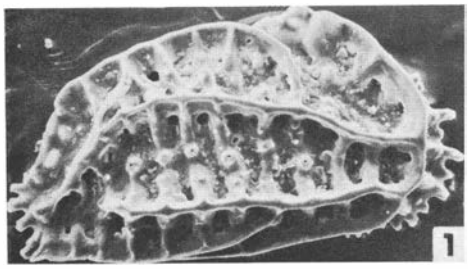
Plate IV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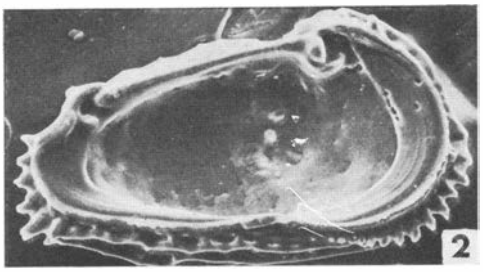
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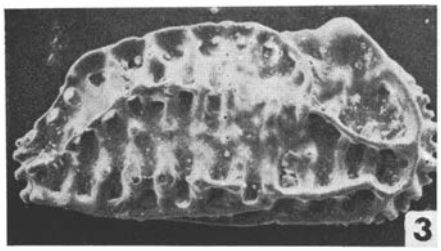
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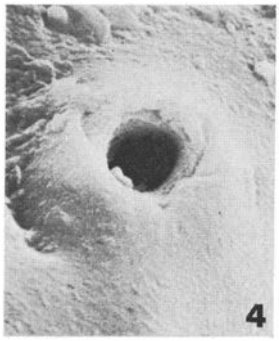
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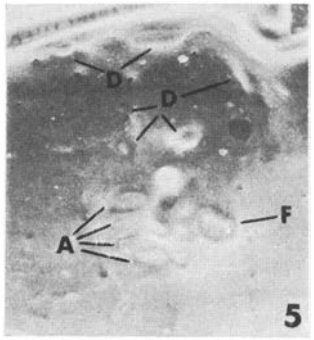

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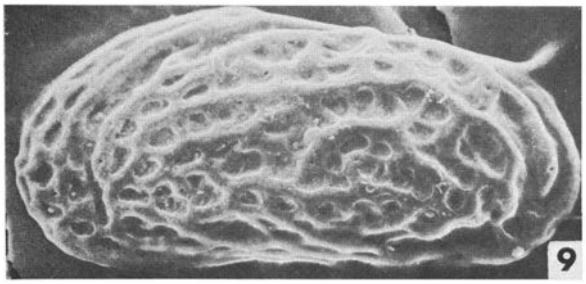
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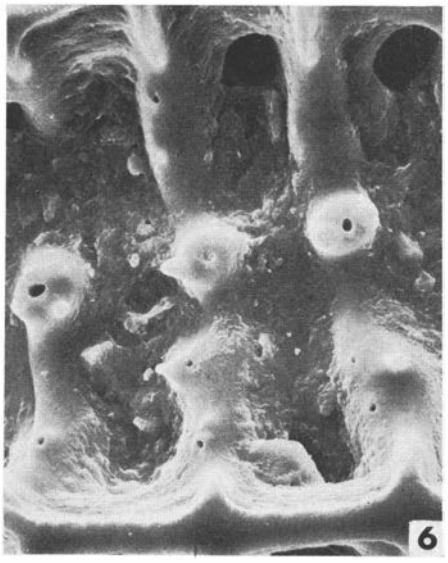
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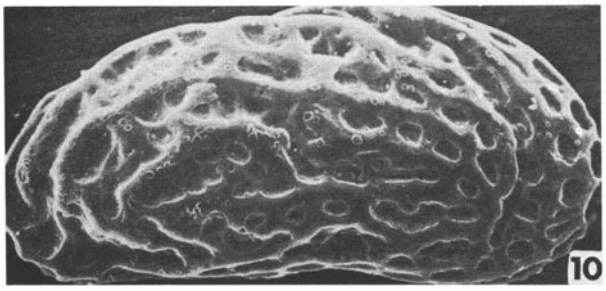
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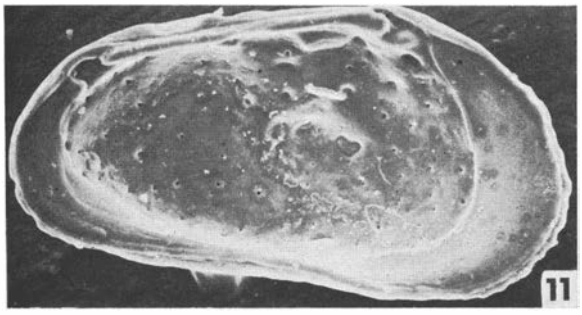
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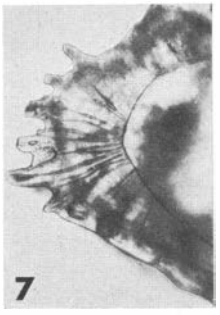
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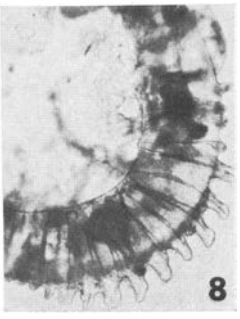
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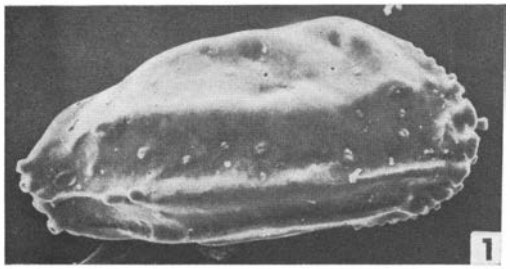
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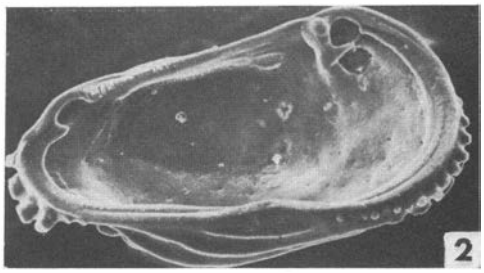
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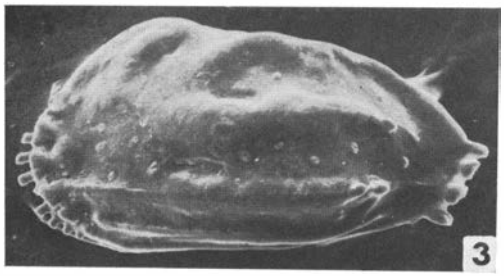
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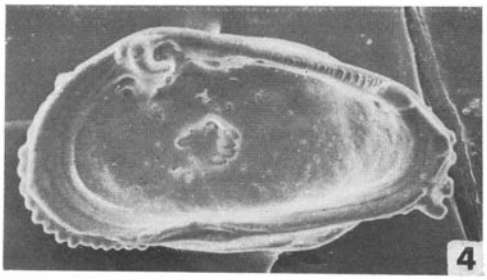
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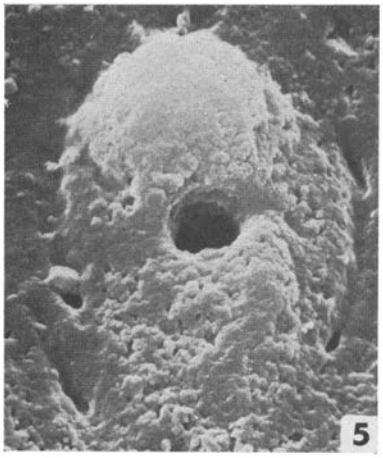
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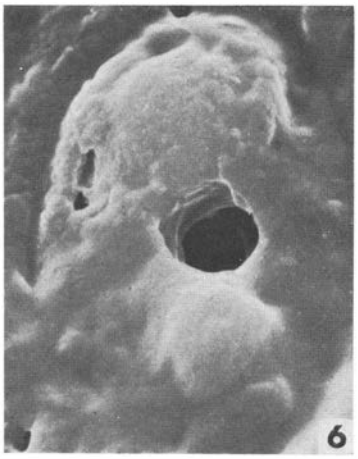
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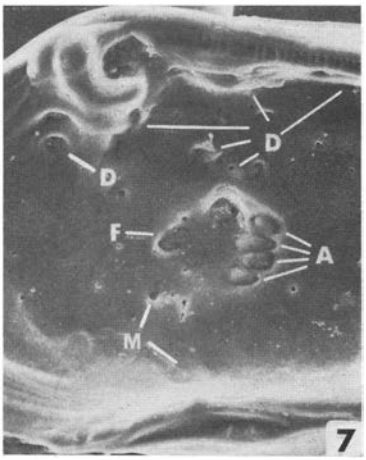

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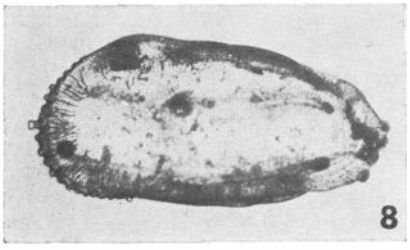
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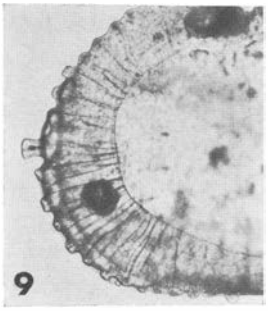
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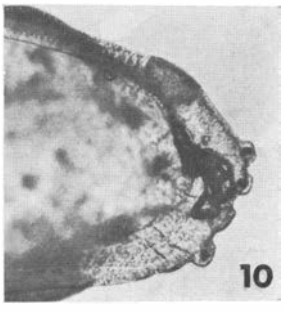
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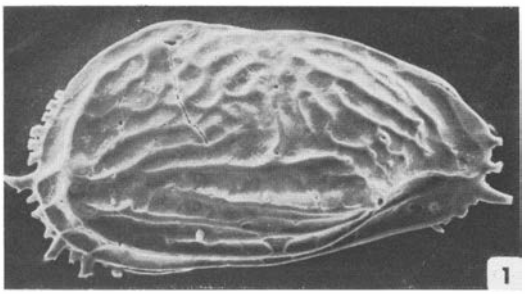
Plate VI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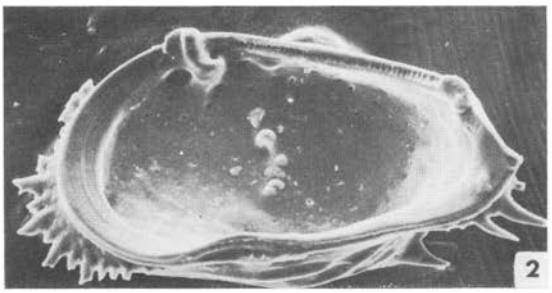
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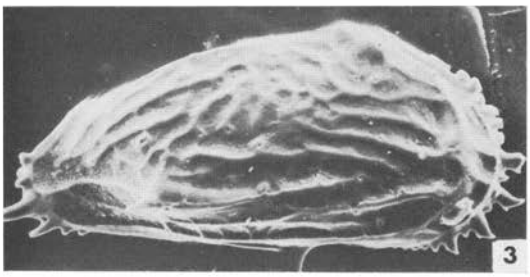
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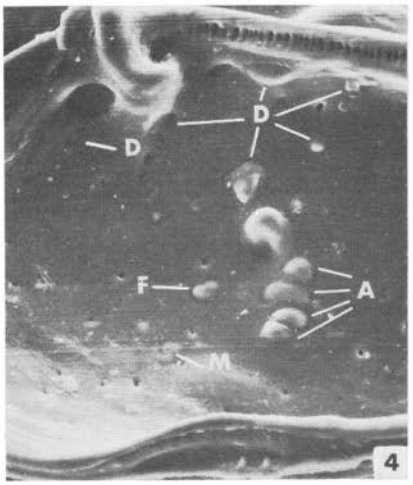

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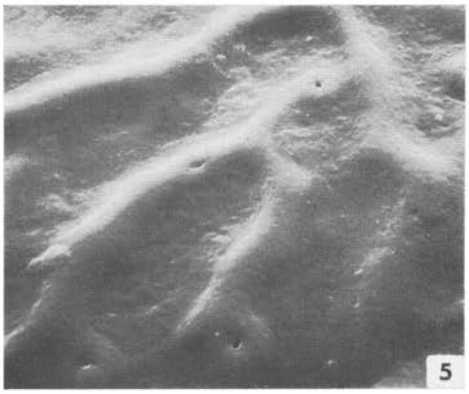
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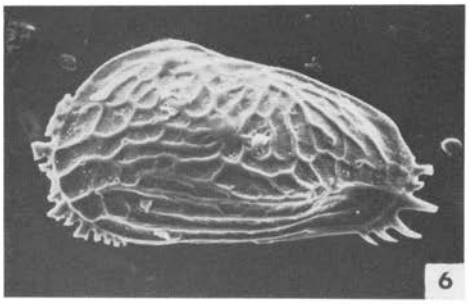
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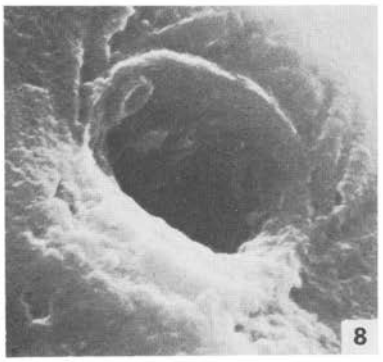
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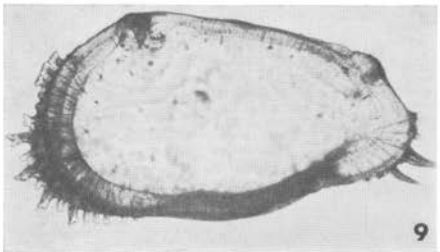
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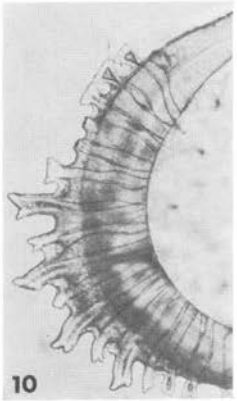
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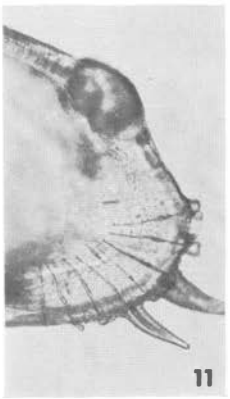
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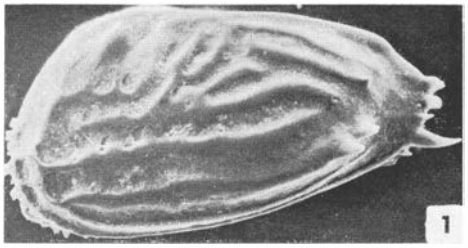
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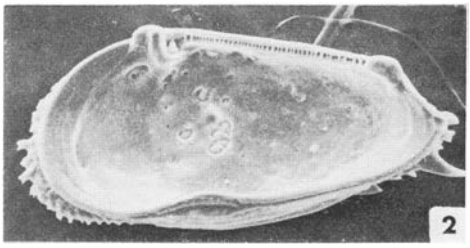
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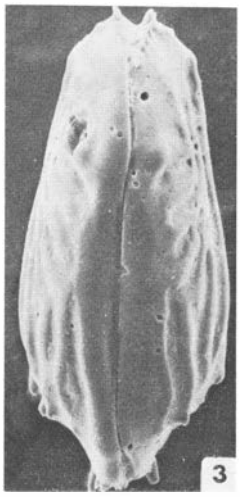
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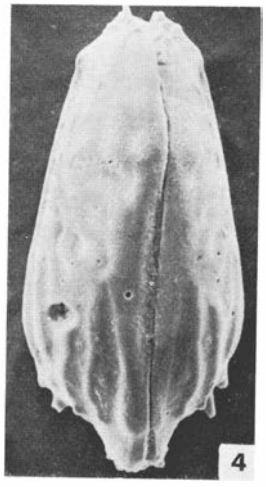
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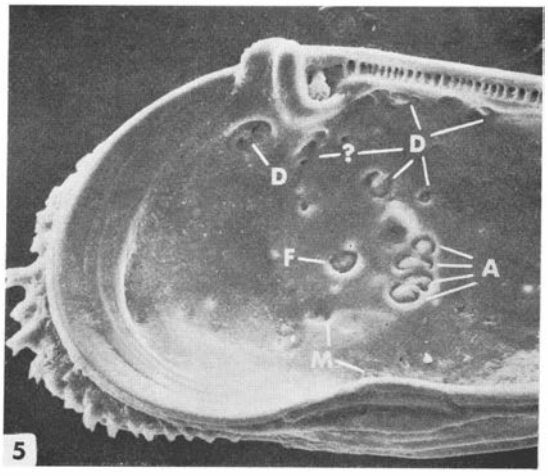

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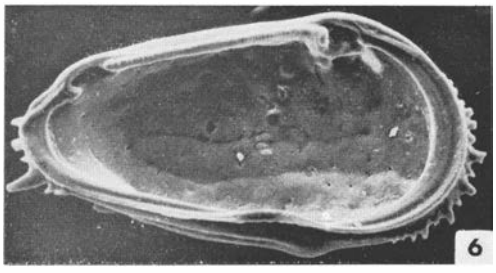
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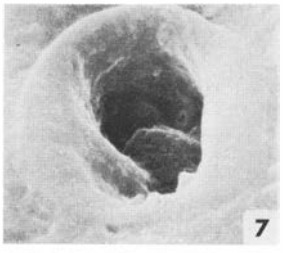
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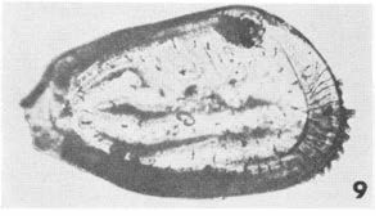
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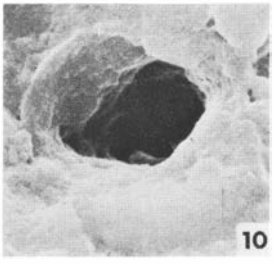
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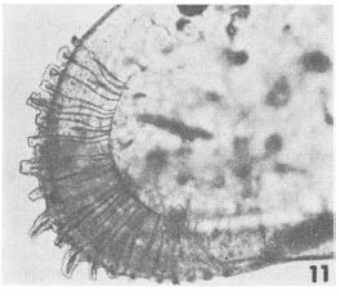
