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Carboniferous pteridosperm frond *Neuropteris heterophylla*; Tertiary Ostracoda from Tanzania

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The Carboniferous pteridosperm frond *Neuropteris heterophylla* (Brongniart) Sternberg

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CONTENTS

SYNOPSIS. New evidence on the frond architecture of *Neuropteris heterophylla* (Brongniart) Sternberg is presented, based on well-preserved adpressions from Clay Cross, Derbyshire. Their cuticles provide the first reported evidence of epidermal structure for this species, including remains of trichomes apparently with *in situ* exudate. The new evidence indicates that this species is more closely related to *Neuropteris ovata* Hoffmann and *Neuropteris flexuosa* Sternberg, rather than to *Laveineopteris loshii* (Brongniart) Cleal *et al.* and *Laveineopteris tenuifolia* (Sternberg) Cleal *et al.*, as argued by some previous authors.

INTRODUCTION

Neuropteris (Brongniart) Sternberg is one of the most widely reported macrofossil form-genera from the Westphalian of Europe and North America. It represents foliage of an extinct group of gymnospermous plants known as the Trigonocarpales Meyen 1987 (Medullosales *auctt.*), which probably grew on levee banks and other raised areas within the equatorial delta plains of the time (Zodrow & Cleal 1988). Recently, our understanding of the form-genus has significantly improved, particularly as a result of frond architecture and cuticle studies (Barthel 1961, 1962, 1976; Reichel & Barthel 1964; Laveine 1966*a*, 1966*b*, 1967, 1987; Laveine & Brousmiche 1982; Zodrow & Cleal 1988; Cleal & Zodrow 1989), and it has become evident that the form-genus is far from homogeneous. As a result, some species have been transferred to other form-genera (e.g. *Paripteris* Gothan, *Neuralethopteris* Cremer *ex* Laveine – see Laveine, 1967) but, until recently, most have been retained in *Neuropteris*. This was partly because the frond of the type-species (*N. heterophylla* (Brongniart) Sternberg, 1825) had not been fully reconstructed, nor was anything known of its epidermal structure. Consequently, it was not possible to say which of the groups recognizable on, say, epidermal structure represented real *Neuropteris*, and which needed to be transferred to other form-genera.

The type species was first published as *Filicites (Nevropteris) heterophyllus* by Brongniart (1822), and was later changed to *Neuropteris heterophylla* (Brongniart) by Sternberg (1825). (Few subsequent authors have recognized the validity of Sternberg's initial publication of this combination, which is often attributed incorrectly to Brongniart (1828) – e.g. Crookall 1959, Laveine 1967). The small holotype was illustrated diagrammatically only (Brongniart 1822: pl. 2, figs 6a, b) and is now reported lost (Laveine 1967). Many authors have regarded it as conspecific with *Laveineopteris loshii* (Brongniart) Cleal *et al.* 1990 (e.g. Stockmans 1933, Havlena 1953, Crookall 1959), a common species distributed widely

through the Westphalian A–C of Europe. Laveine (1967) has argued that this is unlikely, however, basing his contention mainly on a rather larger specimen of *N. heterophylla* figured by Brongniart (1831: pl. 71). This latter specimen is clearly quite different from *Laveineopteris loshii*, and hence many traditional conceptions about *N. heterophylla* (and consequently of the form-genus *Neuropteris* itself) would appear to be ill-founded. *N. heterophylla* as interpreted by Laveine (1967) is in fact an uncommon species; his synonymy refers to only ten undoubted specimens illustrated in the literature, and he figured another three.

The present paper documents some large and excellently preserved specimens in the palaeontological collections of the British Museum (Natural History), from which we have been able to provide a detailed reconstruction of the frond. Some of these specimens also yielded cuticles. The only previous record of *N. heterophylla* cuticles is by Wills (1914), based on specimens from North Wales. As we will argue later, however, Wills' material is almost certainly misidentified, and our specimens provide the first unequivocal evidence of the epidermal structure of this species. The results presented here have important consequences for the generic classification of neuropterid foliage, and have been the basis of the revised classification published by Cleal *et al.* (1990).

MATERIALS

This study is based largely on eight hand-specimens stored in the Department of Palaeontology, British Museum (Natural History) (Accession Numbers V.1797, V.1867, V.1868, V.1871, V.1872, V.2727, V.63152, V.63153). They are all labelled as originating from the 'Coal Measures, Clay Cross, Derbyshire'. No further stratigraphical details are given, but they probably came from the Westphalian B. Cuticles were prepared from four of these specimens: V.1867, V.1868, V.2727 and V.63152.

METHODS

The hand-specimens were photographed using crossed-polar filters. Because of limited page size, we cannot reproduce photographically all the specimens at the same scale; tracings from the photographs are therefore reproduced here at a uniform scale of × ⅓ (Figs 26–28).

Cuticles were prepared using the method outlined by Barthel (1962). Pieces of fossil were removed from the hand-specimens with a small chisel, and then placed in 40% hydrofluoric acid to remove the rock matrix (pre-treatment with hydrochloric acid was found to be unnecessary). The carbonaceous phytoleims (*sensu* Krystofovich 1944) were next oxidized in Schultze's Solution for 1–2 hours, and then treated with a 5% solution of ammonium hydroxide to remove the soluble oxidation products. The resulting cuticles were washed thoroughly in distilled water.

Most of the cuticles were mounted in glycerine jelly containing safranin dye. They were examined with a Leitz Ortholux II microscope, using differential interference phase contrast (Normarski contrast) at high magnifications. In addition, some cuticles were mounted on stubs, thinly coated with gold, and examined at 15 kV with an Hitachi S-800 field emission scanning electron microscope.

DESCRIPTIONS

Frond architecture

In their gross morphology, the specimens dealt with in this paper basically fall into two groups: wide tripinnate pinnae with broad primary racheis; and distally tapered, tripinnate pinnae. These are interpreted as proximal and distal fragments of the frond, respectively, and are most conveniently described separately.

Proximal frond fragments (Figs 1, 2, 26 and 27a). The most proximal part of the frond preserved in these specimens (Fig. 1) shows a primary rachis, 2·5 cm wide, that extends for 1·5 cm before branching dichotomously. The resulting branches lie at 90° to each other near the fork, but then gradually curve inwards towards each other. This curvature is achieved, at least in part, by a series of kinks occurring at about the points of attachment of each secondary pinna on the outward-facing side of the primary rachis (Fig. 2). The primary racheis above the dichotomy are 1·2–1·5 cm wide, tapering to *c.* 0·5 cm wide in the most distal part of the specimens (Figs 1, 2).

The overall shape of the two primary pinnae produced by the dichotomous primary rachis is not shown in these specimens, but they appear to taper proximally, at least on their inward-facing side. Each primary pinna is markedly asymmetrical, although they are essentially symmetrical to each other about the long axis of the frond (Fig. 1). On the outward-facing side of the primary rachis branches, robust secondary pinnae with racheis 0·5–0·6 cm wide are attached at 60°–70°, at intervals of 8–10 cm. Very little of these secondary pinnae is preserved, the longest fragment being only 15 cm long and clearly very incomplete, but they appear to be bipinnate (Fig. 1). Their shape cannot be determined from the fragments preserved. In between these large bipinnate secondary pinnae are much shorter (3–4 cm long) monopinnate intercalated pinnae spaced at 2–3 cm intervals (Fig. 2). They are tapered and terminated by a single rhomboidal apical pinnule.

On the inward-facing side of each primary rachis branch, secondary pinnae are inserted at intervals of 3–5 cm, usually at an angle of 70°–90°. They are 3 cm long and monopinnate near the base of the primary rachis branch (Fig. 1), becoming 30 cm long and bipinnate in the more distal parts (Fig. 2). Adjacent secondary pinnae overlap slightly in the middle of the frond. They appear tapered for much of their length, except in the longer ones which are parallel-sided in their proximal part, and are terminated by a single rhomboidal apical pinnule. There is little evidence of marked differentiation in development of the secondary pinnae, such as is seen on the outward-facing side of the primary racheis, but when they start to become bipinnate (some 20 cm from the base of the specimen), alternate secondary pinnae become shorter and less divided.