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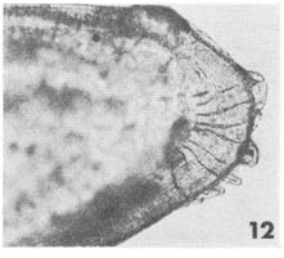
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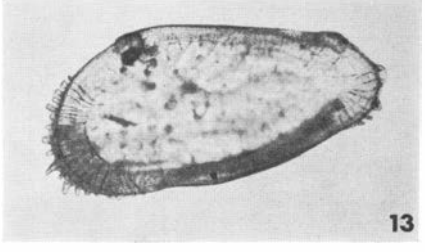
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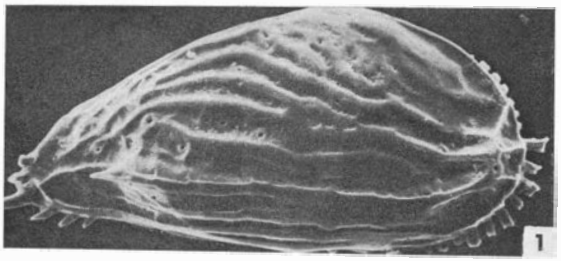
Plate VIII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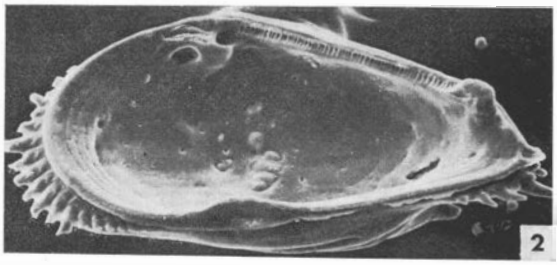
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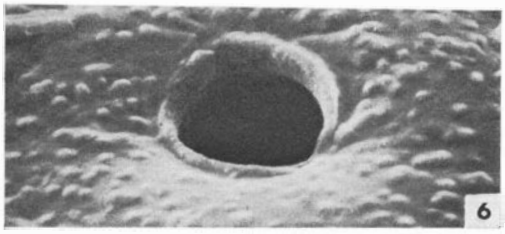
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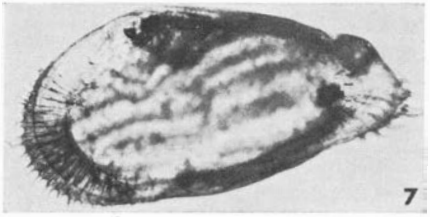
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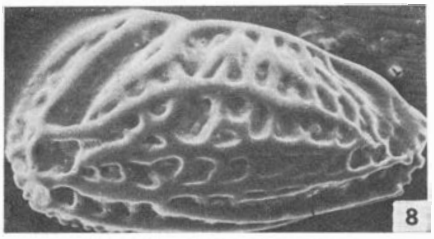
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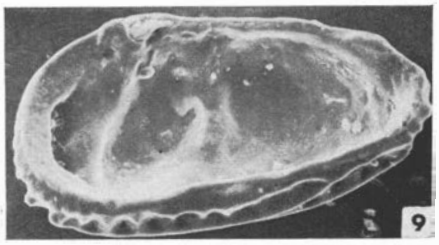
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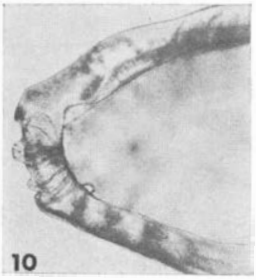
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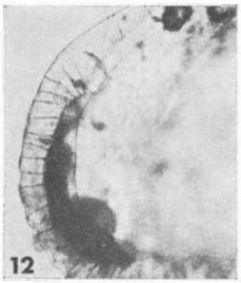
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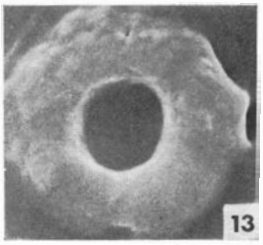
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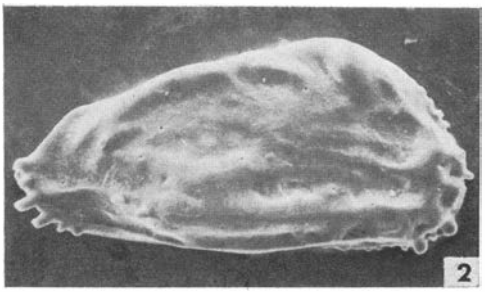
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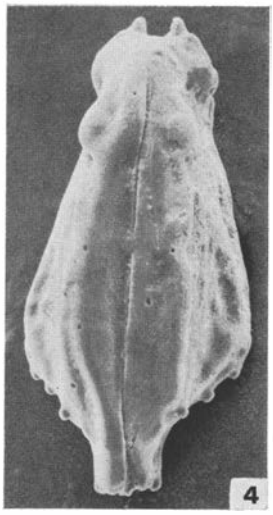
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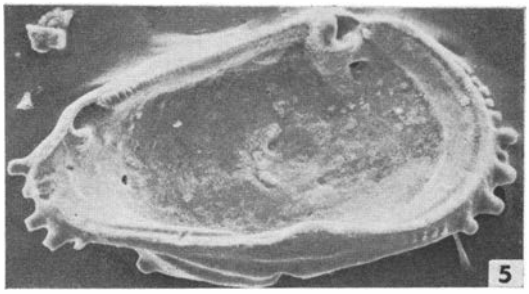
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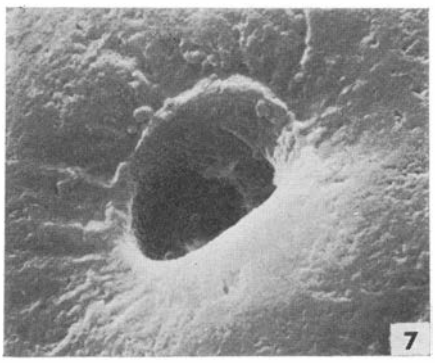
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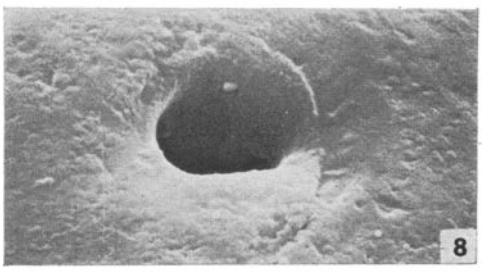
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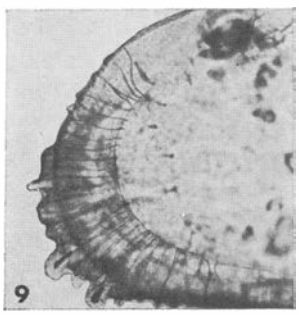
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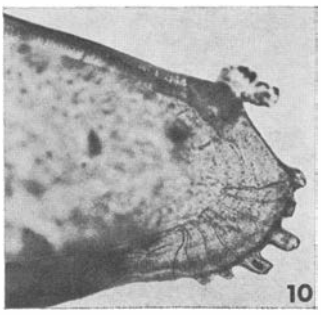
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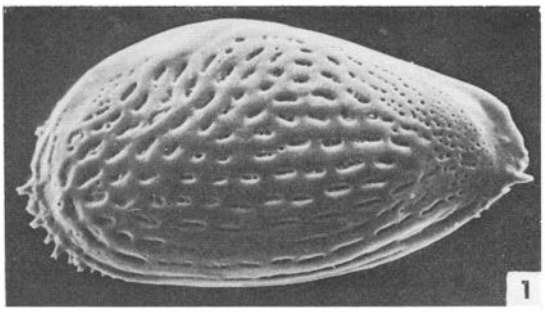
Plate X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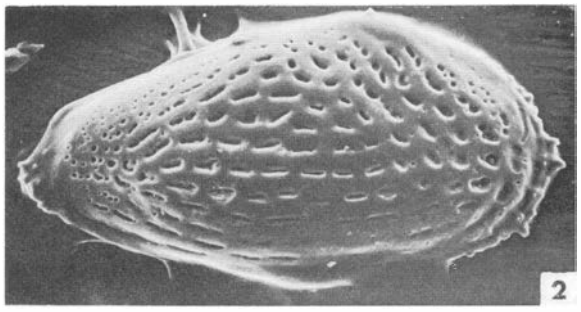
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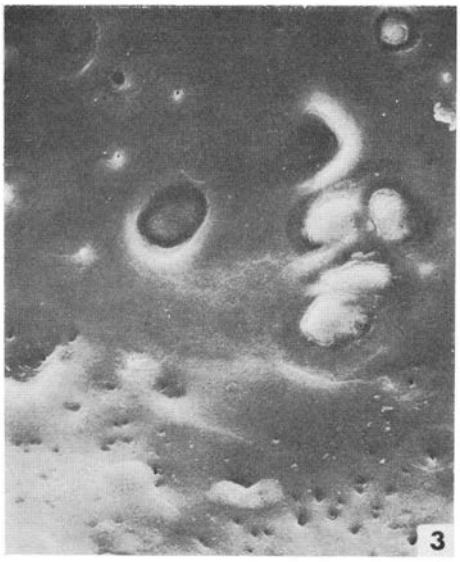
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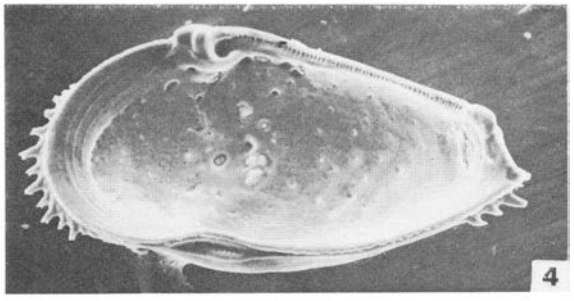
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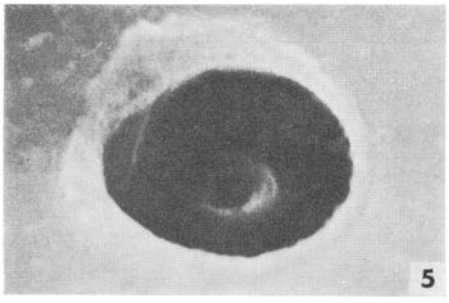
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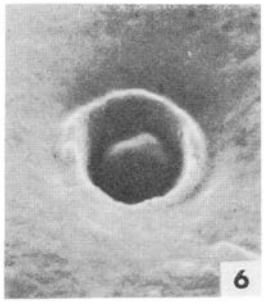
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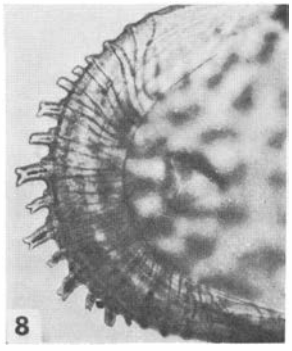
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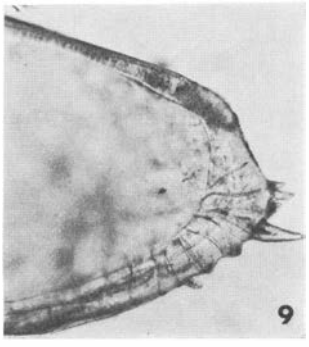
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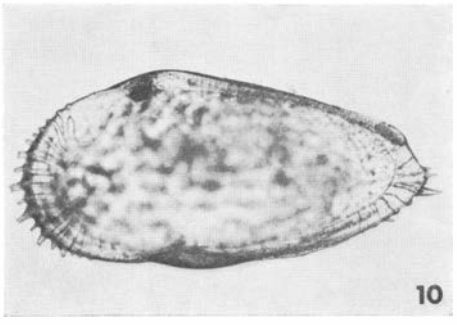
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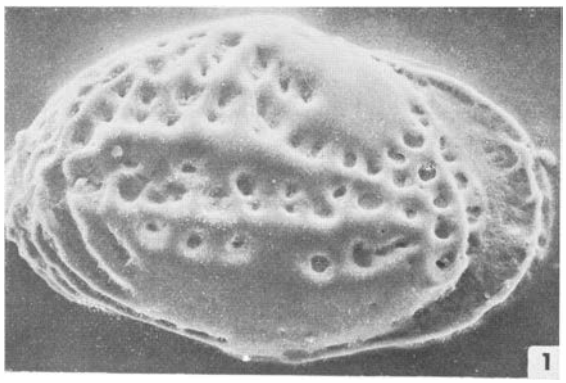
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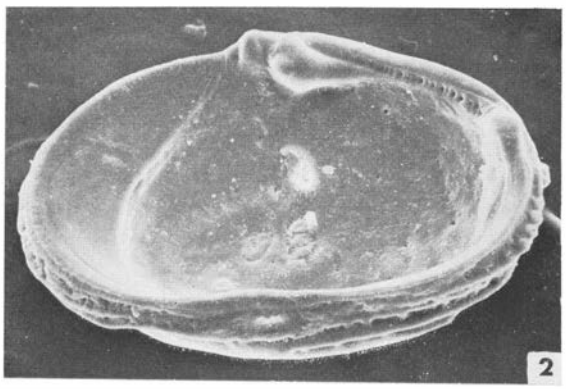
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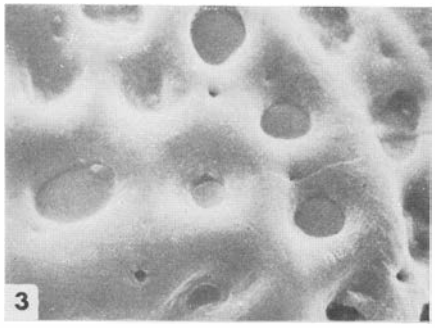
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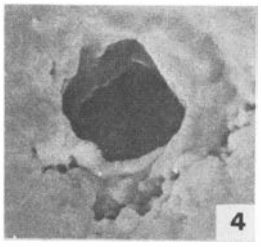
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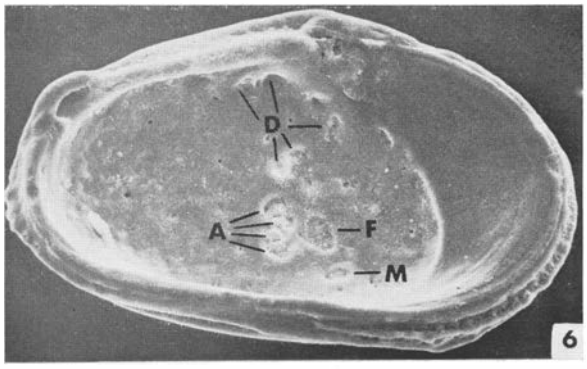

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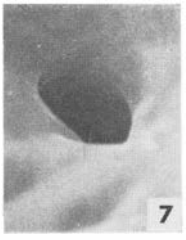
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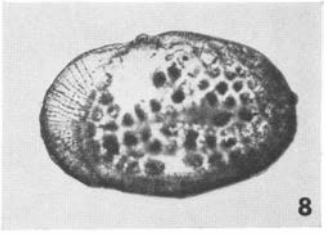
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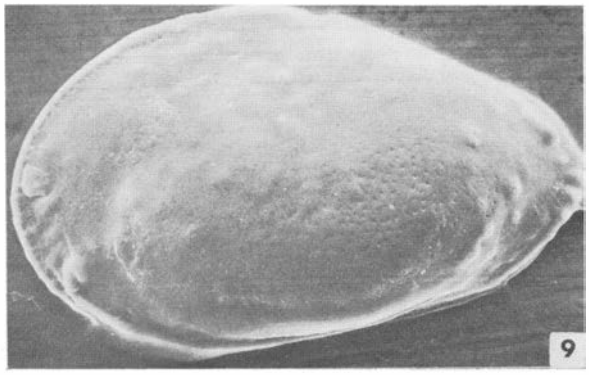
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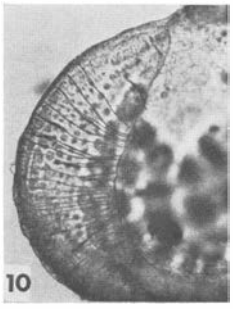
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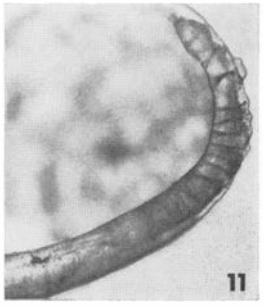
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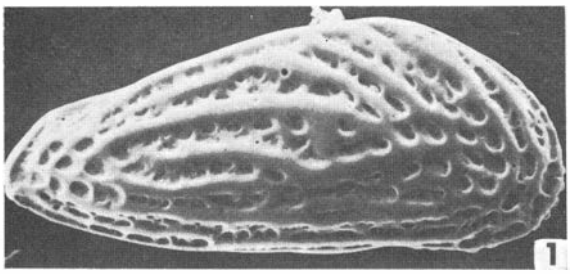
Plate XII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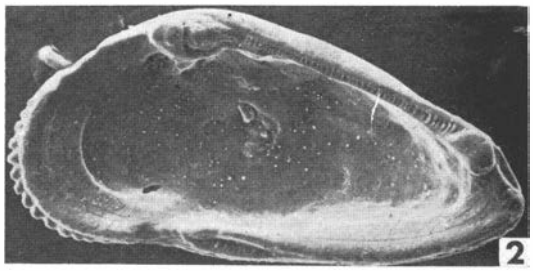
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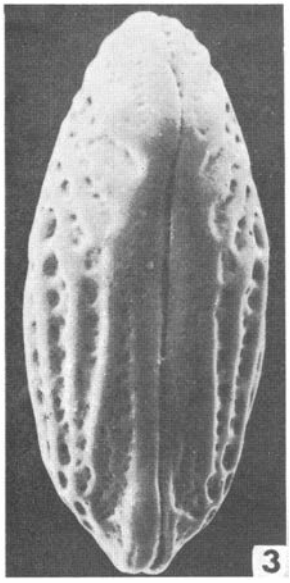
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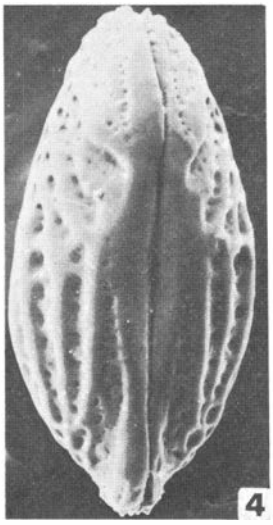
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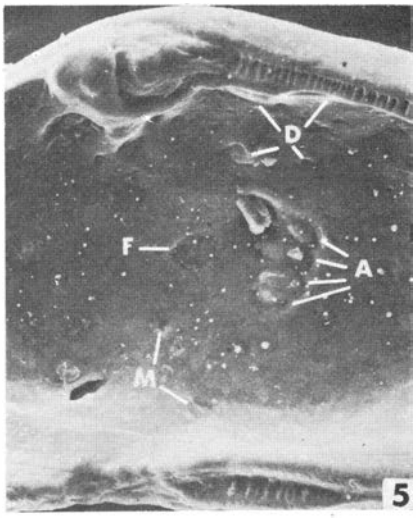

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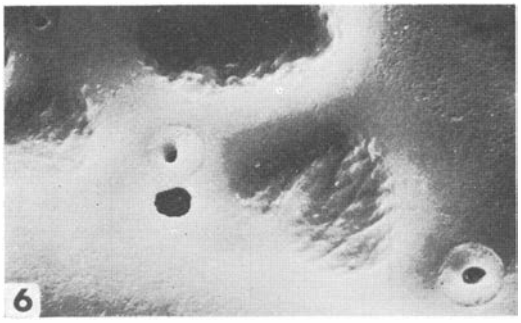
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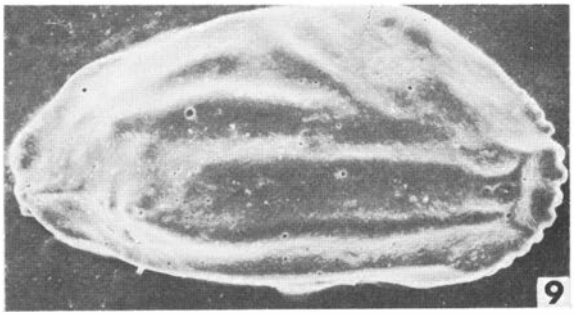
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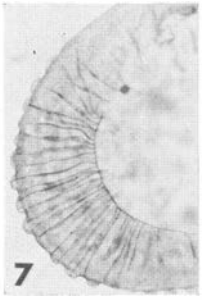
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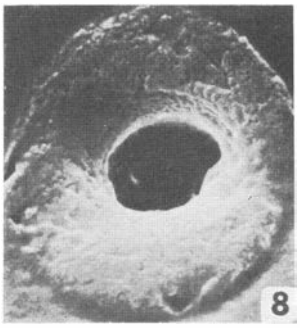
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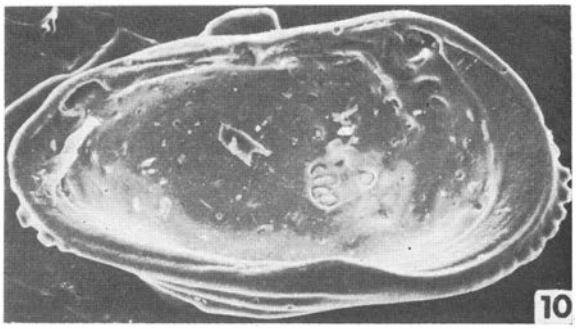
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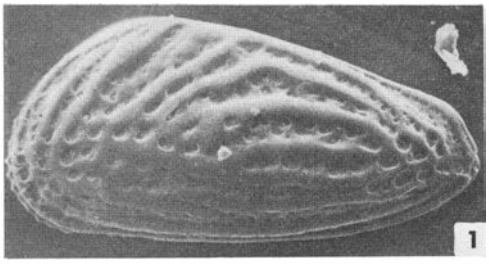
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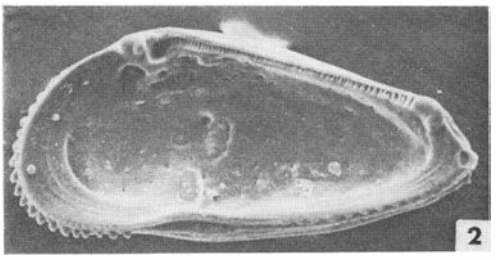
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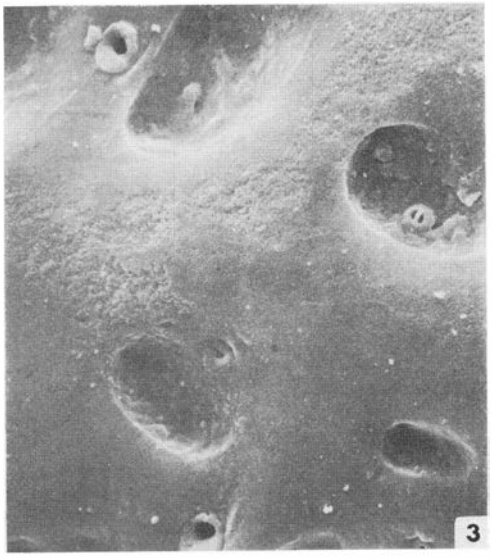
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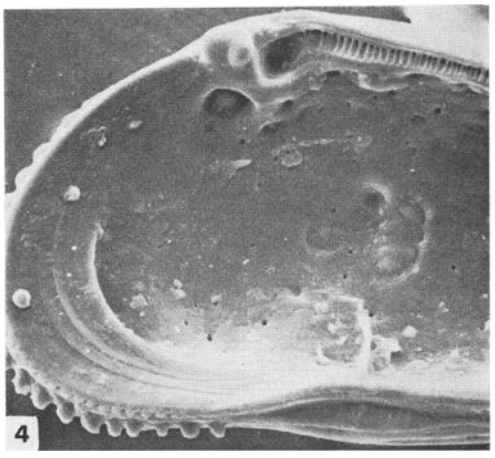
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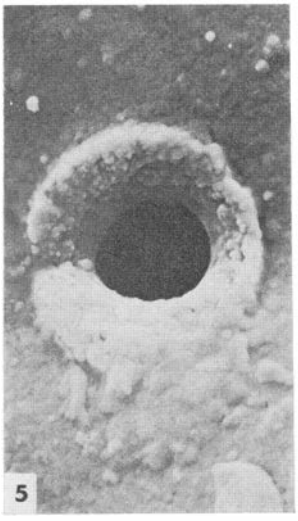
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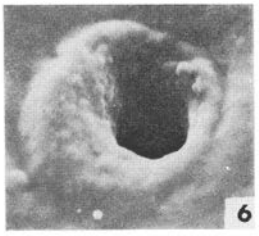
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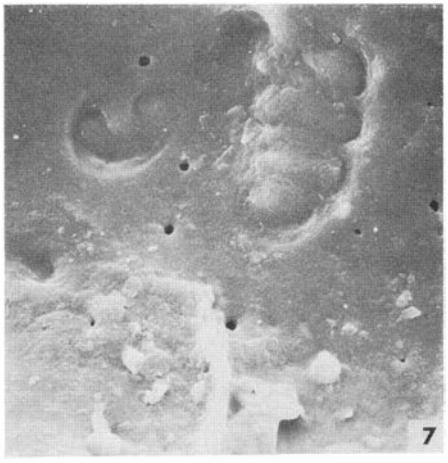
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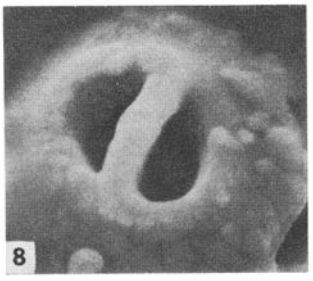
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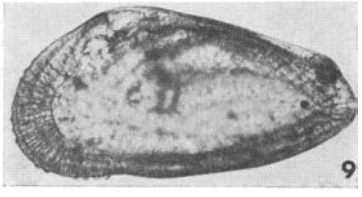
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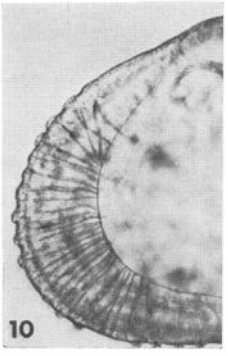
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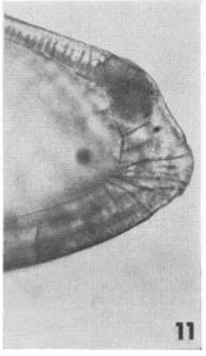
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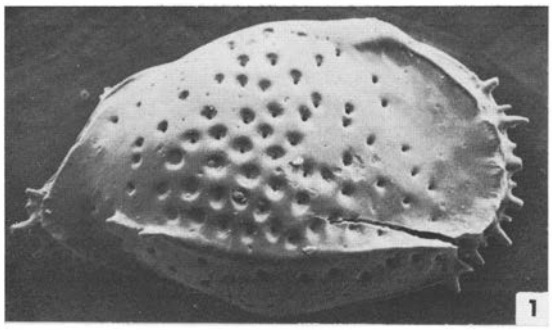
Plate XIV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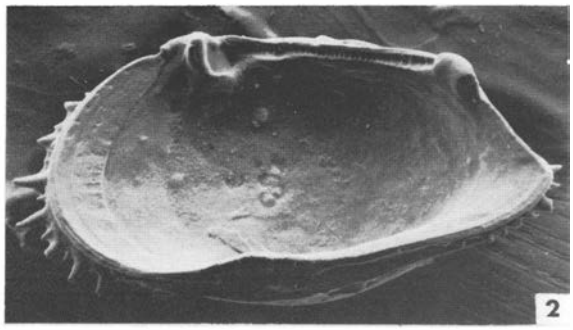
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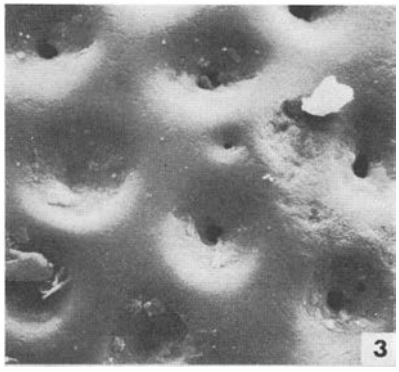
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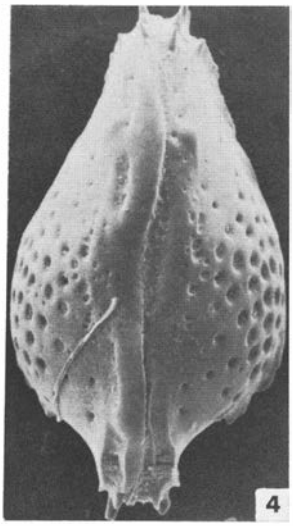
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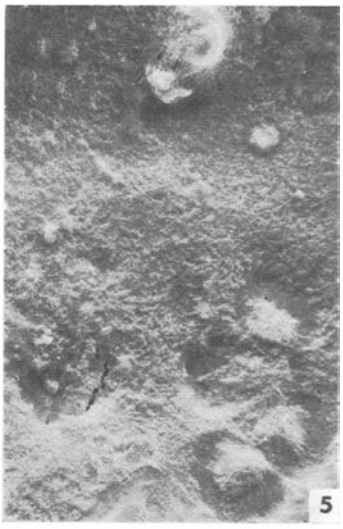
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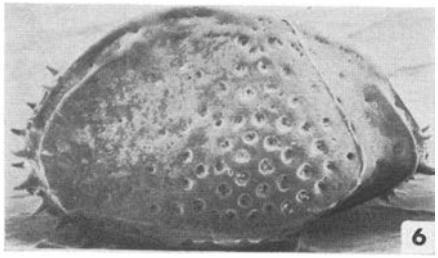
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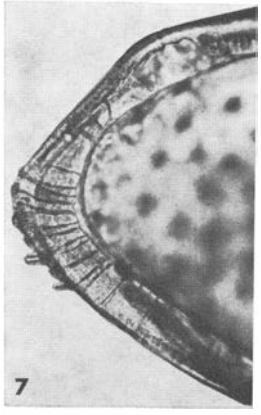
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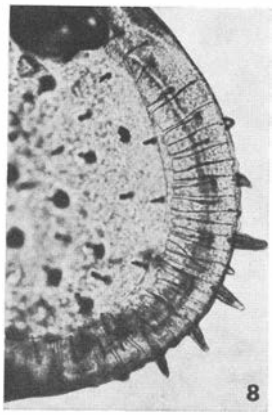
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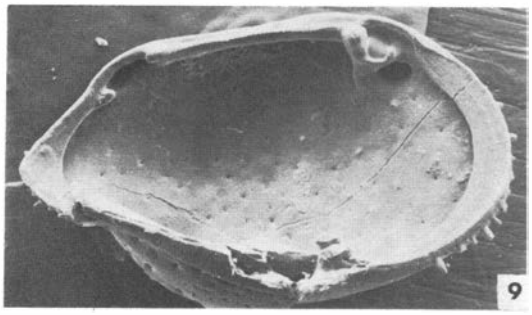
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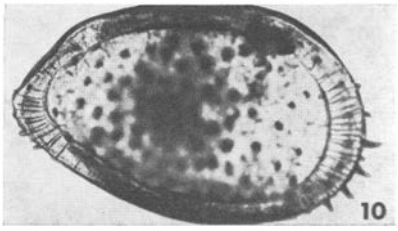
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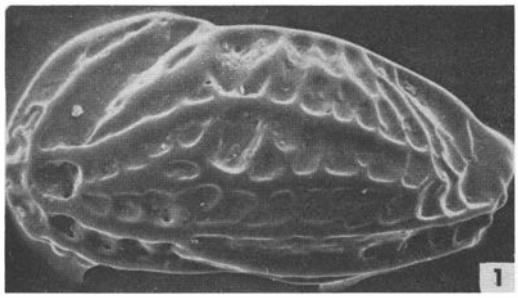
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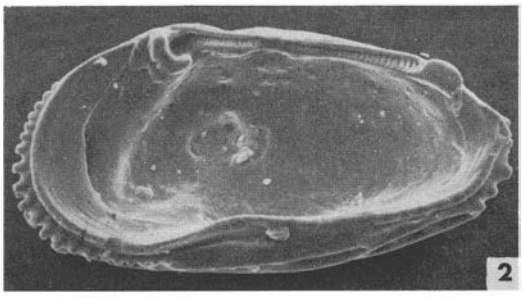
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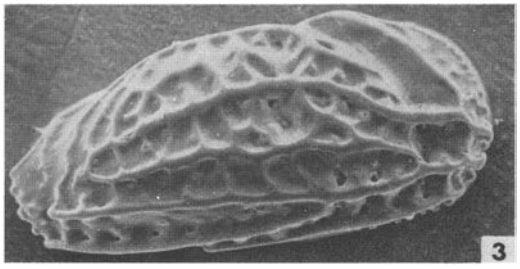
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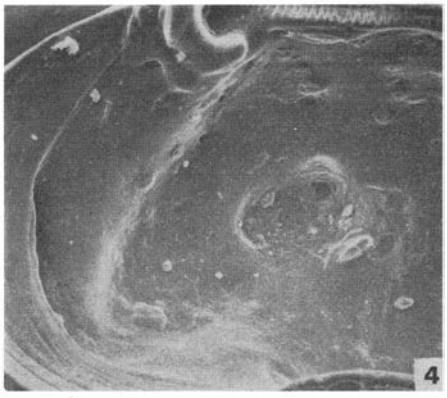
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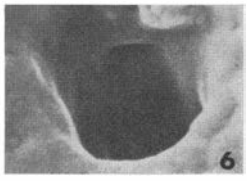
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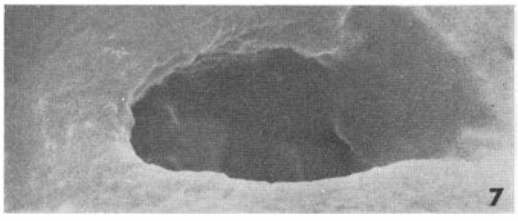
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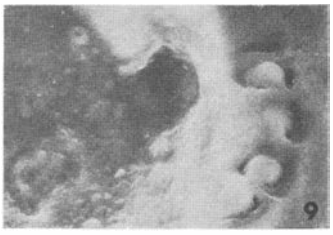
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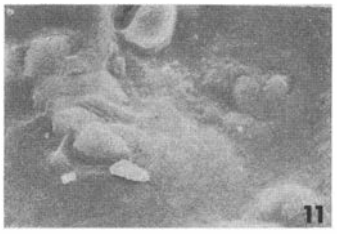
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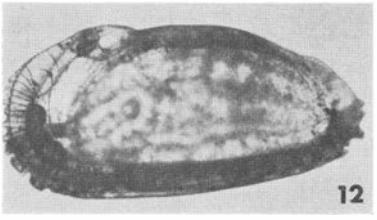
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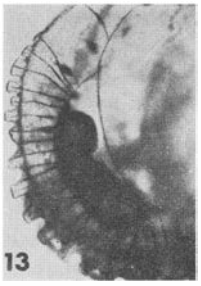
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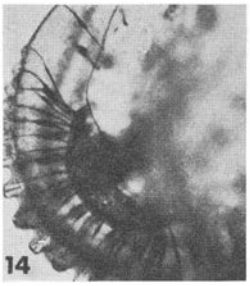
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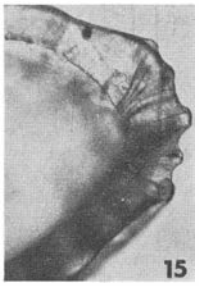
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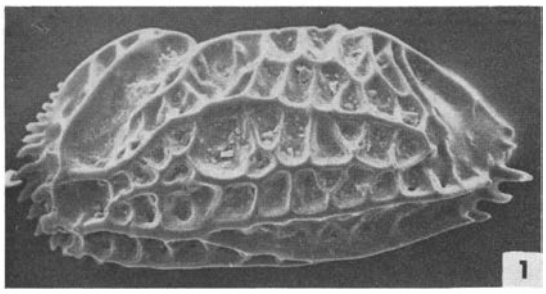
Plate XVI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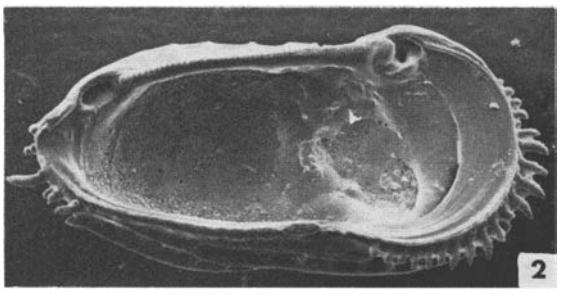