Another specimen with an apparently curved primary rachis is shown in Figs 3 and 27b. The primary rachis is *c.* 1·5 cm wide, tapering distally to 1·0 cm wide. Bipinnate

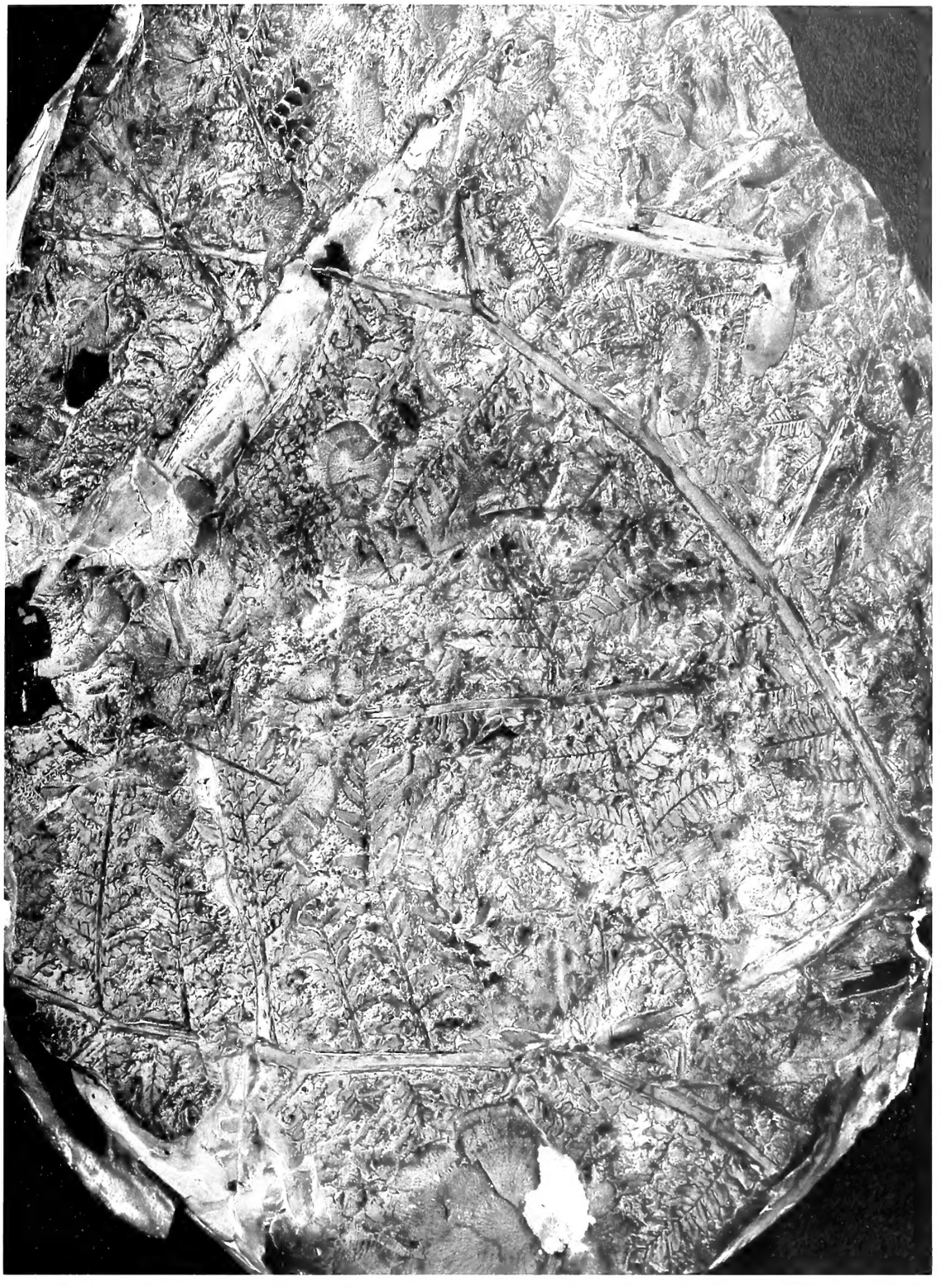


Fig. 1 *Neuropteris heterophylla*. Basal part of frond, showing dichotomy of primary rachis, photographed with crossed-polar filters. V.1797, × ⅓. See also Fig. 26.

secondary pinnae are attached at 60°–70° at *c.* 6 cm intervals on the right side of the specimen, but there is little evidence of secondary pinnae on the other side except for one short stump of secondary rachis. Short monopinnate pinnae are intercalated between the secondary pinnae, spaced at intervals of 1·5–2·0 cm. (In the middle of the specimen is a detached pinna of *Neuropteris semireticulata* Josten, unconnected with the *N. heterophylla* frond fragment.) If this was

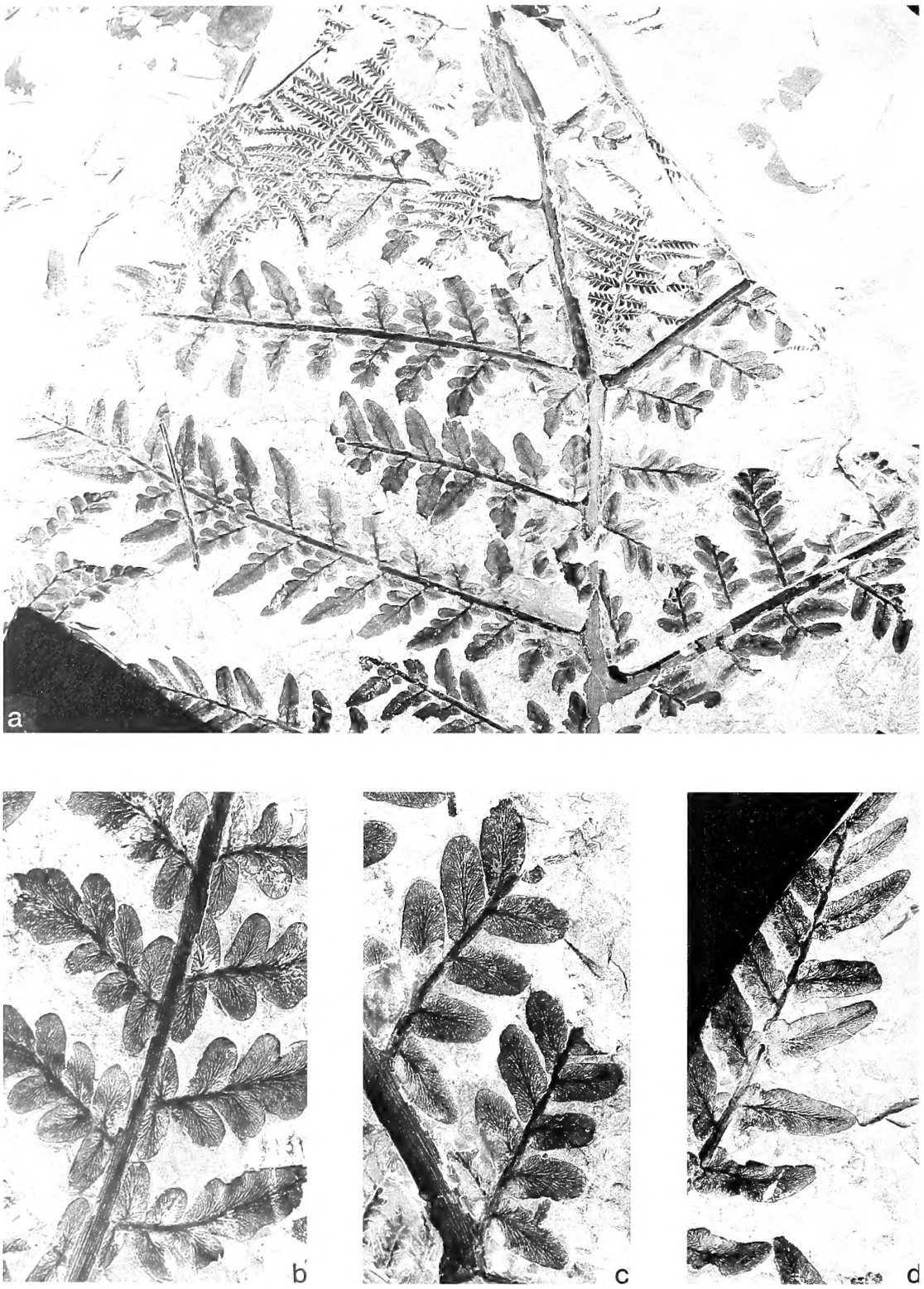


Fig. 2 *Neuropteris heterophylla*, photographed with crossed-polar filters. Fig. 2a, primary rachis immediately above the dichotomy near base of frond. (The pinna fragment shown at the top is of the fern *Senftenbergia plumosa* (Artis) Zeiller.) V.1872, × ⅔. Figs 2b–d, details of Fig. 2a showing range of form of lateral pinnules, × 1. See also Fig. 27a.