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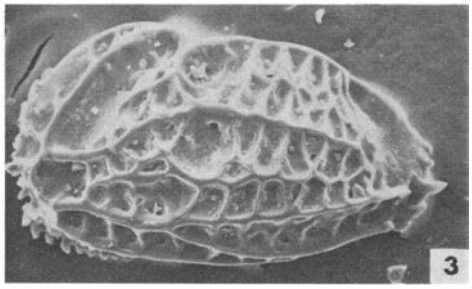
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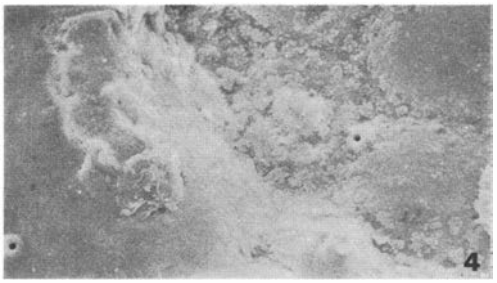
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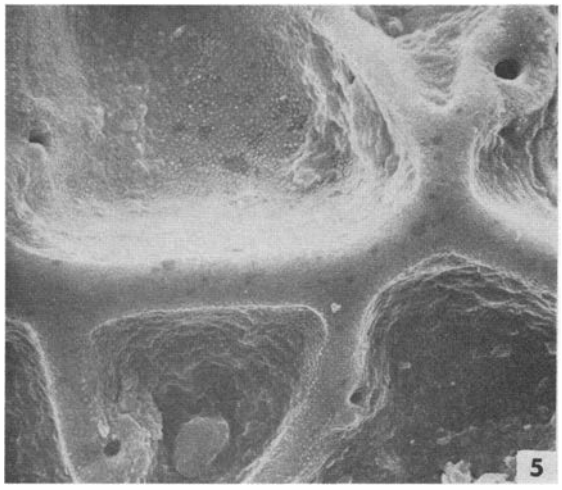
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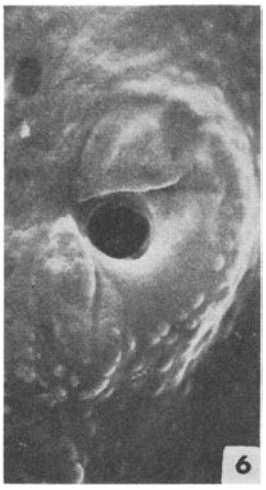
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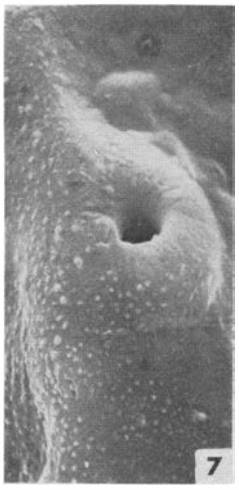
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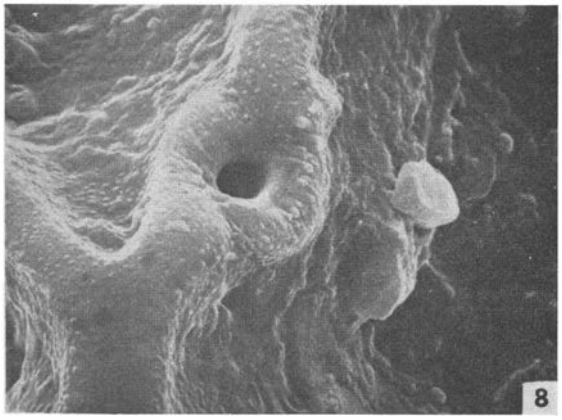
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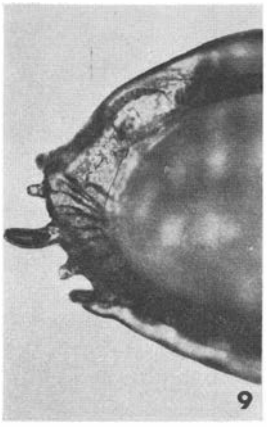
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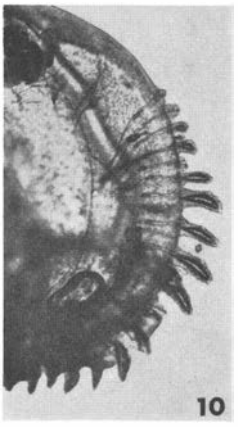
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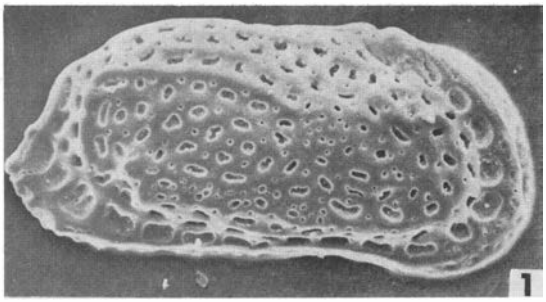
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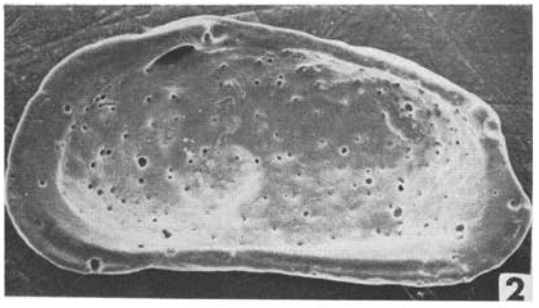
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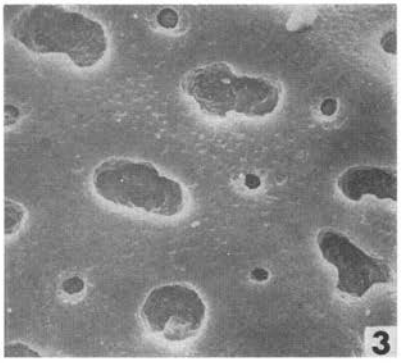
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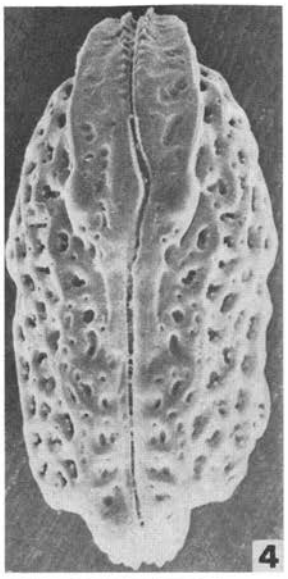
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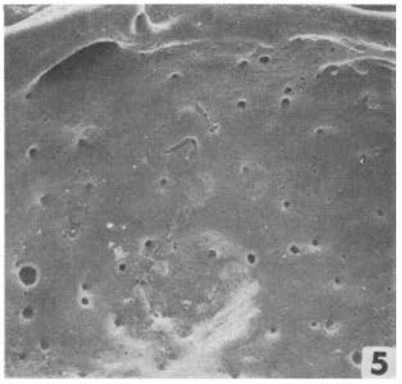
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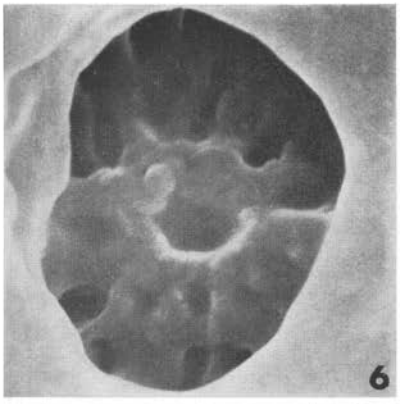
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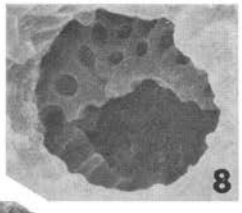
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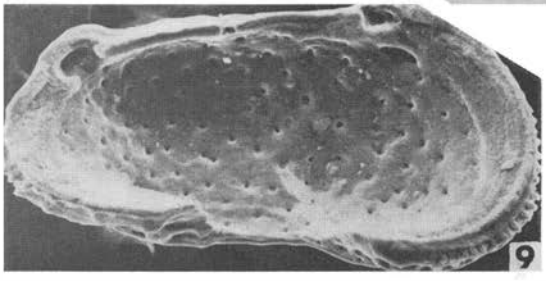
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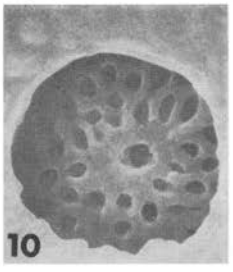
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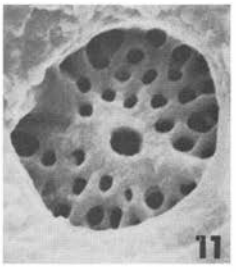
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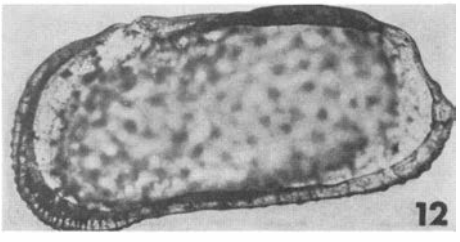
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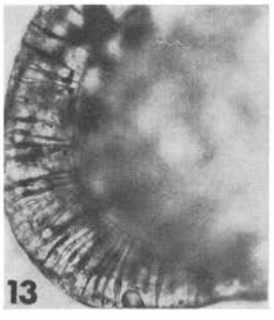
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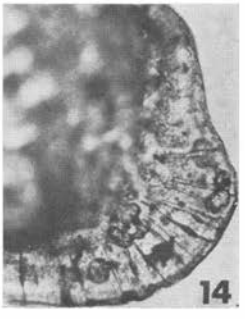
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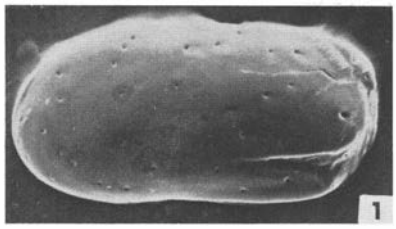
Plate XVIII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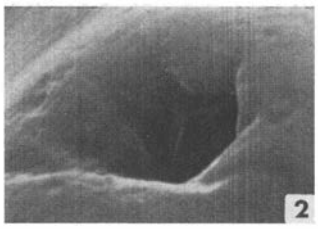
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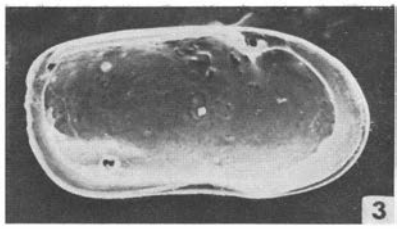
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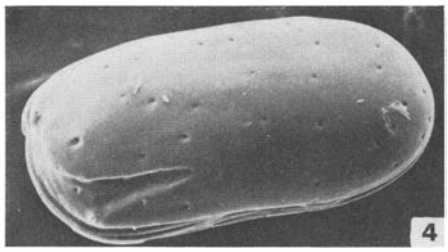
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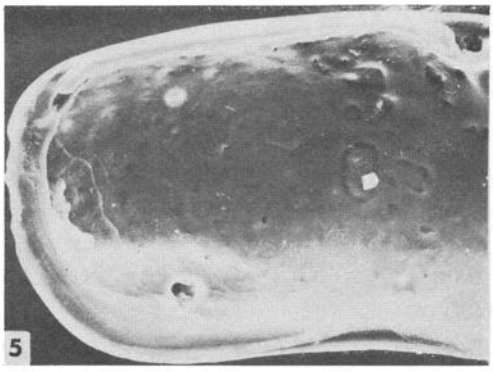
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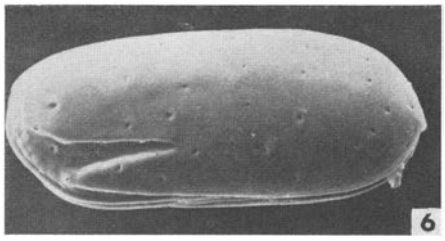
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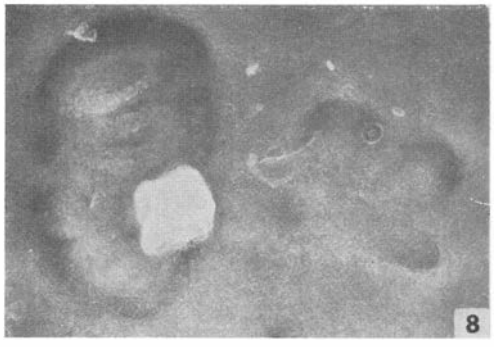
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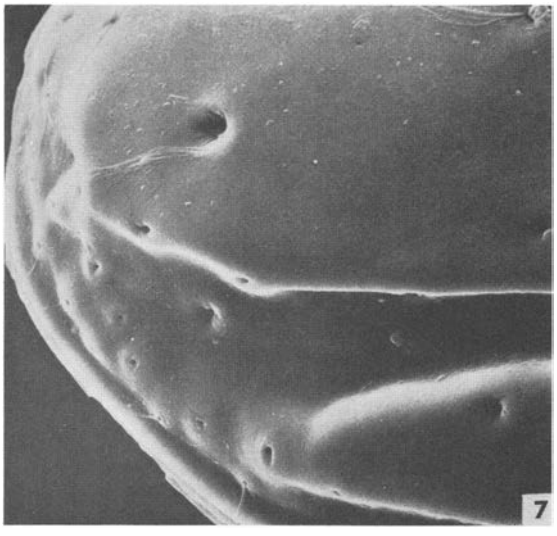
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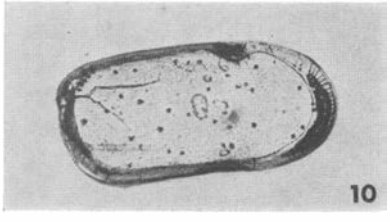
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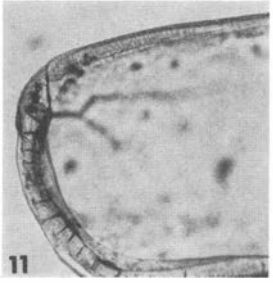
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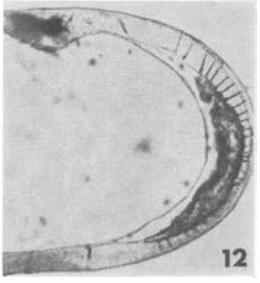
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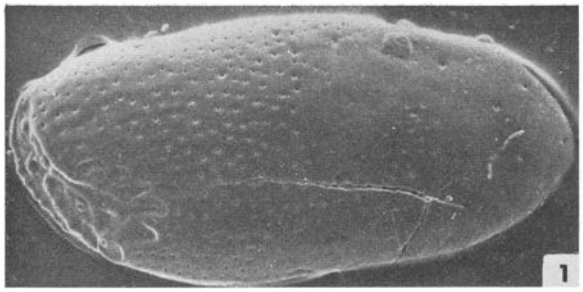
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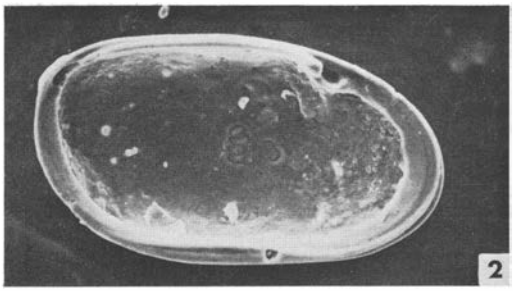
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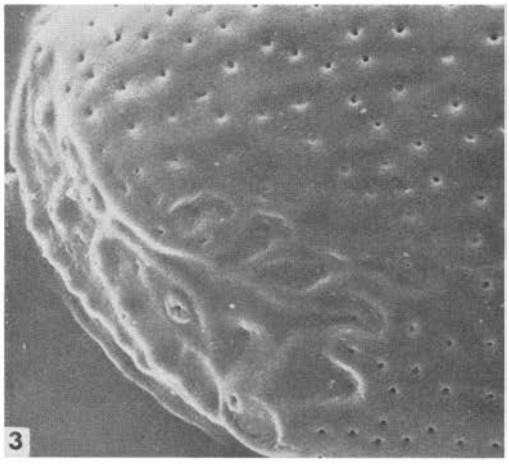
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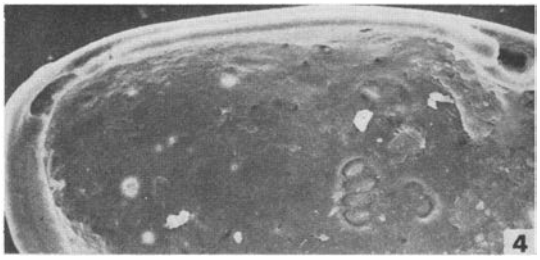
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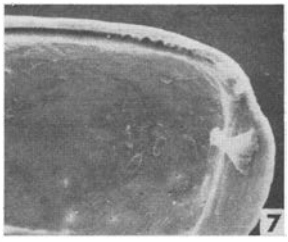
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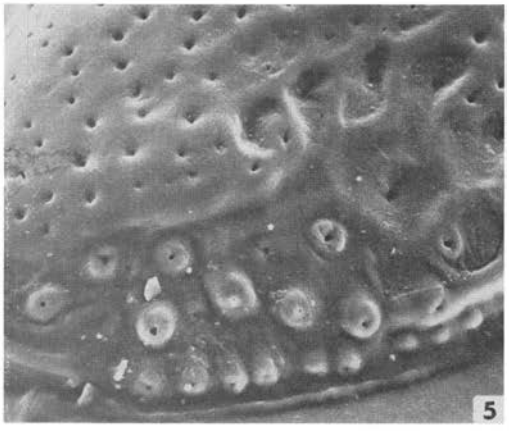
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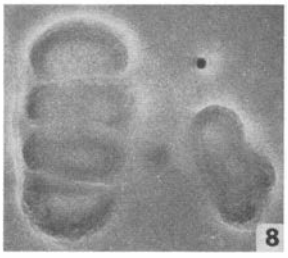
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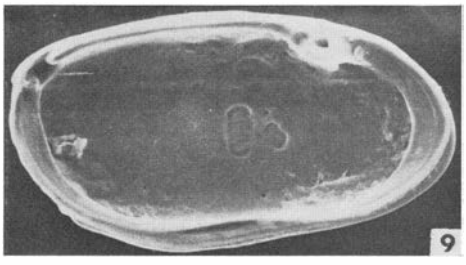
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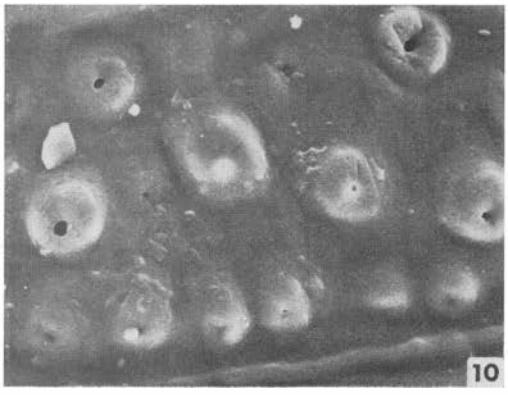
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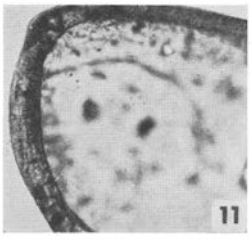
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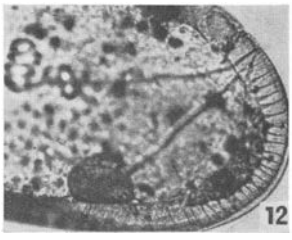
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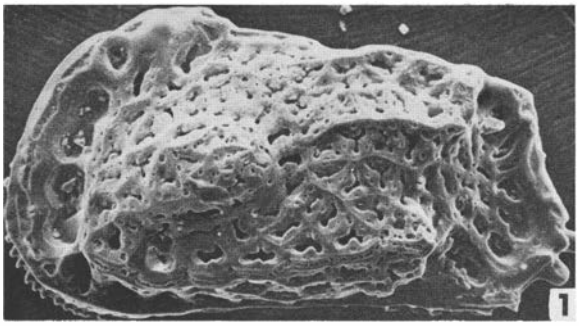
Plate XX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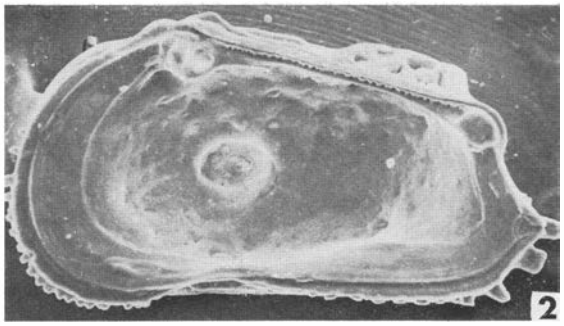
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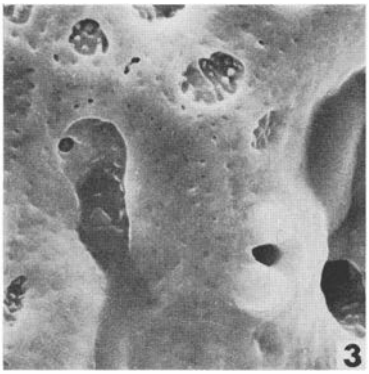
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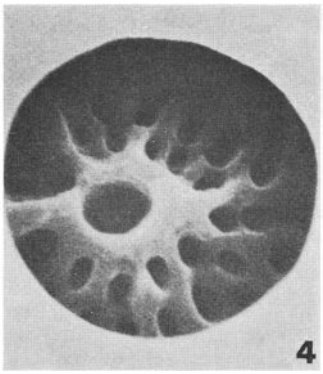
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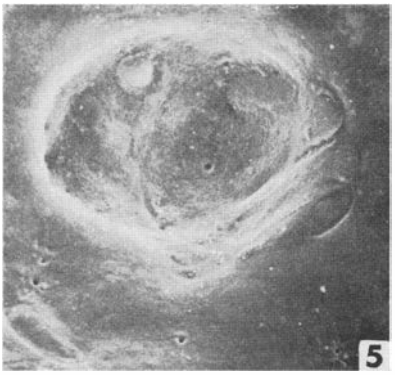
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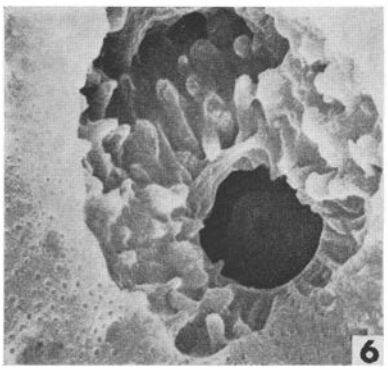
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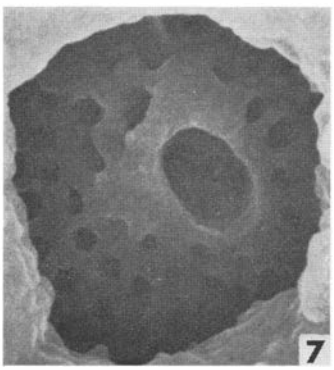
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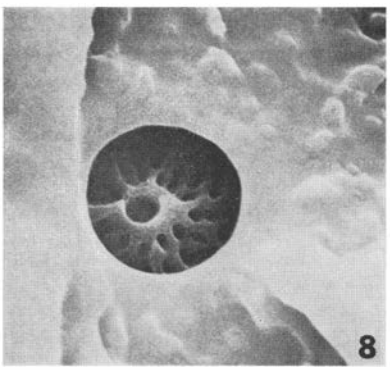
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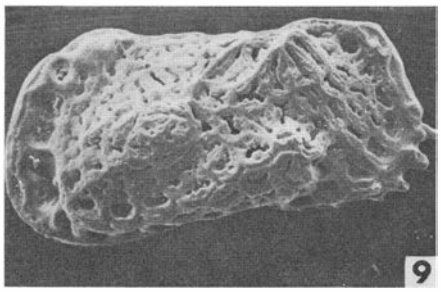
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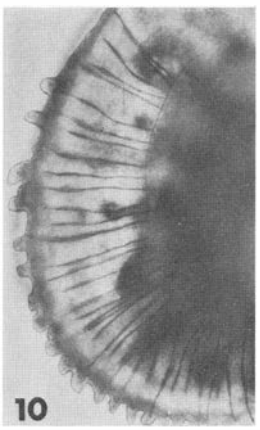
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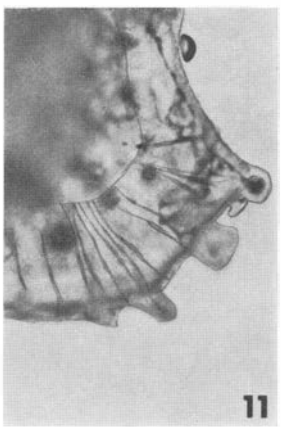
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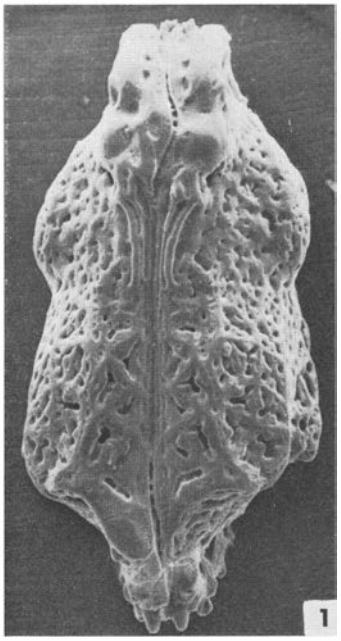
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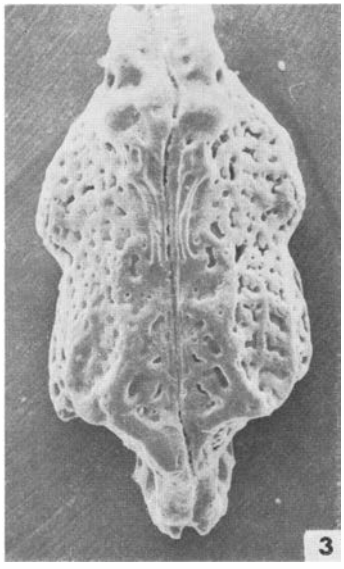
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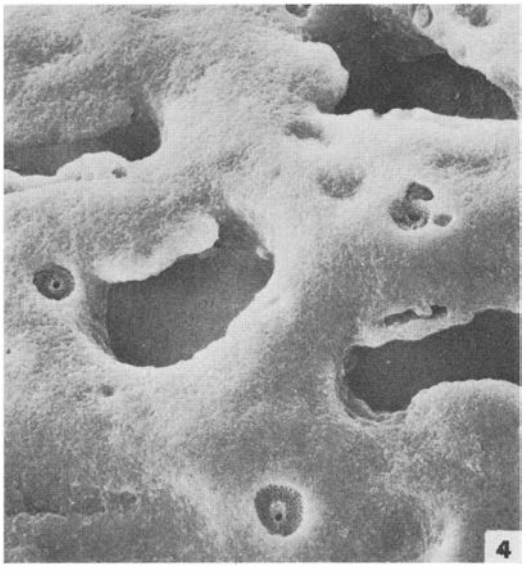
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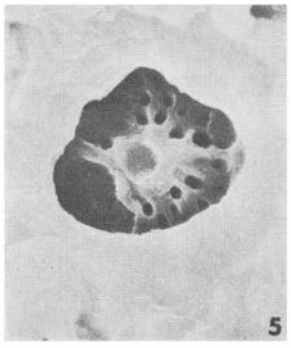
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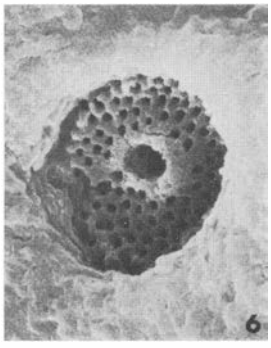
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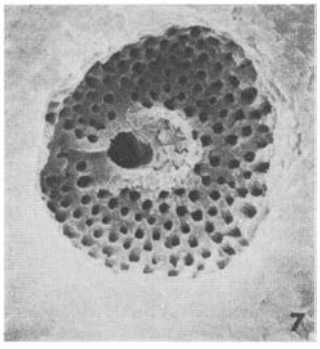
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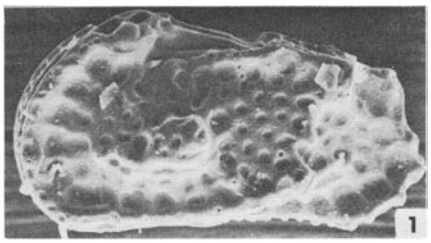
Plate XXII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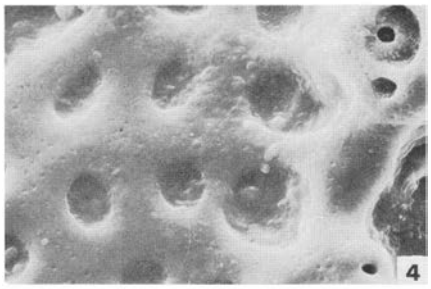
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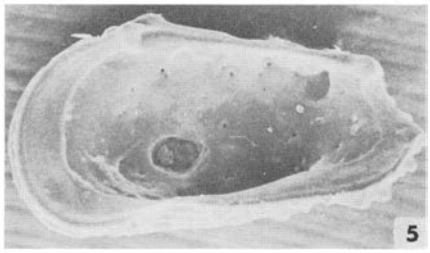
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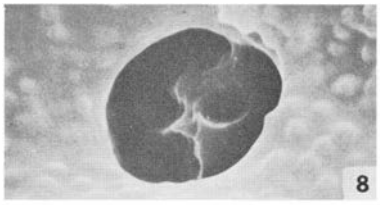
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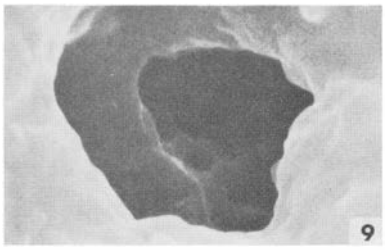
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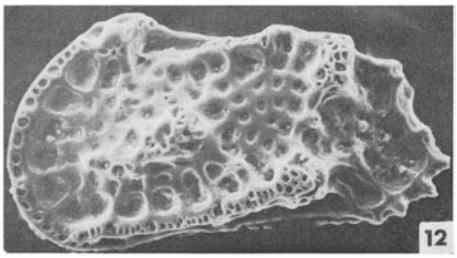
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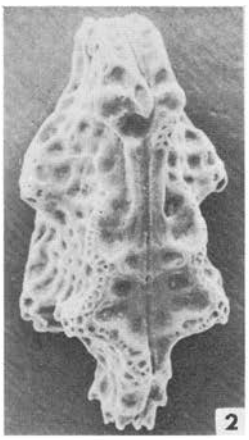
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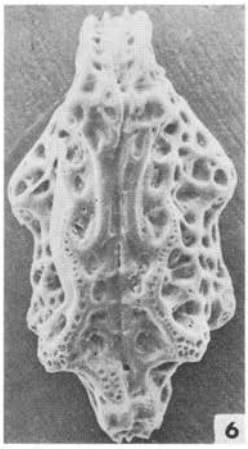
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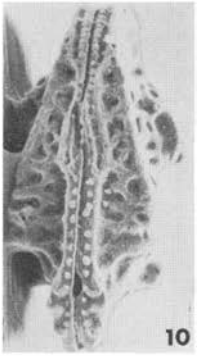
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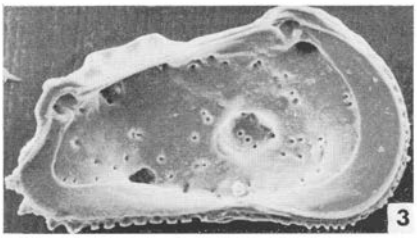
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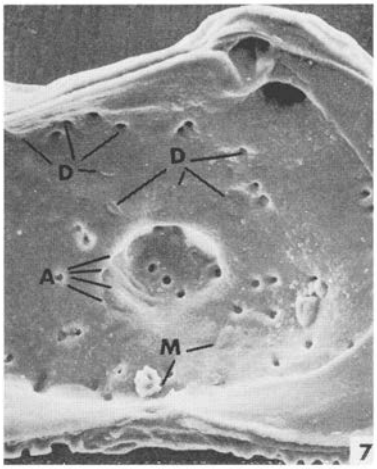

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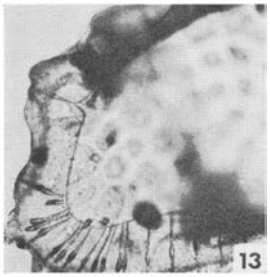
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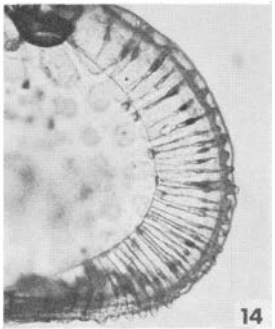
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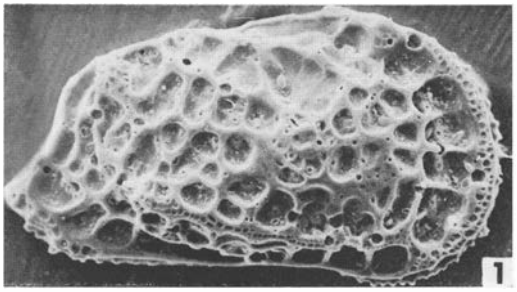
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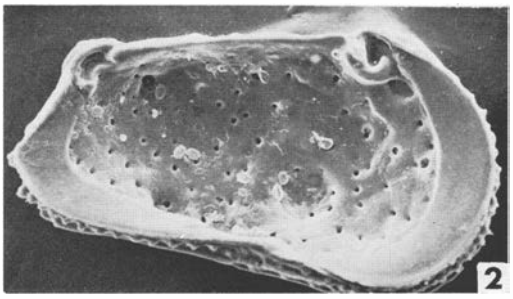
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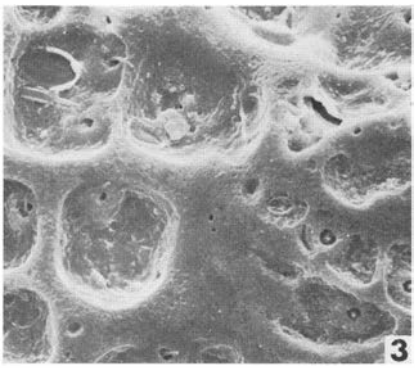
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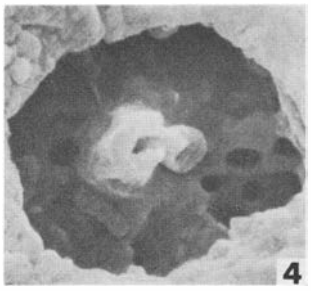
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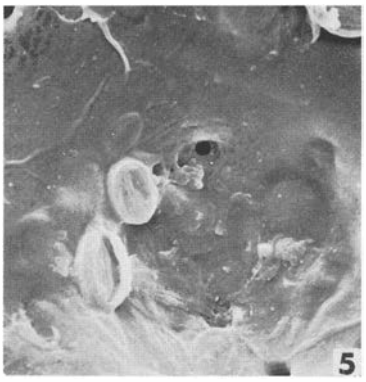
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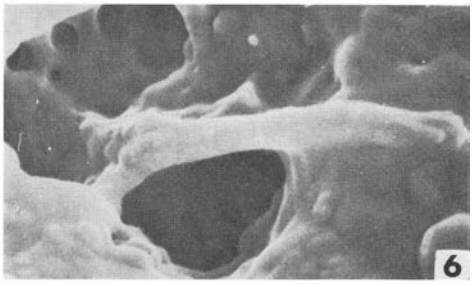
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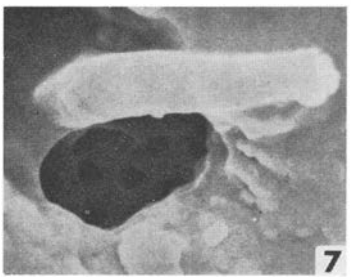
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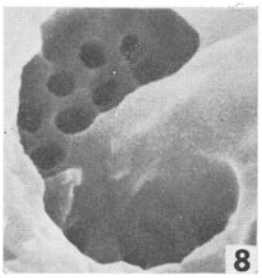