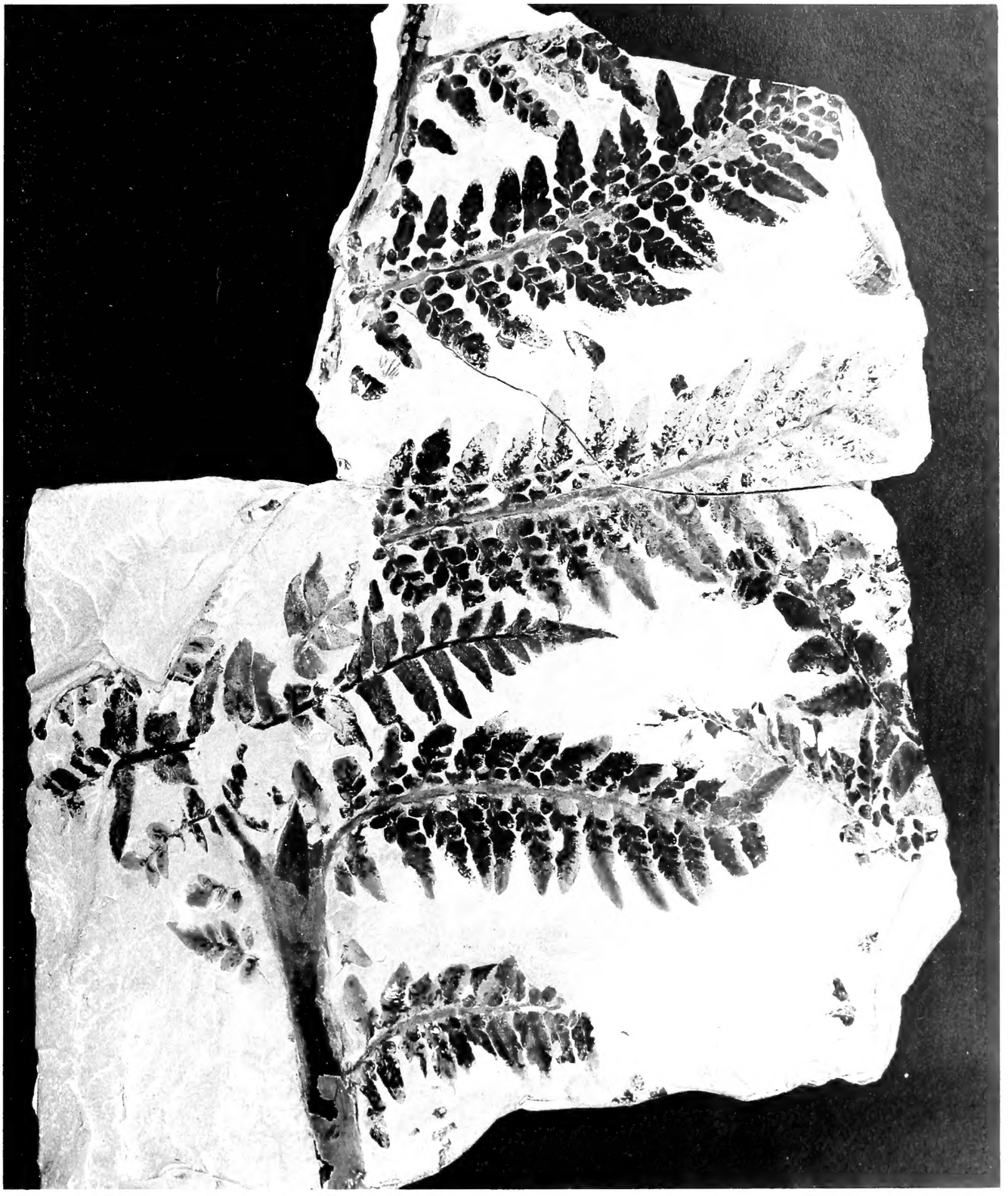
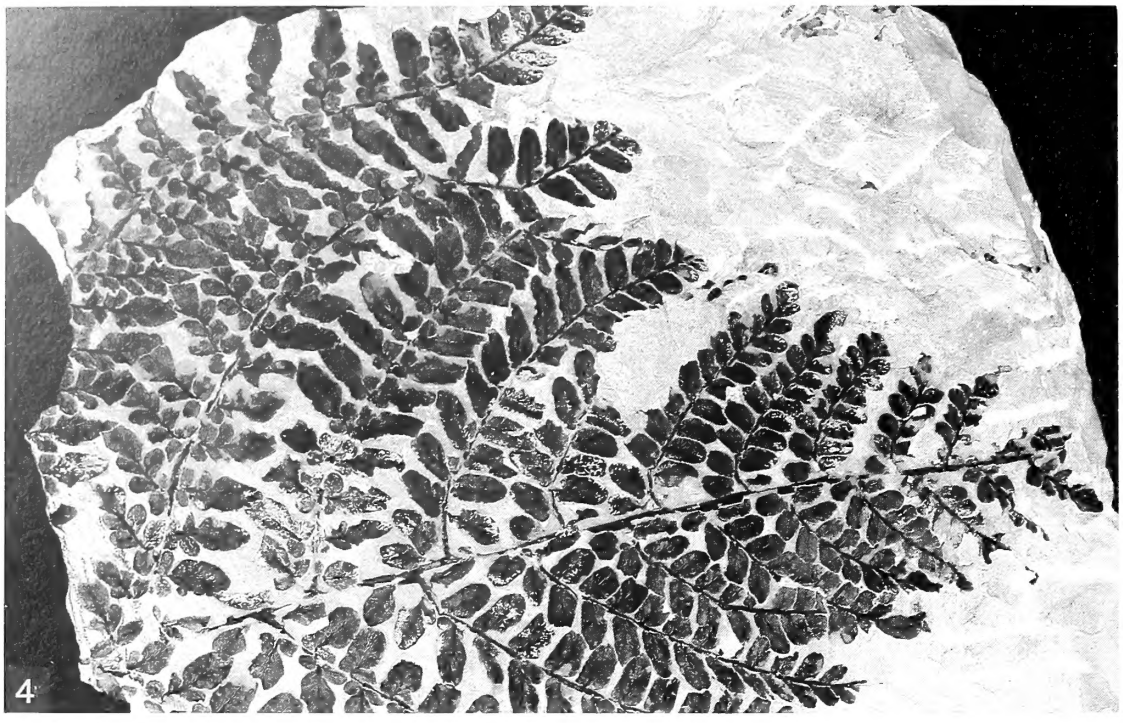
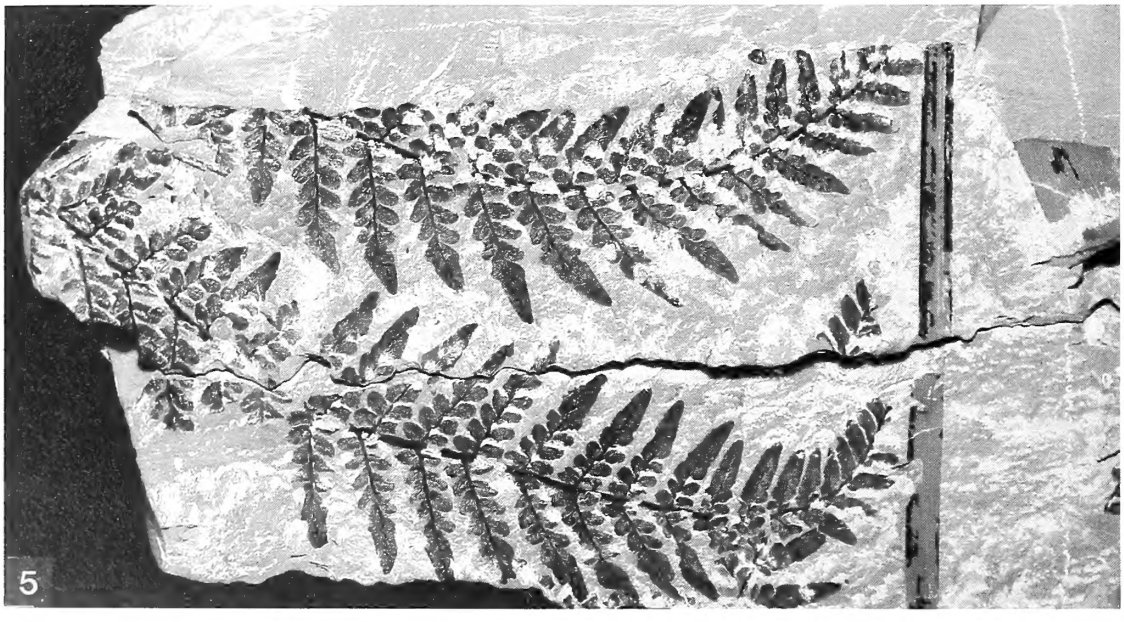


Fig. 3 *Neuropteris heterophylla*. Primary rachis probably just above dichotomy near base of frond, together with a detached fragment of a *N. semireticulata* Josten pinna, photographed with crossed-polar filters. V.63152, × ⅔. See also Fig. 27b.





Figs 4, 5 *Neuropteris heterophylla*, photographed with crossed-polar filters. Fig. 4, distal part of primary pinna branch. V.1867, × ⅔. See also Fig. 28c. Fig. 5, two bipinnate pinnae. V.1871, × ⅔. See also Fig. 28e.

part of a primary rachis from just above the main dichotomy, the greater width of the rachis and spacing of the secondary racheis suggest that it must have originated from a significantly larger frond than the specimens in Figs 1 and 2.

Distal frond fragments (Figs 4, 6–8, 28). These are distal segments of tripinnate pinnae, which are markedly asymmetrical about the primary rachis. The secondary pinnae on one side of the primary rachis are both longer and more pinnately divided than on the other. It is probable that the longer and more divided secondary pinnae were facing outwards from the frond, in which case Figs 4, 6 and 7 show left-hand primary pinna branches, and Fig. 8 a right-hand primary pinna branch. The primary rachis in most of the specimens is more or less straight, except that in Fig. 8, where curvature is accompanied by apparent distortion of the secondary pinnae, and may thus be a taphonomic effect. The widest primary racheis in these distal primary pinna fragments are 6 mm wide (Figs 6–7), and thus overlap with the width of the most distal preserved part of the primary pinnae in Fig. 1.