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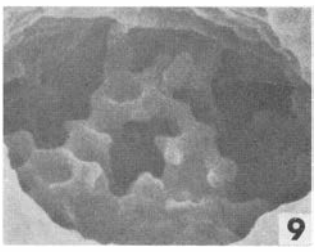
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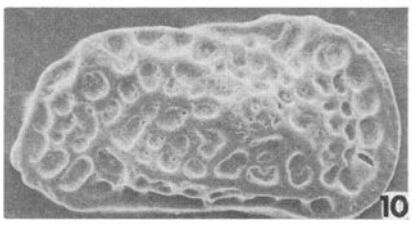
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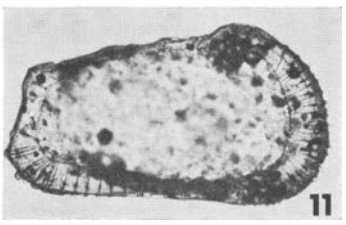
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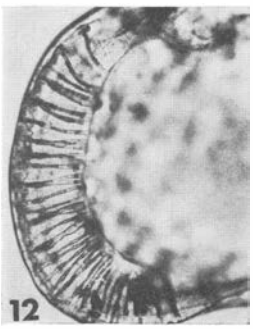
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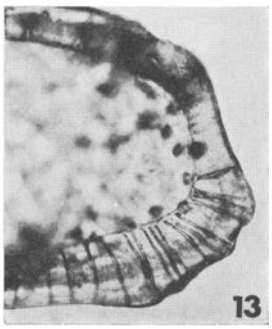
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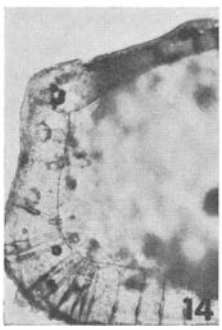
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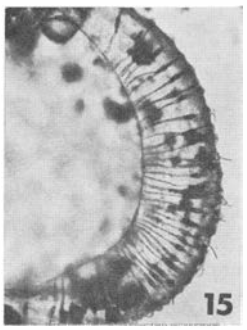
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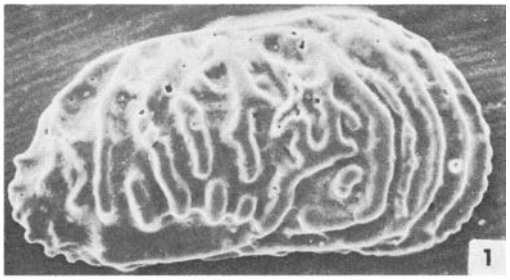
Plate XXIV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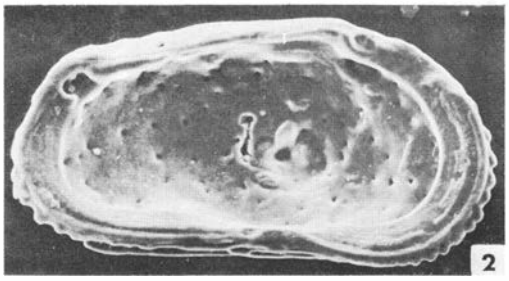
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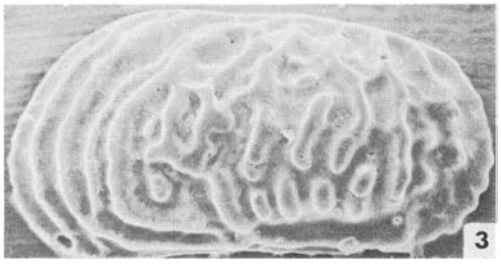
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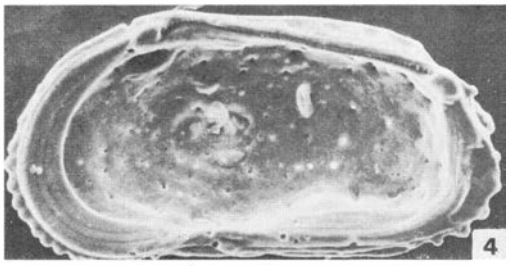
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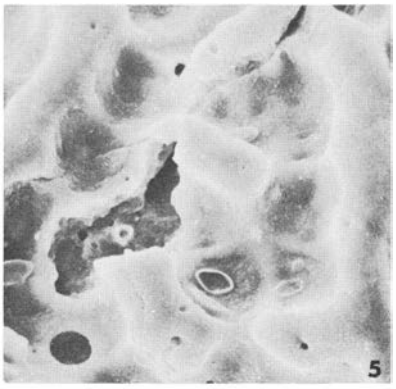
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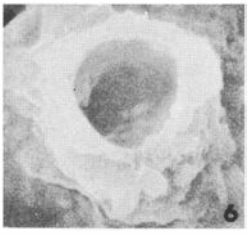
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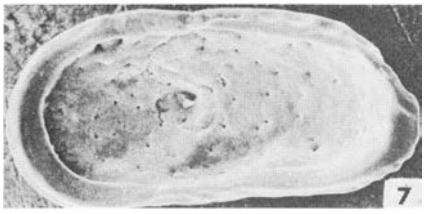
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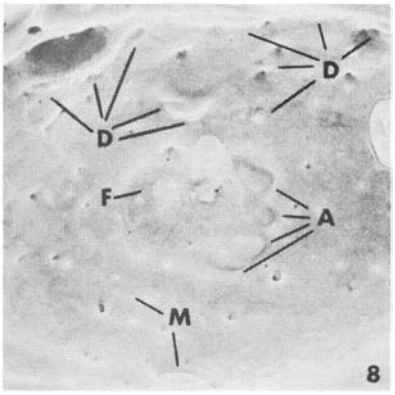

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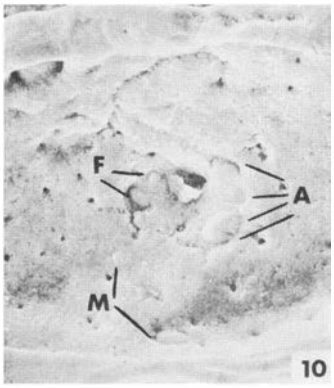

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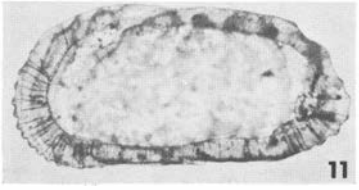
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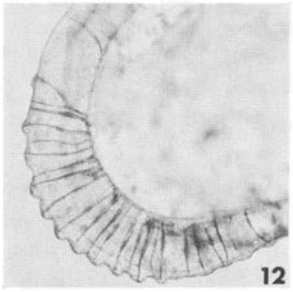
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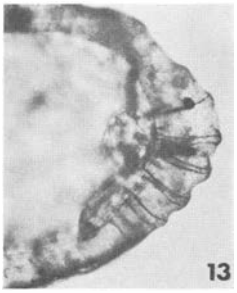
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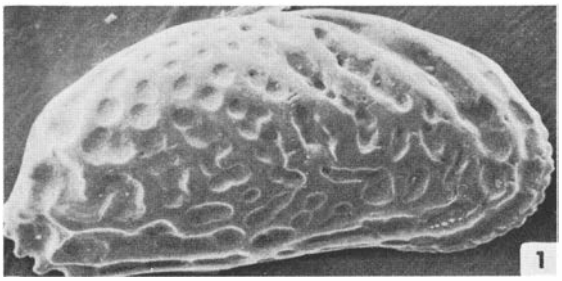
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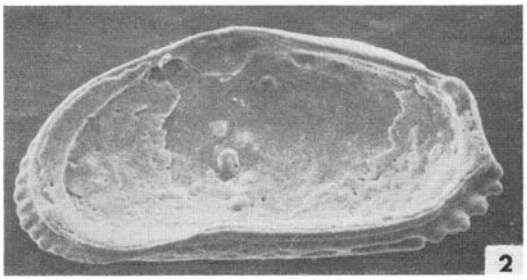
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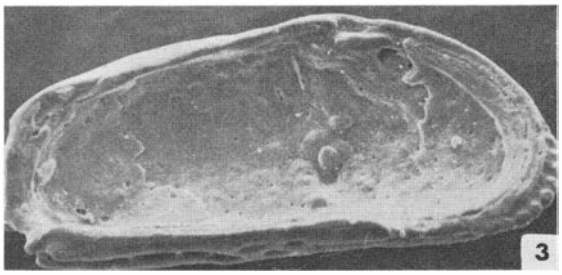
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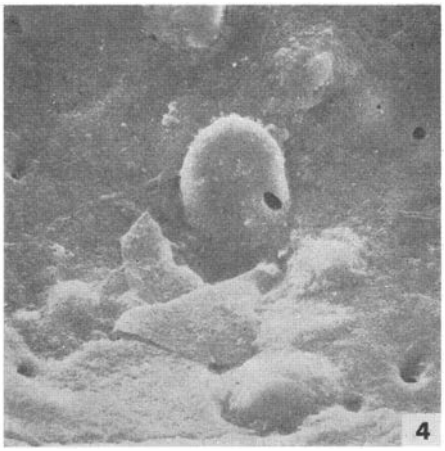
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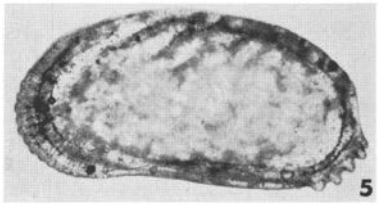
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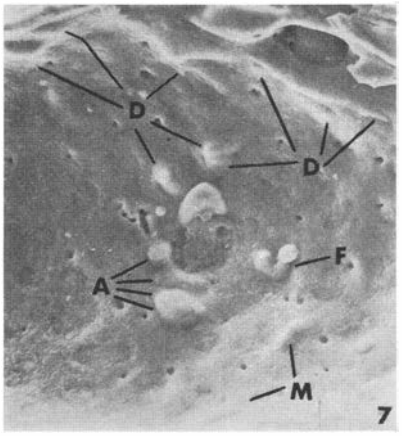

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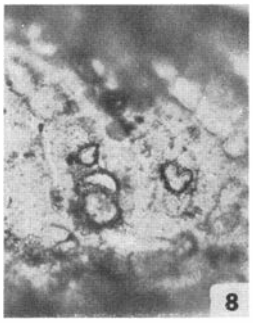
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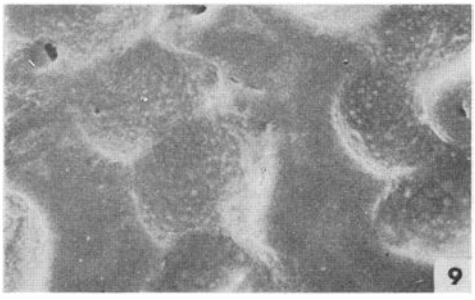
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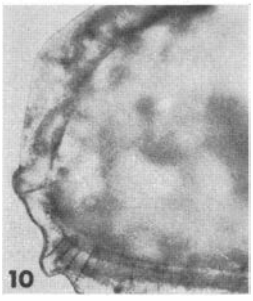
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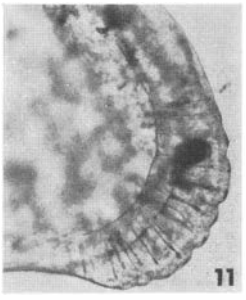
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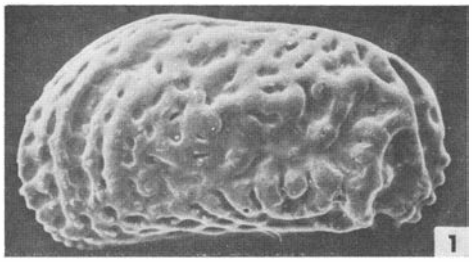
Plate XXVI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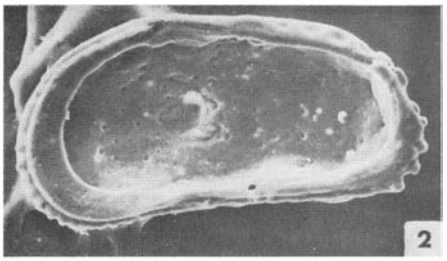
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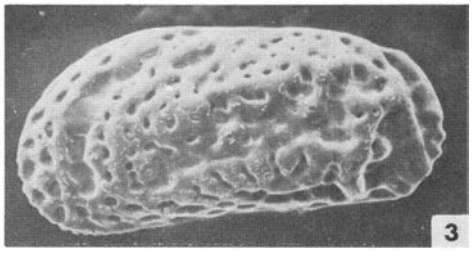
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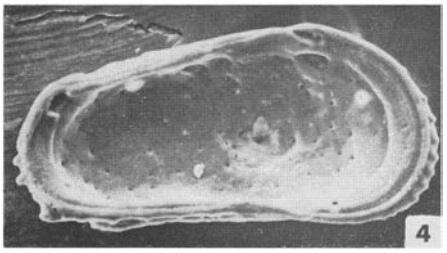
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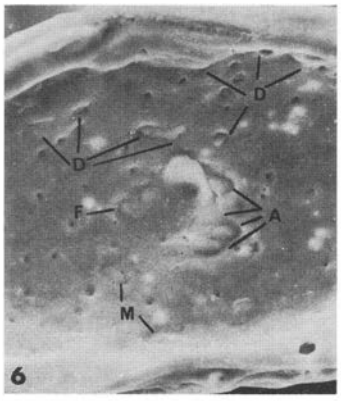

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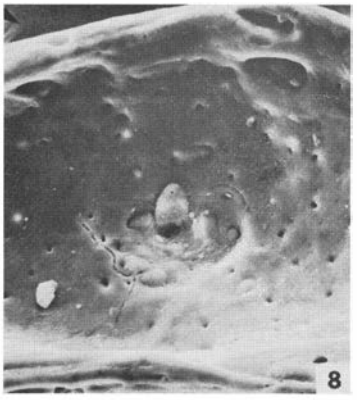
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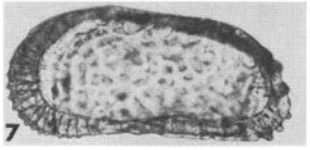
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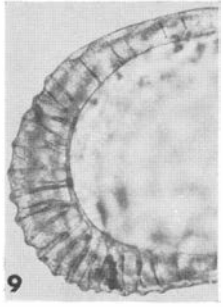
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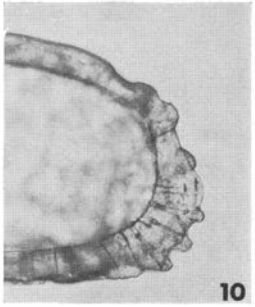
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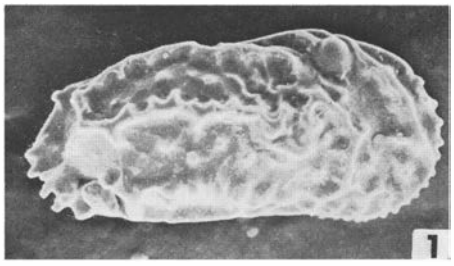
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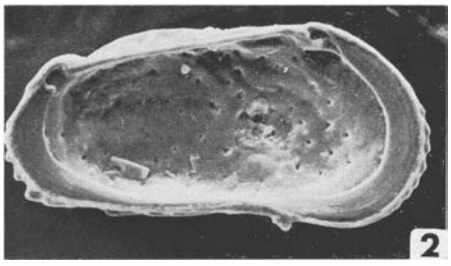
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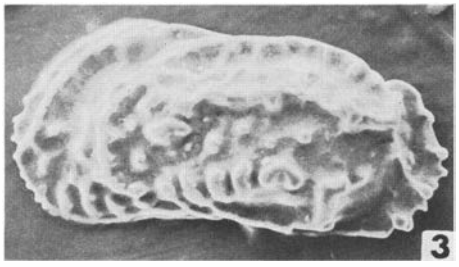
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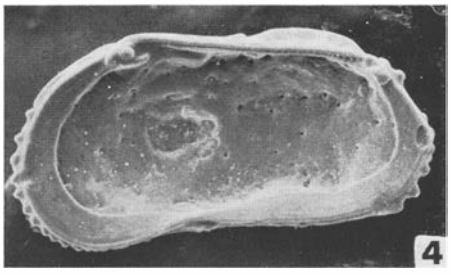
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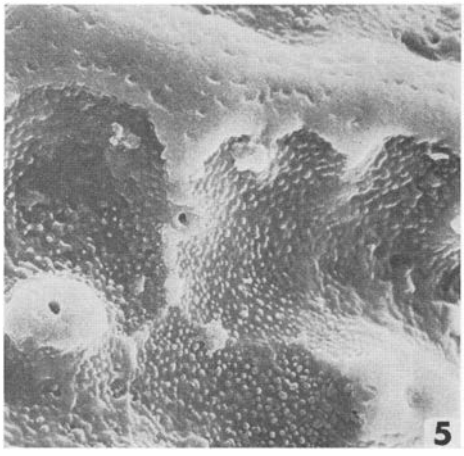
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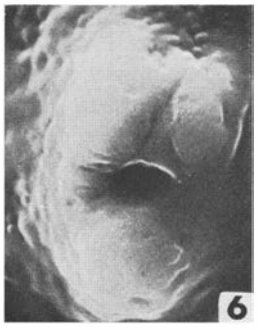
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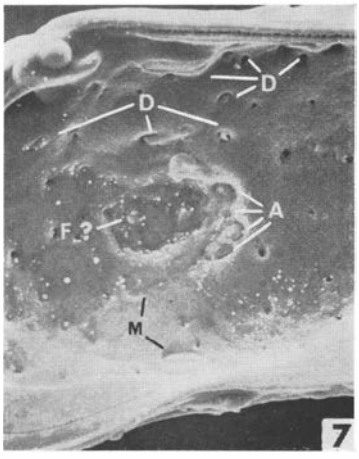

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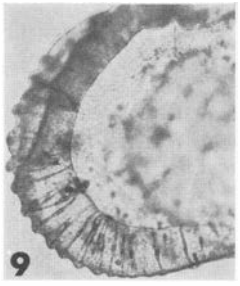
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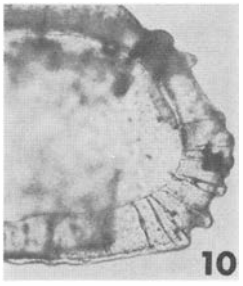
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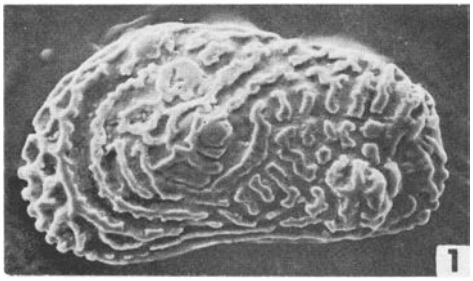
Plate XXVIII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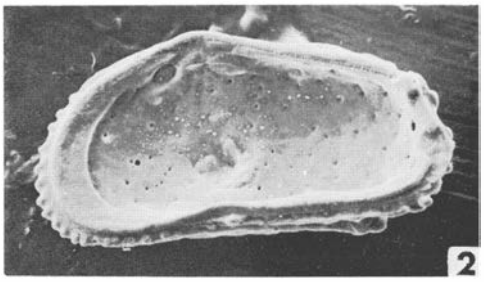
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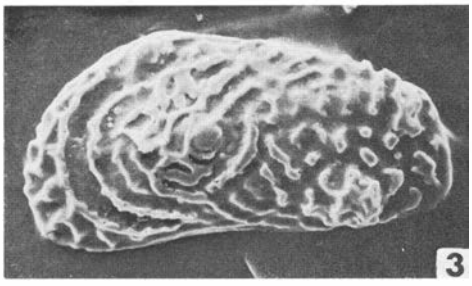
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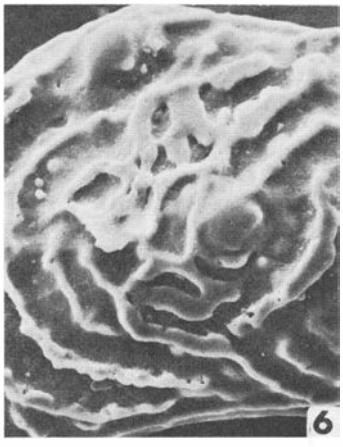
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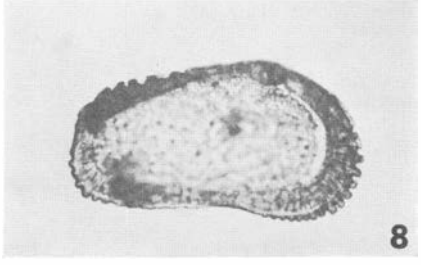
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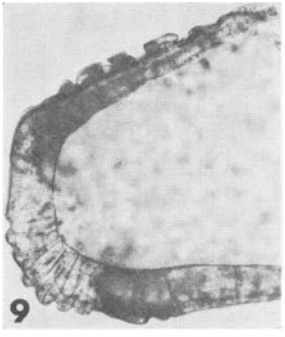
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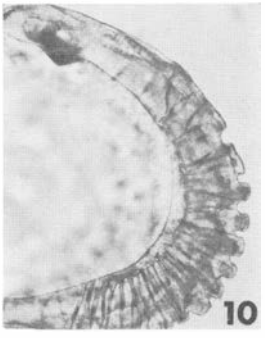
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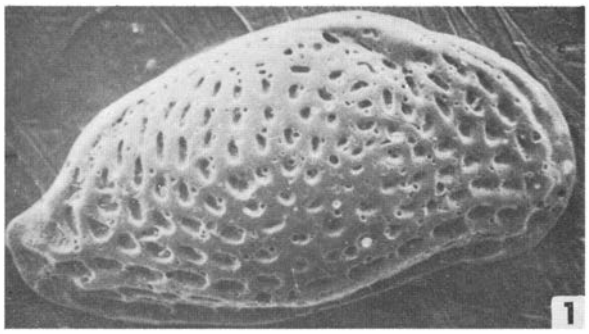
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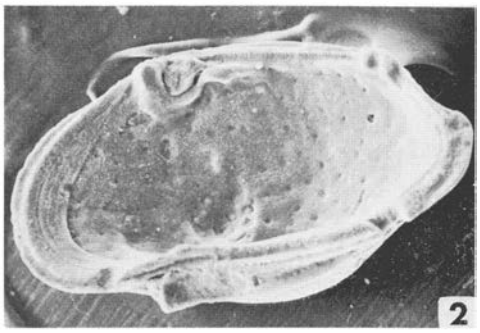
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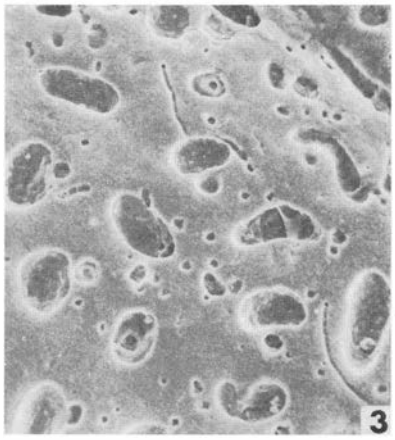
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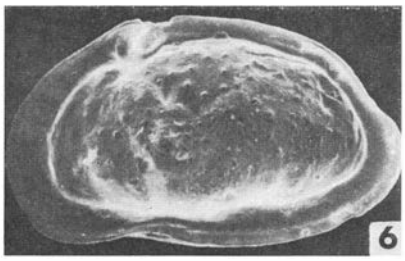
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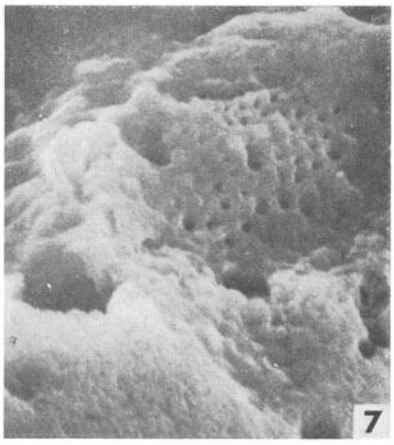
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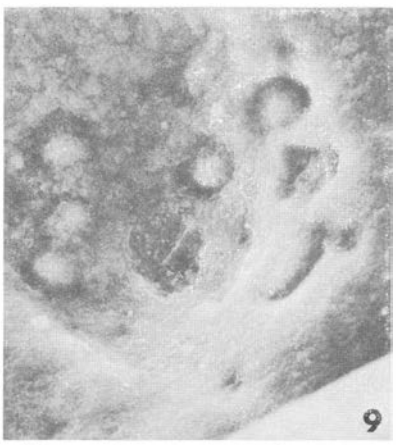
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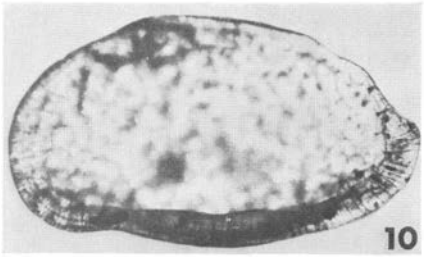
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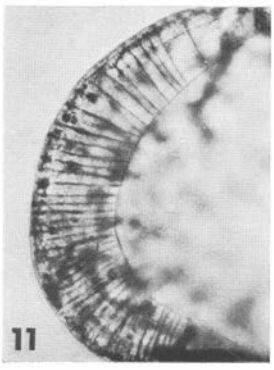
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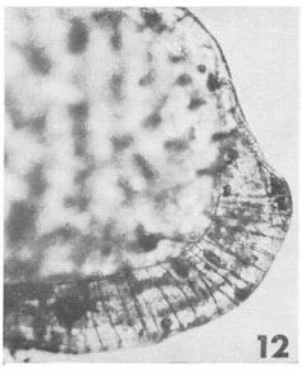
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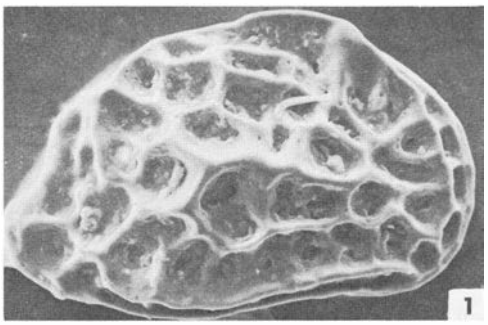
Plate XXX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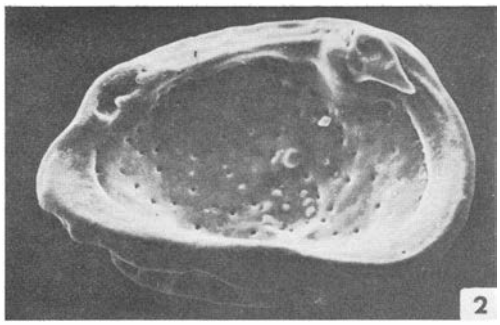
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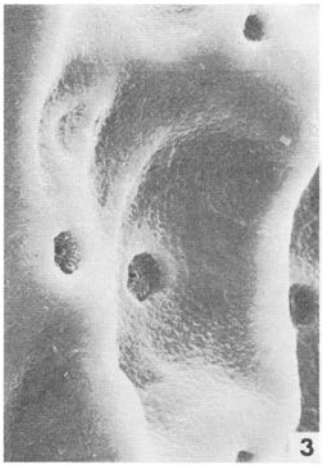
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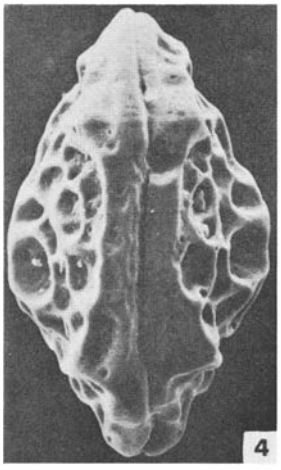
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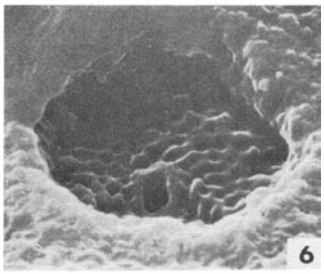
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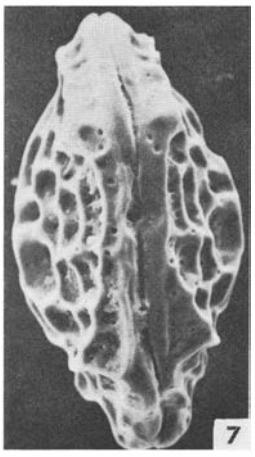
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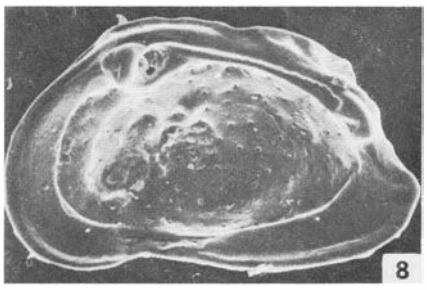
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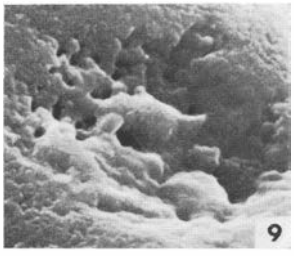
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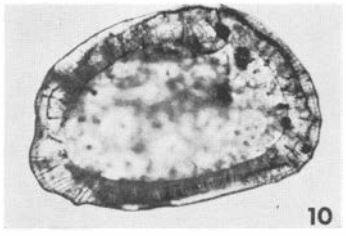
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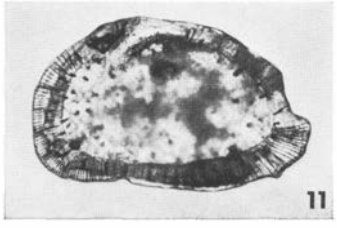
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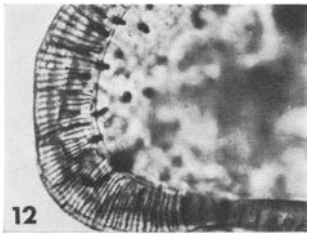
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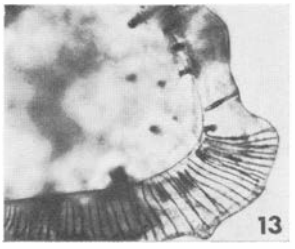
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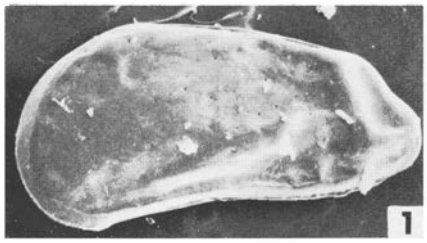
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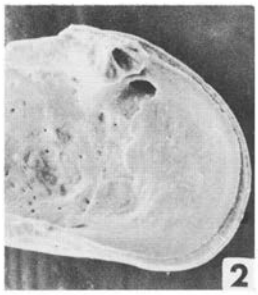
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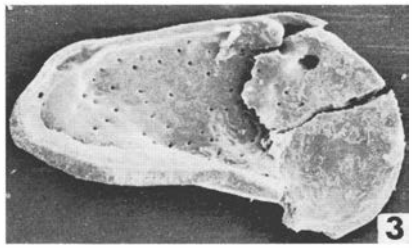
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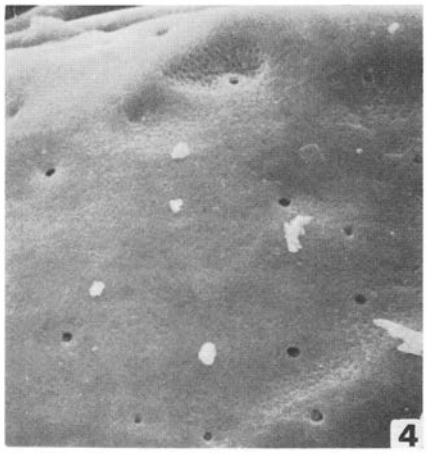
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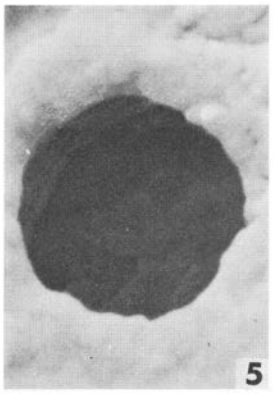
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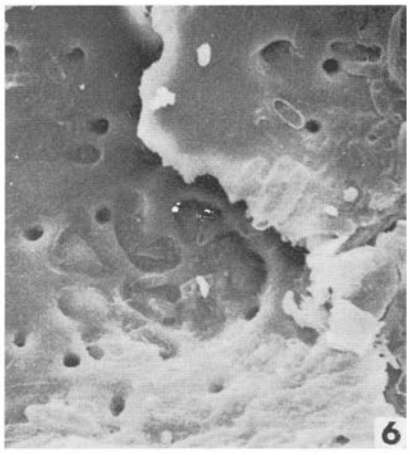
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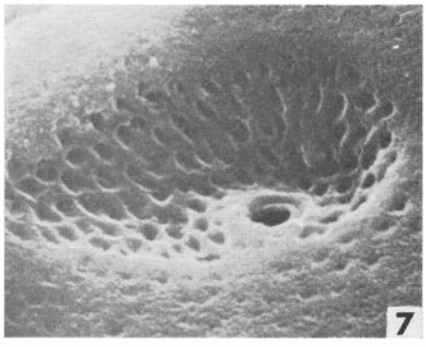