Fig. 6 *Neuropteris heterophylla.* Near distal part of primary pinna, photographed with crossed-polar filters. V.1868, × ⅔. See also Fig. 28b.

Secondary pinnae are attached at 60°–90° (most usually *c.* 70°) on either side of the primary rachis. They are parallel-sided for much of their length, but are gently tapered in their distal part and terminated by a small, rhomboidal apical pinnule, *c.* 1 cm long. The secondary racheis are 0·5–3 mm wide. In the distal part of the frond the secondary pinnae are monopinnate and oppositely arranged at intervals of 1–3 cm; lower in the frond they become bipinnate and alternately arranged at intervals of up to 5 cm. Where the secondary pinnae are bipinnate, one or two short, monopinnate pinnae are intercalated on the primary rachis between them. They are up to 2 cm long with a rhomboidal apical pinnule, and are spaced at intervals of *c.* 1 cm.

Tertiary pinnae are attached to the secondary racheis at 80°–90°, except near the secondary pinna apex where they are more oblique (*c.* 60°). They are spaced at intervals of 0·4 cm for the shorter pinnae, increasing to 0·8 cm in the longest preserved pinnae, and are oppositely or sub-oppositely

Fig. 7 *Neuropteris heterophylla*. Distal part of primary pinna, photographed with crossed-polar filters. V.2727, × ⅔. See also Fig. 28a.

arranged. They are parallel-sided for most of their length, and terminated by a single, rhomboidal apical pinnule, *c.* 1 cm long.

Pinnule morphology

Typical pinnules are shown in Figs 2b–d. They vary from 3 to 15 mm long and are 3–6 mm wide. The smallest pinnules are round to oval, about as broad as long; but the larger ones are more elongate, parallel-sided to linguaeform with a round apex. The longest pinnules are sometimes subtriangular with a bluntly acuminate apex. An acroscopic and sometimes a basiscopic swelling occurs near the base of the larger pinnules. In the largest pinnules the former becomes more prominent, until it eventually develops into a discrete, subsidiary order pinnule. Except near the pinna apex, the

Fig. 8 *Neuropteris heterophylla.* Distal part of primary pinna, photographed with crossed-polar filters. V.63153, × ⅔. See also Fig. 28d.

pinnules are at least partially constricted at the base. The degree of constriction is often more pronounced on the acroscopic side, with the pinnule being partially fused to the rachis on the basiscopic side. Only the largest pinnules tend to be equally constricted on both acroscopic and basiscopic sides. The angle of attachment of the pinnules to the rachis is usually 70°–80°. High in the pinna it sometimes appears to be as low as 60°, but this may be due to taphonomic distortion.

In the smallest pinnules there is little or no evidence of a midvein. In most pinnules, however, a thin midvein arises from the rachis at a low angle on the basiscopic side of the pinnule. It then curves and lies along the long axis of the pinnule. In most pinnules, the midvein is restricted to the

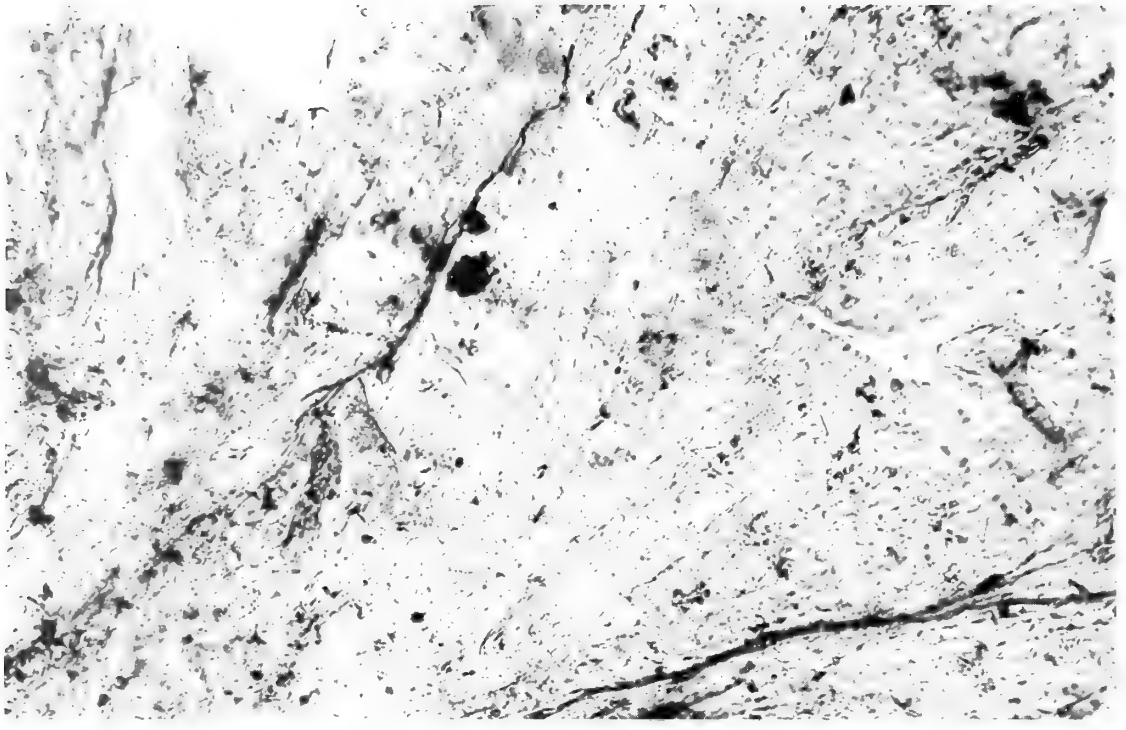


Fig. 9 *Neuropteris heterophylla*. Cuticle from adaxial surface of pinnule showing differentiation of cells in costal and intercostal fields, photographed using bright field illumination. V.2727$1, × 125.

lower half of the pinnule, but in the largest forms it may extend for up to two-thirds of the pinnule length. This decurrent midvein is never very pronounced, being only slightly wider than the lateral veins.

Lateral veins occur alternately on either side of the midvein, attached at intervals of 0·5–1·0 mm. They initially lie at a low angle to the midvein, extend for a short distance in an approximately straight line, and then arch to meet the pinnule margin at 80°–90°. They may branch up to four times, depending on the width of the pinnule. The angle of branching is usually 20°–30°, which often gives the veining a somewhat flexuous appearance. The vein density along the pinnule margin may vary from 40 to 55 per cm, but is usually between 48 and 52 per cm.

Cuticles

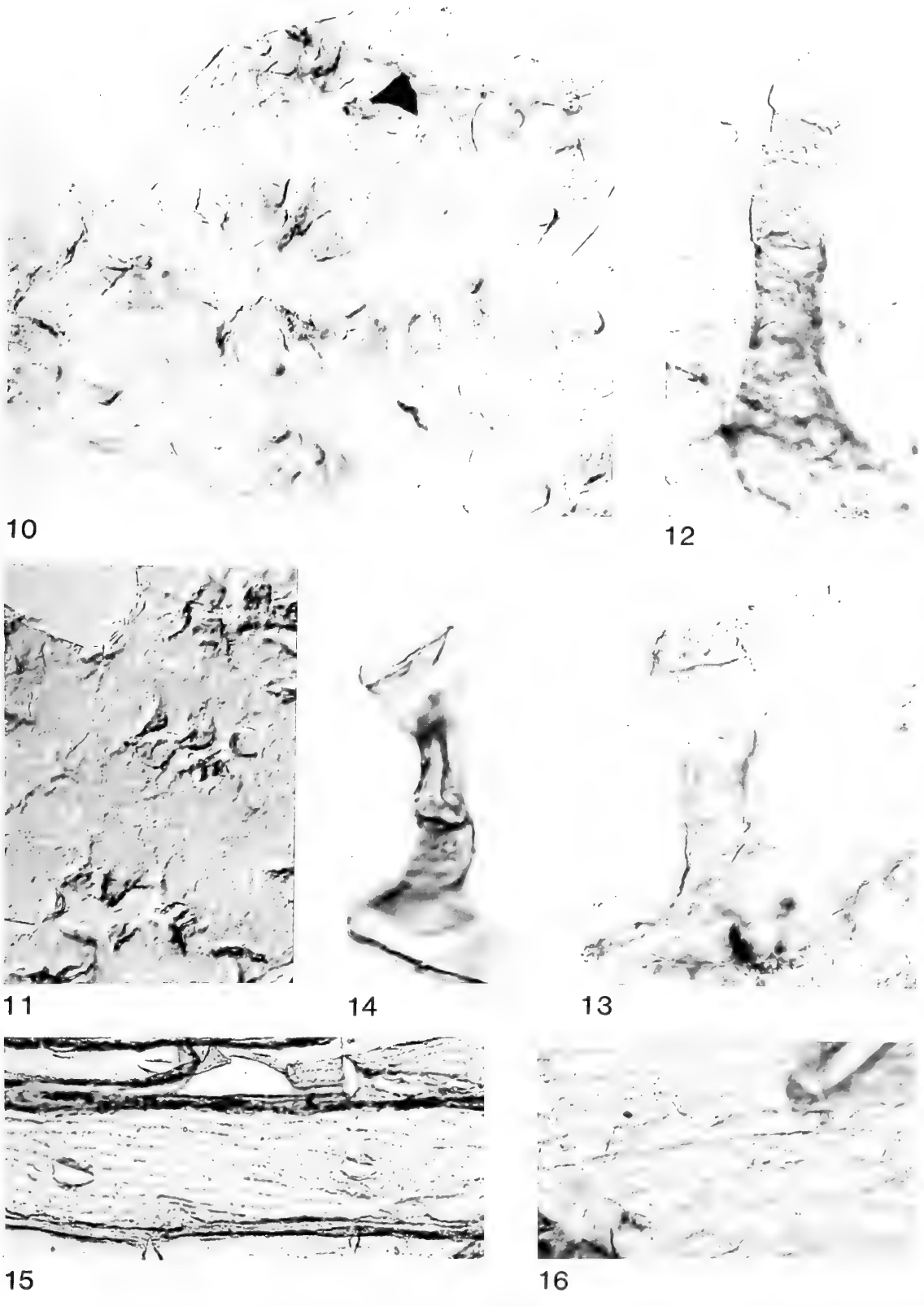
The adaxial cuticles from the pinnules appear robust, but have weakly developed intercellular flanges (Fig. 9). There is some differentiation in cell structure in the costal and intercostal fields. In the costal fields, the cells are elongate and subrhomboidal, up to 150 μm long × 20 μm wide (Fig. 17). Their long axes are aligned approximately parallel to the veins. In the intercostal fields the intercellular flanges are very weak, but there is a faint impression of shorter and more irregularly polygonal cells, up to 50 μm long × 20 μm wide (Fig. 18). Again, their long axes are aligned more or less parallel to the veins.

The abaxial cuticles are significantly thinner, and only small fragments could be prepared. Intercellular flanges, although not prominently developed, are clearly visible. Costal cells are elongate, parallel-sided and approximately 15 μm wide. It was impossible to determine their length. The intercostal cells are irregularly polygonal, 40–60 μm long and 12–18 μm wide, with their long axes aligned parallel to the nervation (Figs 10 and 20).

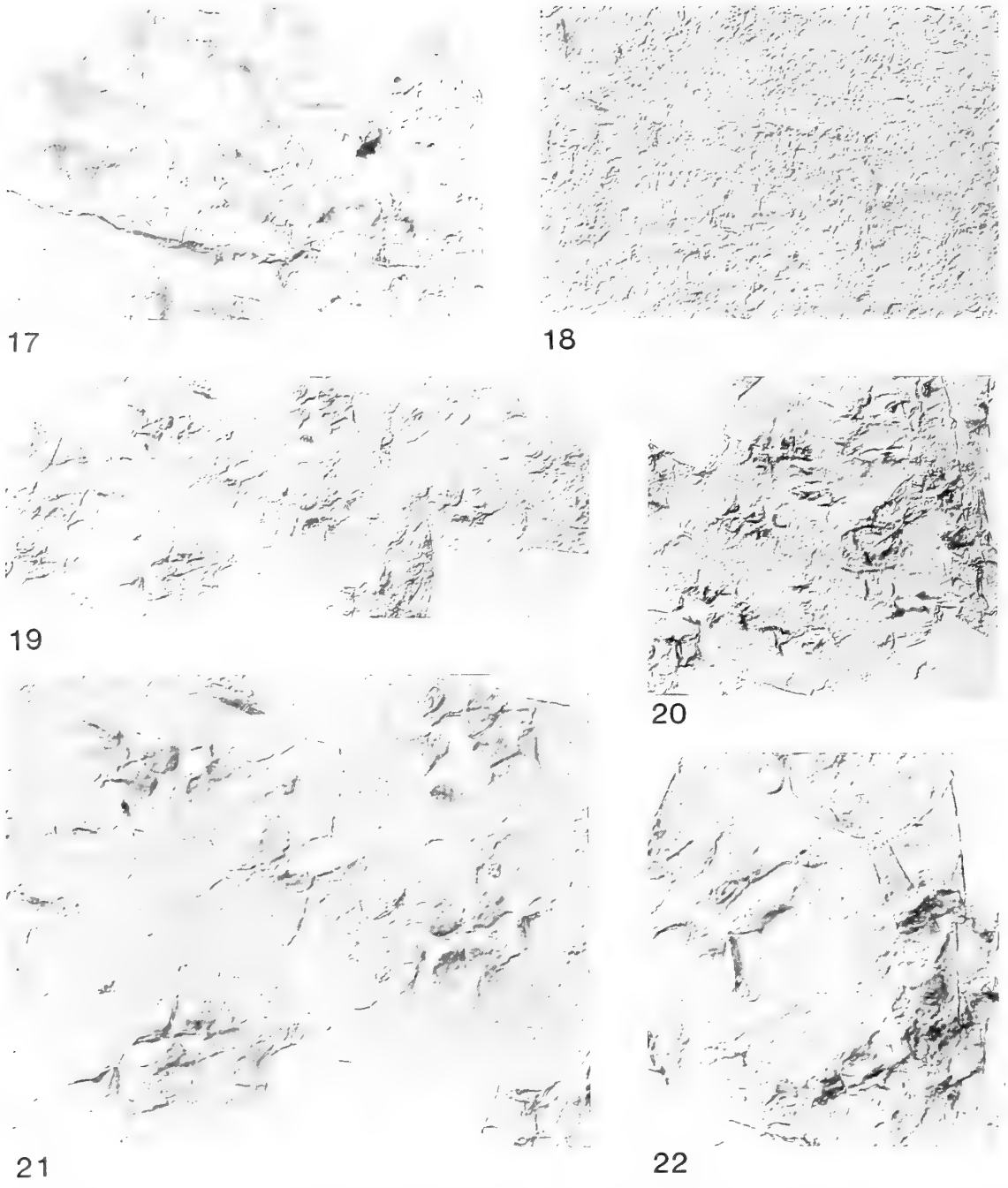
Stomata are restricted to the intercostal fields of the abaxial surface (Figs 10–11 and 19–22). They are anomocytic, with their polar axes approximately parallel to the veins. Their guard cells are 20–25 μm long and 5 μm wide. They do not seem to be significantly sunken.

Papillae occur in the costal fields of the abaxial epidermis (Fig. 10). They are 30–40 μm wide at their base and 25–35 μm high. Smaller papillae, 15–25 μm wide at their base and 10–20 μm high, also occur in the intercostal fields of the abaxial epidermis (Figs 19–20). They are less densely distributed than in the costal fields, and are mainly on the stomatal neighbour cells, where they appear to over-arch the guard cells (Figs 10–11 and 21–22).

Multicellular trichomes are also restricted to the abaxial epidermis, occurring mainly in the intercostal fields (Figs 12–14 and 23). They are 25–30 μm in diameter at their base, tapering to 20 μm. They consist of a uniseriate string of cells 25–35 μm long, and there is a slight constriction of the trichome at the junction of each cell (Fig. 12). The longest preserved fragment is 130 μm long, but is clearly incomplete (Fig. 12). Other examples are only 100 μm long, but seem to be entire and terminated by a swollen cell 35 μm in diameter, resembling a glandular structure (Figs 13–14). When viewed by SEM, these terminal structures appear to have ruptured, and situated on and near the apex of the trichome is an amorphous mass (Fig. 23; see also Fig. 13 for a view using light microscopy). Similar amorphous masses observed on these cuticles using light microscopy could be seen to have taken the safranin dye, and are almost certainly organic in origin. Being consistently associated with the trichome apices, they are, in our view, probably the remains of exudate produced by the trichomes. However, the volume of this



Figs 10–16 *Neuropteris heterophylla*. Cuticles photographed using Normarski contrast (except Fig. 15). Figs 10–11, cuticles from abaxial surface of pinnule, showing papillate stomata, × 500. Fig. 10, V.1867$2. Fig. 11, V.1867$1. Figs 12–14, multicellular trichomes from abaxial surface of pinnule, × 500. Figs 12–13, V.63152$2. Fig. 14, V.2727$8. Fig. 15, cuticle from rachis, using bright field illumination. V.2727$8, × 125. Fig. 16, cuticle from rachis. V.2727$9, × 500.



Figs 17–22 *Neuropteris heterophylla*. Cuticles photographed using Normarski contrast. Fig. 17, cuticle from costal field on adaxial surface of pinnule. V.2727$1, × 250. Fig. 18, cuticle from intercostal field on adaxial surface of pinnule. V.1867$1, × 250. Figs 19–20, cuticles from abaxial surface of pinnule, showing parallel alignment of stomatal polar axes. V.1867$1, × 250. Figs. 21–22, details of papillate stomata. V.1867$1, × 500.

exudate often seems larger than could be contained in just the apical cell (e.g. Fig. 23d). This suggests that either the entire trichome functioned as a gland, in which case the transverse cell walls must have broken down when the trichome had become fully developed; or the exudate originated from a superficial cell within the body of the pinnule, and was channelled through the trichome to its apex.