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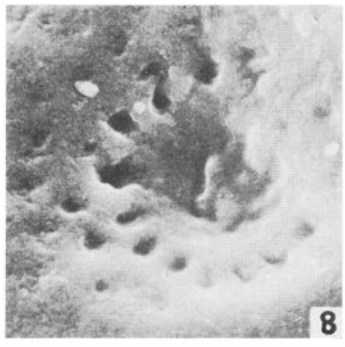
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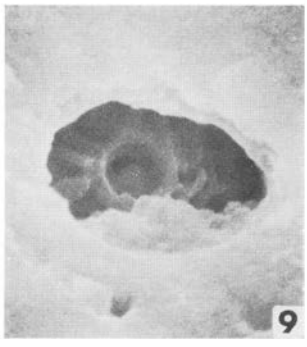
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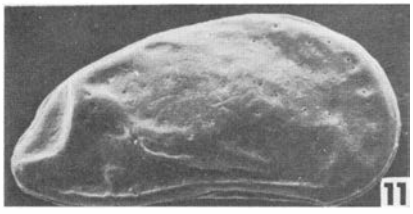
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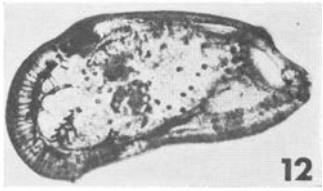
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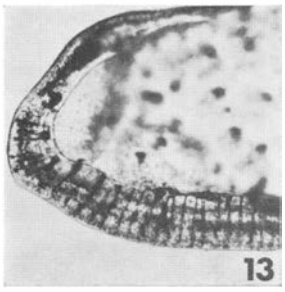
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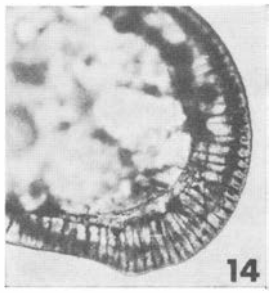
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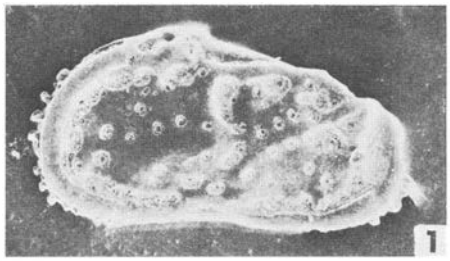
Plate XXXII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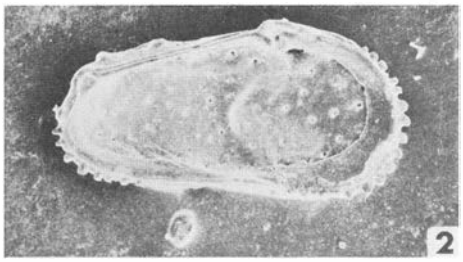
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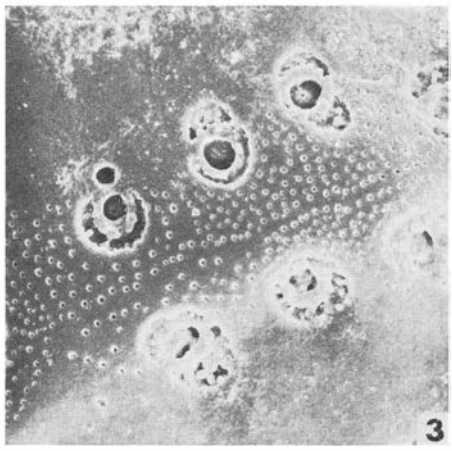
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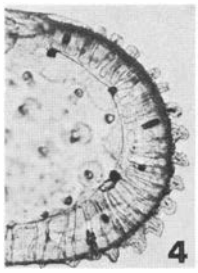
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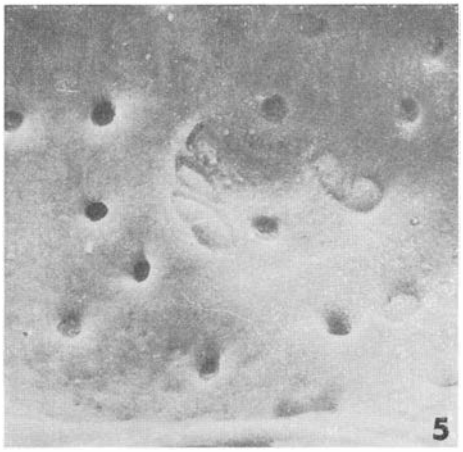
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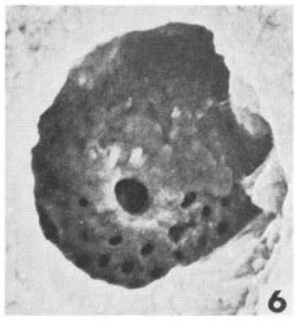
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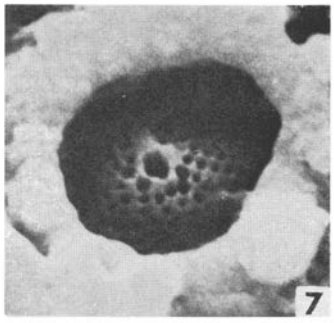
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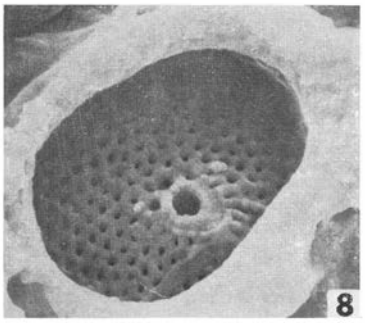
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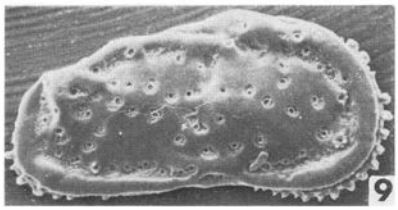
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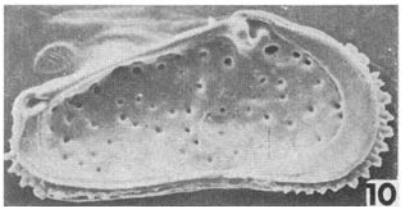
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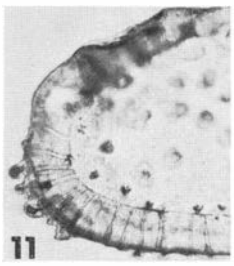
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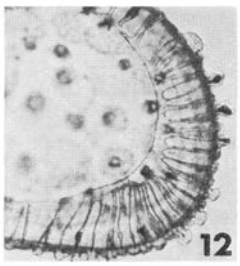
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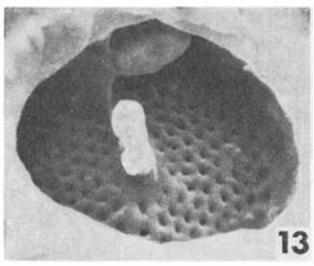
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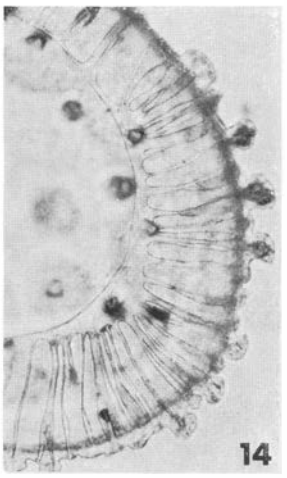
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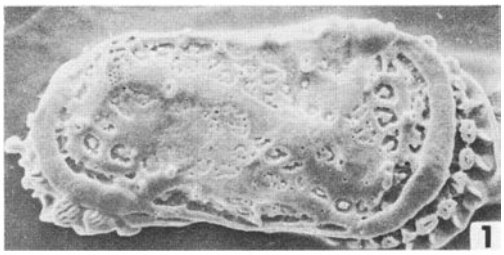
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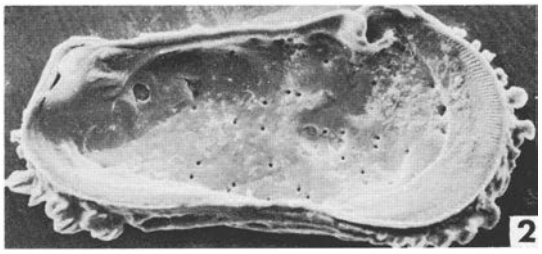
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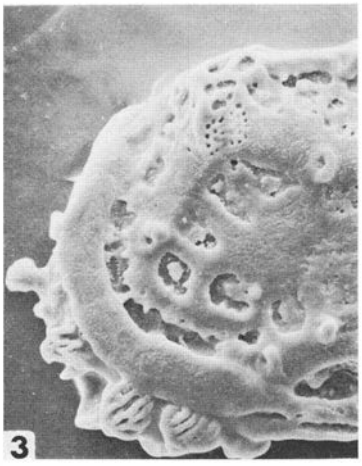
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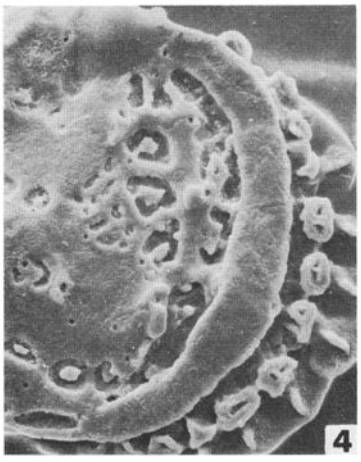
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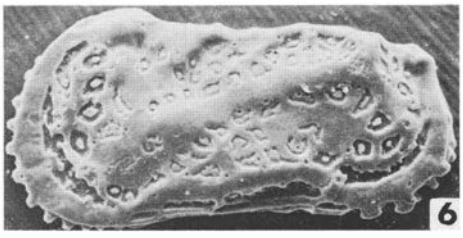
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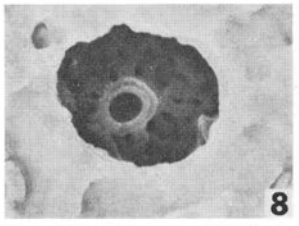
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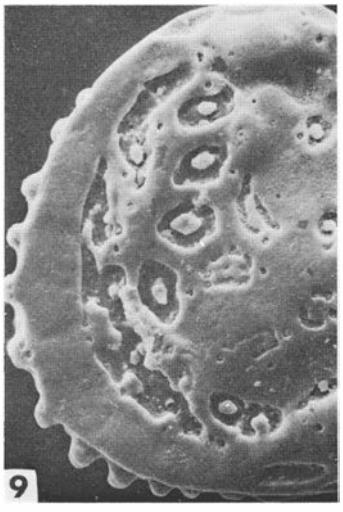
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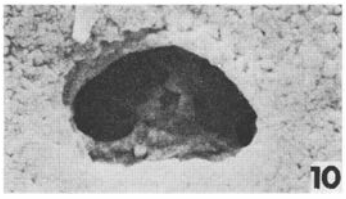
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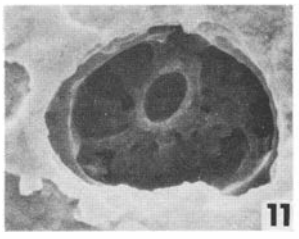
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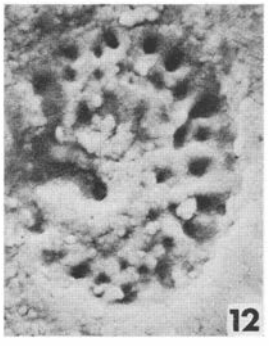
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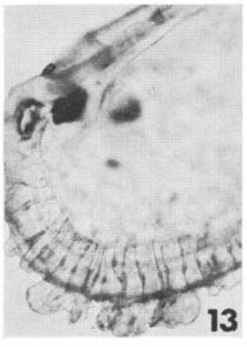
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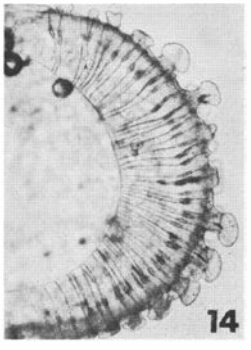
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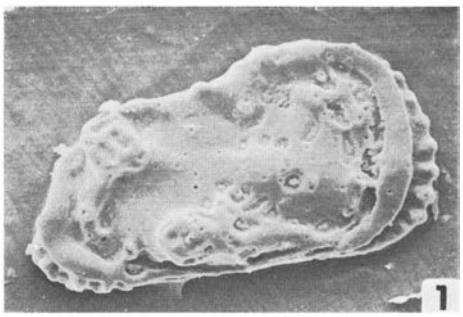
Plate XXXIV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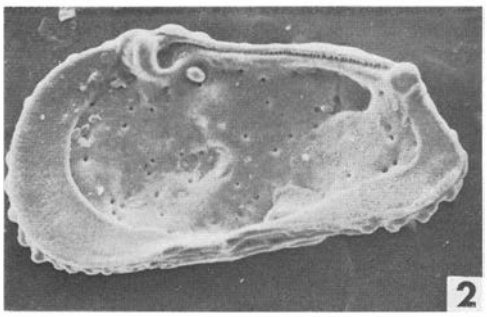
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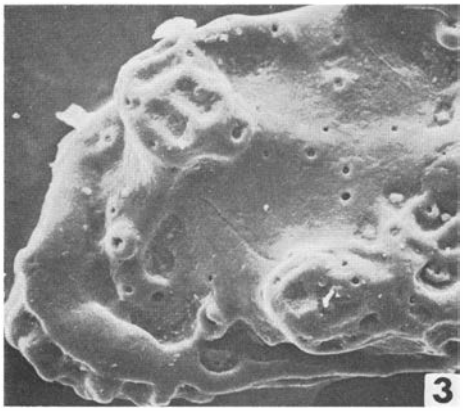
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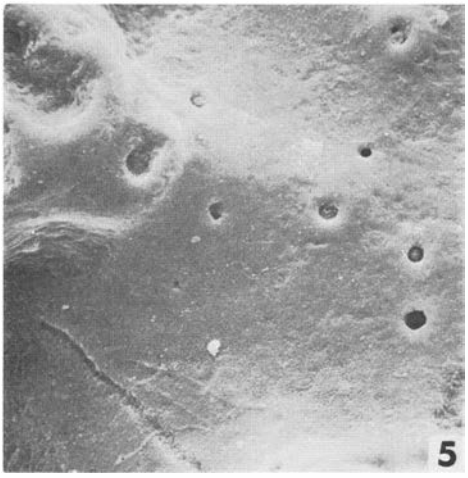
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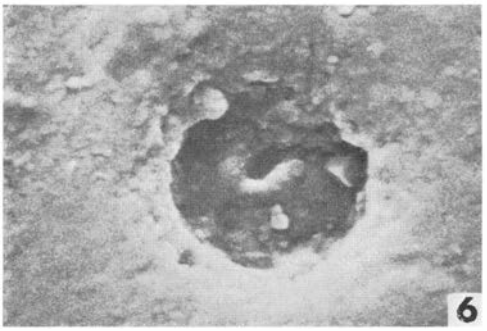
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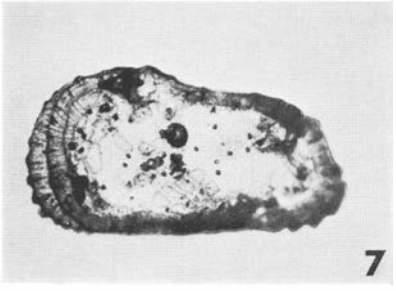
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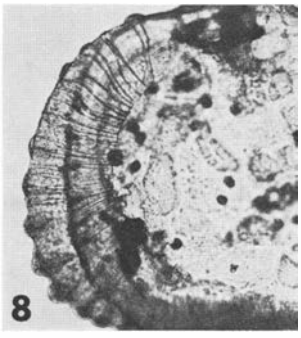
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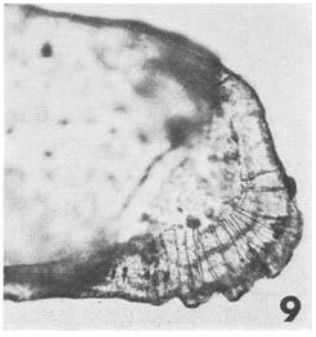
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