Associated miospores

Attached to many of the cuticles prepared during this study were numerous miospores, mostly *c.* 25 μm in diameter (Figs 24–25). Dr B. Owens has kindly examined SEM photographs of some of them and concluded that they are a mixed assemblage, dominated by ?*Lycospora*, ?*Densosporites* and ?*Granulatisporites*. These trilete form-genera are believed to have been mostly produced by lycophytes and ferns (Smith & Butterworth 1967) and are quite different from the monolete prepollen produced by most medullosans (Stidd 1981). The only possible medullosan male reproductive organ to produce trilete prepollen is *Potoniea* (Halle 1933, Florin 1937), which Millay & Taylor (1979) have interpreted as an early offshoot from the main medullosan stock (see also Stidd 1978, 1981). In

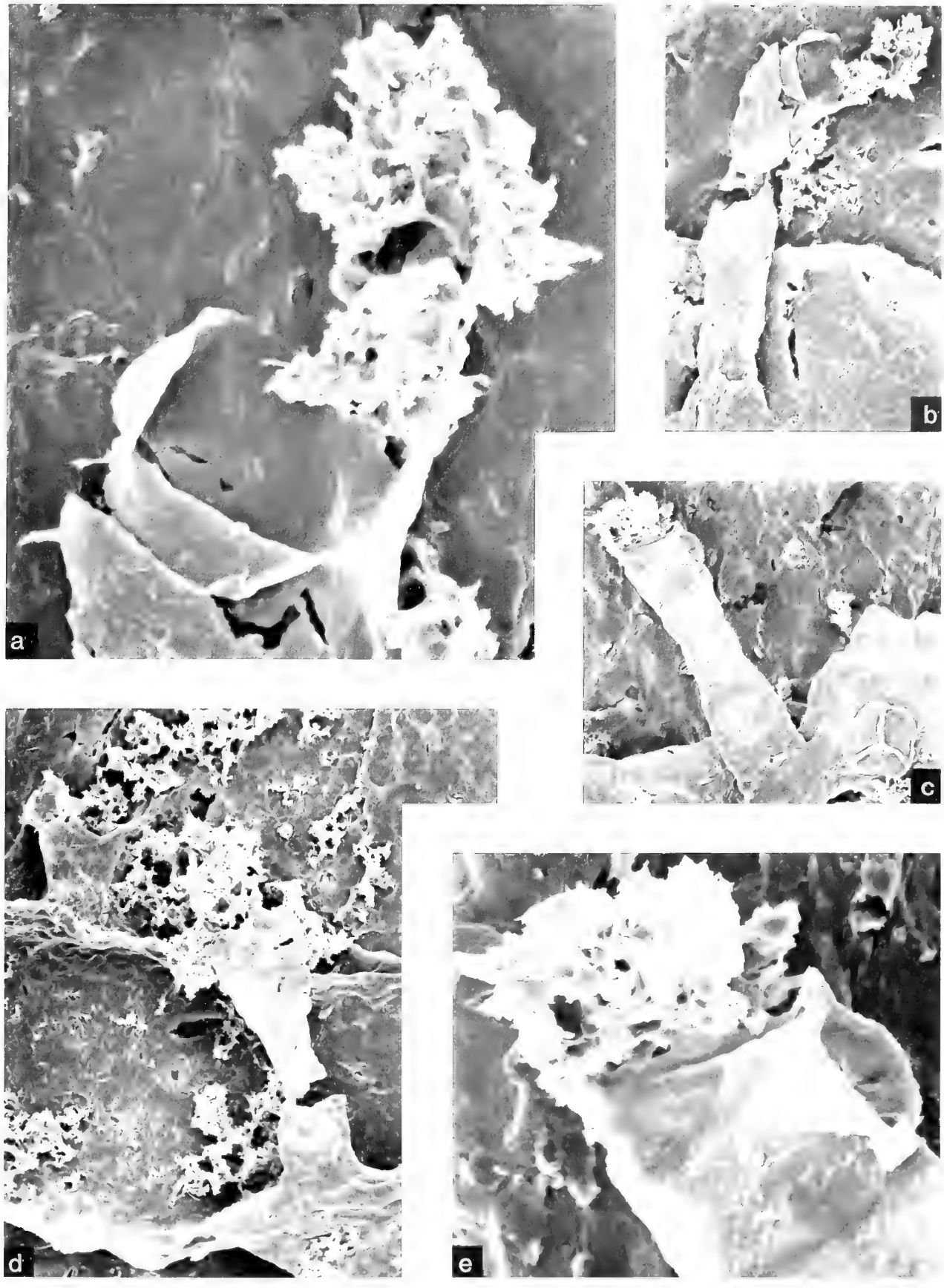


Fig. 23 *Neuropteris heterophylla*. Scanning electron micrographs of multicellular trichomes showing glandular tips with *in situ* exudate. V.2727\$11. Figs 23a and 23e, × 2000. Figs 23b–d, × 500.

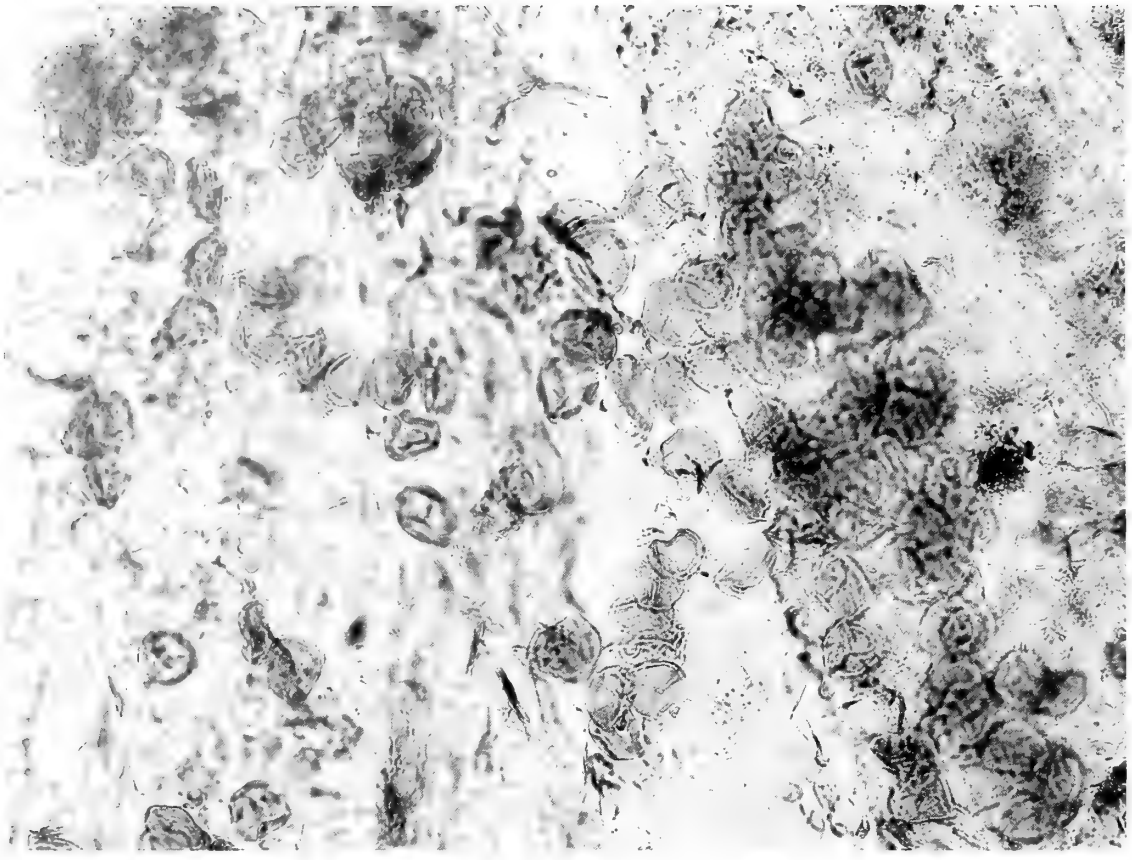


Fig. 24 *Neuropteris heterophylla*. Cuticle from abaxial surface of pinnule, photographed using bright field illumination, showing numerous spores attached. V.2727$2, × 250.

any case *Potoniea* prepollen is significantly larger (40–90 μm in diameter), has a less prominent tetrad mark than the miospores attached to our cuticles, and displays a distal sulcus. In our view, therefore, the miospores are unlikely to have anything to do with the plant which produced the *N. heterophylla* fronds. They probably only reflect the general spore/pollen rain in these lycophyte-dominated forests.

DISCUSSION

Reconstruction of frond

Based mainly on the specimens from Clay Cross described in this paper, we propose a reconstruction of the *N. heterophylla* frond, shown in Fig. 29. For convenience, the specimens have been reproduced at a unified scale as drawings (Figs 26–28), and the following discussion will refer to these rather than the photographs illustrated earlier in the paper. The reconstructed frond shows the following key features.

Dichotomy of primary rachis. This is particularly well seen in Fig. 26. The dichotomy is wide-angled and the resulting branches curve distally towards one another. It is also shown by the specimen figured by Brongniart (1831: pl. 71). Brongniart's drawing of this specimen suggests that the fork was a lateral branch, but Laveine's (1967: pl. A) photograph clearly shows that the right-hand side of the frond fragment is distorted. Taking this distortion into account, Brongniart's specimen shows the same pattern of branching as our Fig. 26, and differs only in having a narrower primary rachis and closer-spaced secondary pinnae (see comments below on estimated frond sizes).

Another, but less complete specimen figured by Laveine (1967: pl. M, fig. 1), part of which is also figured by Zeiller (1886: pl. 44), shows part of the frond just above the dichotomy. The two primary pinna branches lie at *c.* 80° to each other, although the dichotomy itself is not preserved.

Architecture below dichotomy. The specimen in Fig. 26 shows little of the frond below the dichotomy, but some evidence about this part of the frond is supplied by the specimen figured by Brongniart (1831: pl. 71). A 4-cm length of the main rachis below the dichotomy is preserved, and has monopinnate pinnae attached on either side. The only other specimen which probably shows this part of the frond is that illustrated by Crookall (1959: pl. 33, fig. 2), which has a rachis 0·9 cm wide, bearing short monopinnate pinnae. It compares favourably with the structure and dimensions of that part of the Brongniart (1831) specimen lying below the dichotomy, and it is difficult to see where else it could have occurred in the frond. The Crookall specimen is 13 cm long, and this is thus the minimum distance below the dichotomy that these monopinnate pinnae could have been attached.

There is no evidence of orbiculoid cyclopterid pinnules being attached to the primary rachis near the dichotomy, as in *Laveineopteris loshii* (Brongniart) Cleal *et al.* (von Roehl,

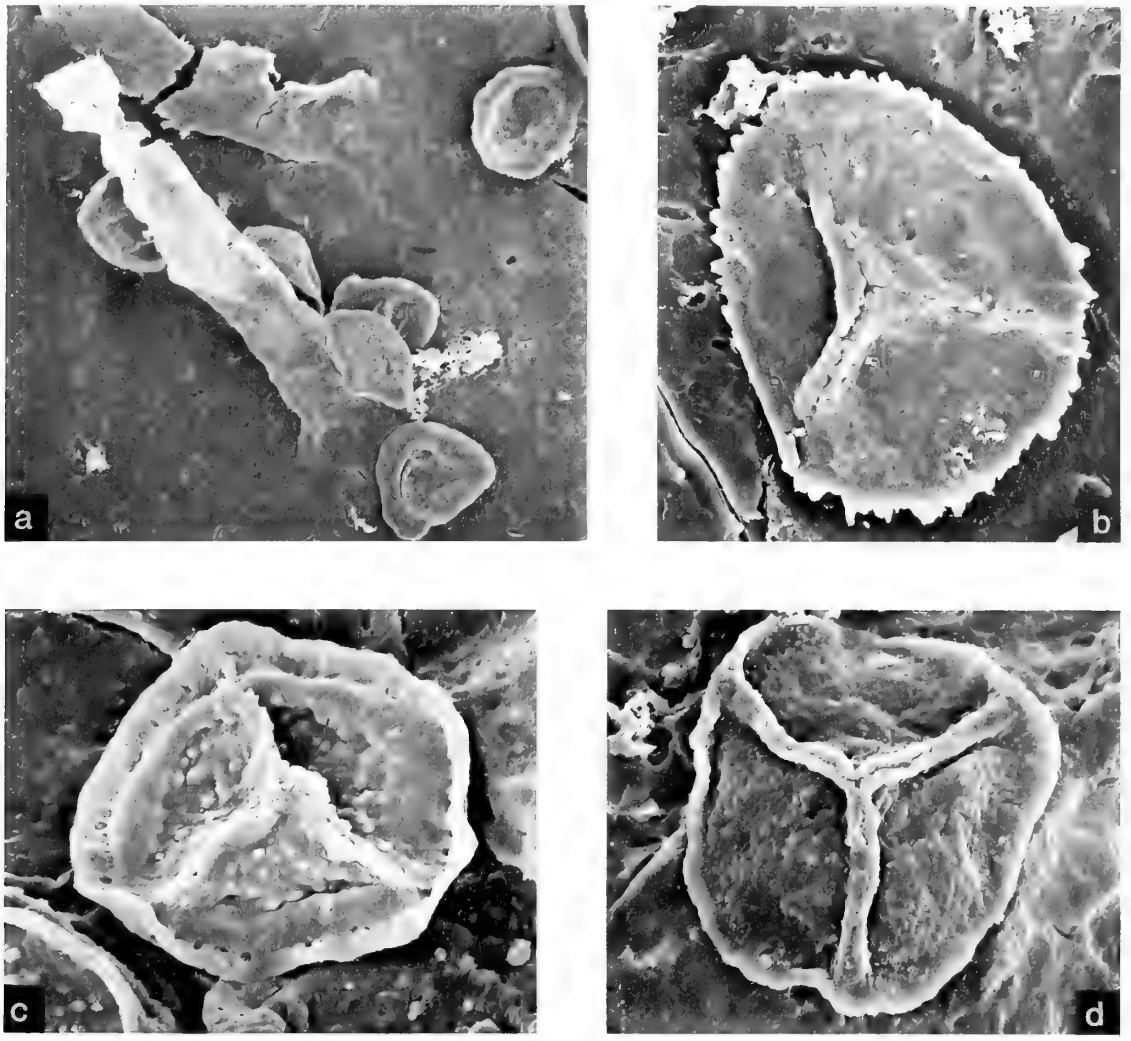


Fig. 25 *Neuropteris heterophylla.* Scanning electron micrographs of spores attached to cuticle from abaxial surface of pinnule, V.2727$11. Fig. 25a, cluster of spores near base of multicellular trichome, × 500. Fig. 25b, unidentified azonate spore with equatorial ornamentation. Fig. 25c, ?*Densosporites* sp. Fig. 25d, ?*Granulatisporites* sp. Figs 25b–d, × 2000.

1868: pl. 17), *Laveineopteris rarinervis* (Bunbury) Cleal *et al.* (Carpentier, 1930: pl. 8; Gothan, 1953: text-fig. 8; Laveine, 1967: pl. 41, fig. 3; pl. 45, fig. 3; pl. O, fig. 1). The specimen identified as *N. heterophylla* with possible cyclopterids attached (Gothan, 1953: text-fig. 6) has been re-identified as *L. loshii* by Laveine (1967). The architecture seen in *N. heterophylla* is nearer to that of *N. obliqua* (Gothan, 1953: text-fig. 7) and *N. ovata* Hoffmann (Zodrow & Cleal 1988). Neither V.1797 nor the specimen figured by Brongniart (1831: pl. 71) show any evidence of the type of enlarged pinnules present in the lower part of the *N. ovata* and *N. obliqua* fronds (sometimes referred to as forma *impar* pinnules). However, the specimen of *N. heterophylla* illustrated by Laveine (1967: pls 11–12), which is probably part of a left-hand primary pinna just above the basal dichotomy, seems to have large, subtriangular pinnules, similar in shape to the forma *impar* pinnules from the base of the *N. obliqua* fronds.

Primary pinna branches immediately above dichotomy. A distinctive feature of *N. heterophylla* is the way that the primary pinna branches compensate for the reduced space available on their inward-facing side, due to the curvature of the primary rachis. It is achieved by the secondary pinnae being alternately long and short along that part of the primary rachis showing maximum curvature. It has not been demonstrated in any other neuropteroid species, nor in related fronds such as *Odontopteris* (Zeiller 1906) or *Callipteridium* (Wendel 1980). It can be clearly seen in Figs 26 and 27a.

Primary pinna terminals. These are well shown in Figs 28a–d. Another example was figured by Zeiller (1879: pl. 164, fig. 1; refigured by Zeiller, 1886: pl. 43, fig. 1). They become tripinnate at only a short distance from the pinna apex, and are normally distinctly asymmetrical about the primary rachis. This asymmetry is almost certainly a continuation of the asymmetry of the lower part of the primary pinna, with the side with the longer secondary pinnae facing outwards from the frond.

The small specimen shown in Fig. 28e may also have come from near a primary pinna terminal. However, bipinnate pinnae are also known attached to the inward-facing side of the primary pinna, lower in the frond (e.g. *c.* 40 cm above the dichotomy in Fig. 26). Since only two pinnae are shown in

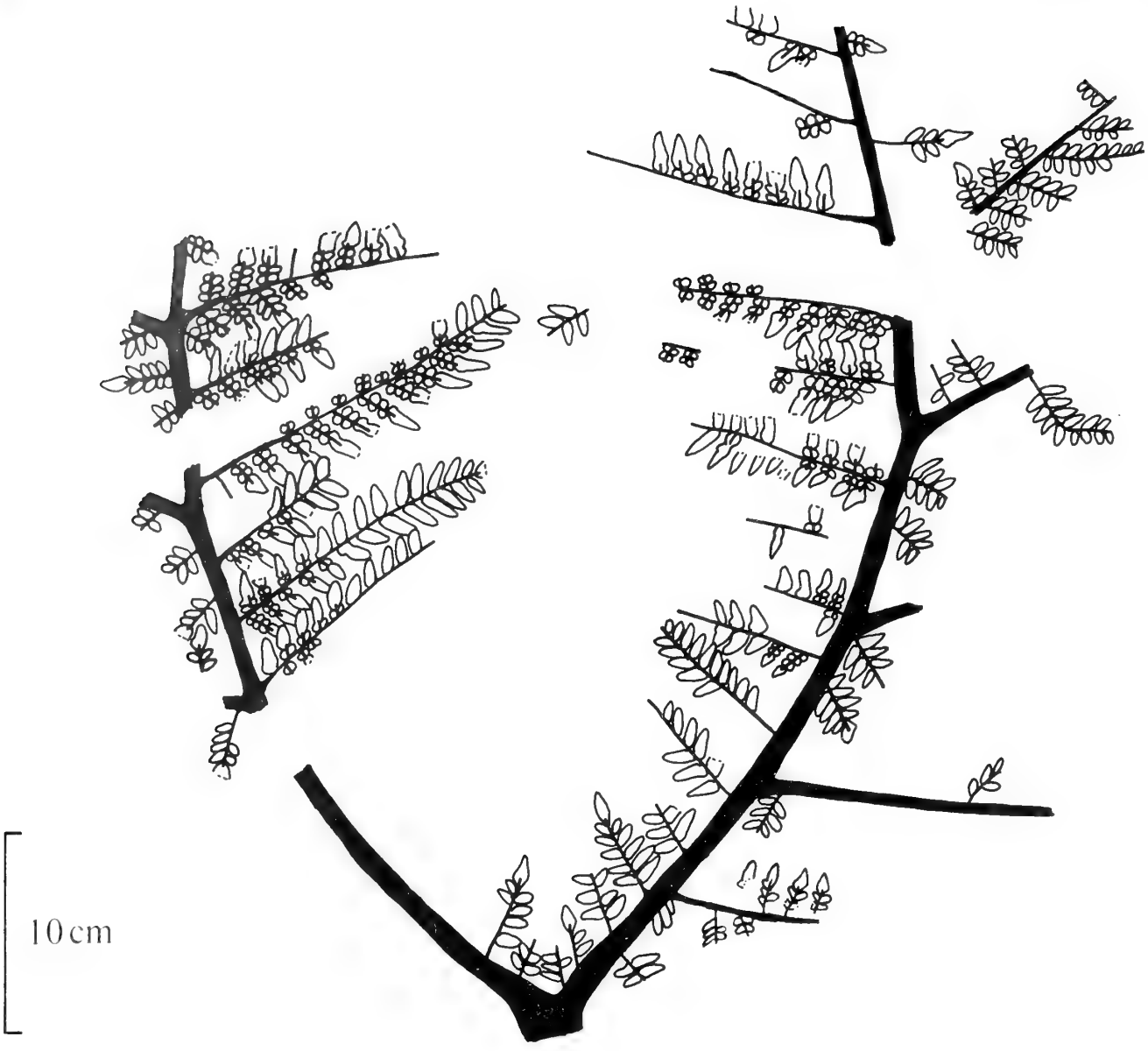


Fig. 26 *Neuropteris heterophylla*. Drawing of specimen shown in Fig. 1, showing dichotomy of primary rachis near the base of the frond. V.1797, × 0.3.

Fig. 28e, it is impossible to determine whether they are alternating long and short, as is characteristic of the lower part of the frond. This demonstrates the difficulty of positioning such small specimens within so complex a structure as the *N. heterophylla* frond.

Size and degree of pinnation of secondary pinnae. No complete secondary pinnae have been found attached to the outward-facing sides of the primary pinnae in the basal part of the frond. The longest known examples are 13 cm long (Fig. 26; see also Laveine, 1967: pl. 11, fig. 1), but are clearly very incomplete. The longest detached example is probably that shown in Crookall (1959: pl. 25, figs 1–2). It is a 17-cm long near terminal fragment of a bipinnate pinna. It is more or less symmetrical about the penultimate rachis, and is thus quite different from the asymmetrical terminals of the primary pinnae (discussed above). In nearly all of the known specimens, these outward-facing secondary pinnae are bipinnate. Just one (Laveine, 1967: pls 11–12) shows a tendency to become tripinnate.

Size of frond. None of the specimens described in this study, or documented in the literature, are complete enough to give a very reliable estimate of the overall size of the frond. However, using the largest available specimen (Fig. 26) it is possible to assess the approximate distance from the dichotomy to the frond apex (hereafter referred to as the DAD). Assuming that the two primary pinna branches, which curve distally in towards one another, did not overlap significantly at the frond apex, then the DAD in this frond was about 1 m. Using this as a base-line, it is possible to estimate the DAD of fronds in other, less complete specimens, using the assumption that frond size is broadly correlated with primary rachis width (PRW) and the spacing

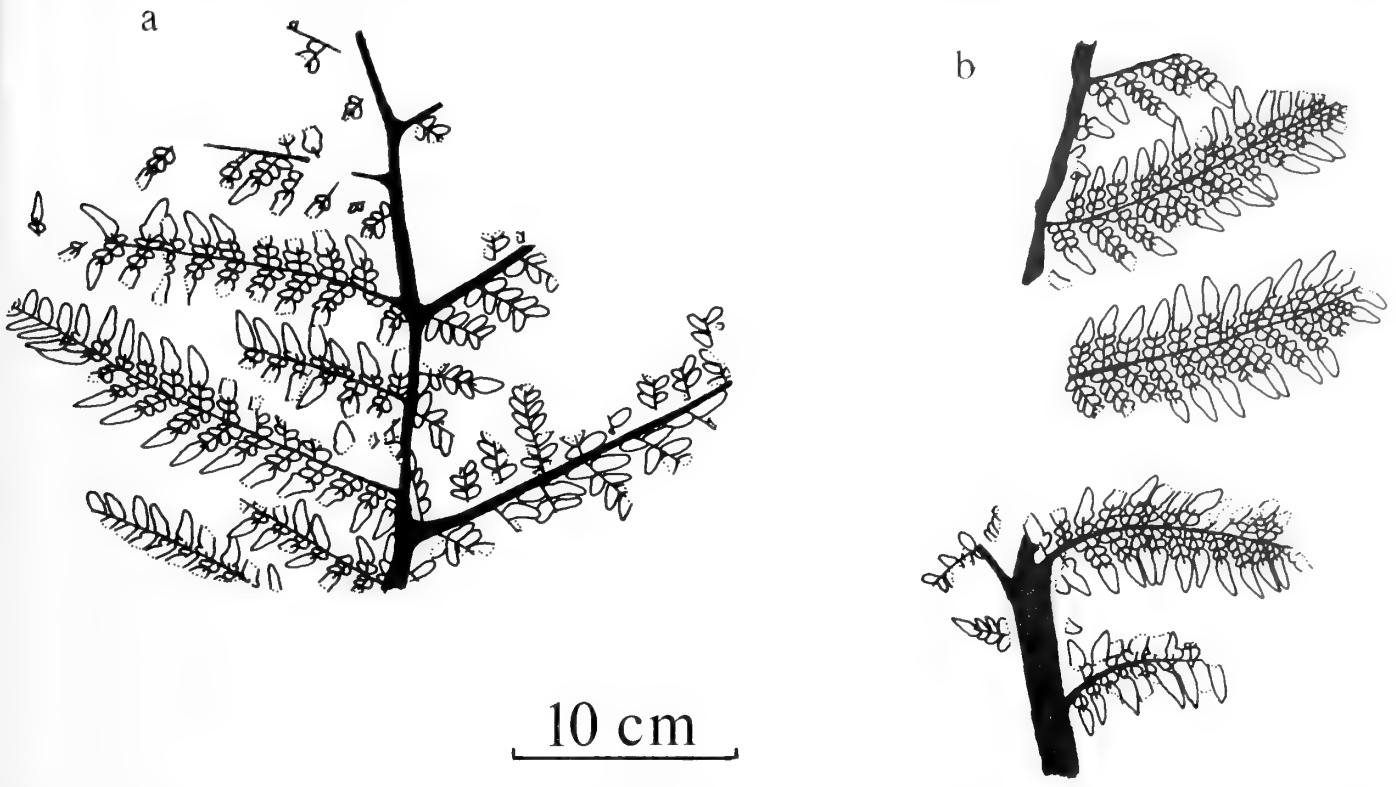


Fig. 27 *Neuropteris heterophylla.* Drawings of specimens shown in Figs 2–3, showing parts of primary rachis near the main dichotomy of the frond. Fig. 27a, V.1872. Fig. 27b, V.63152. Both × 0.3.

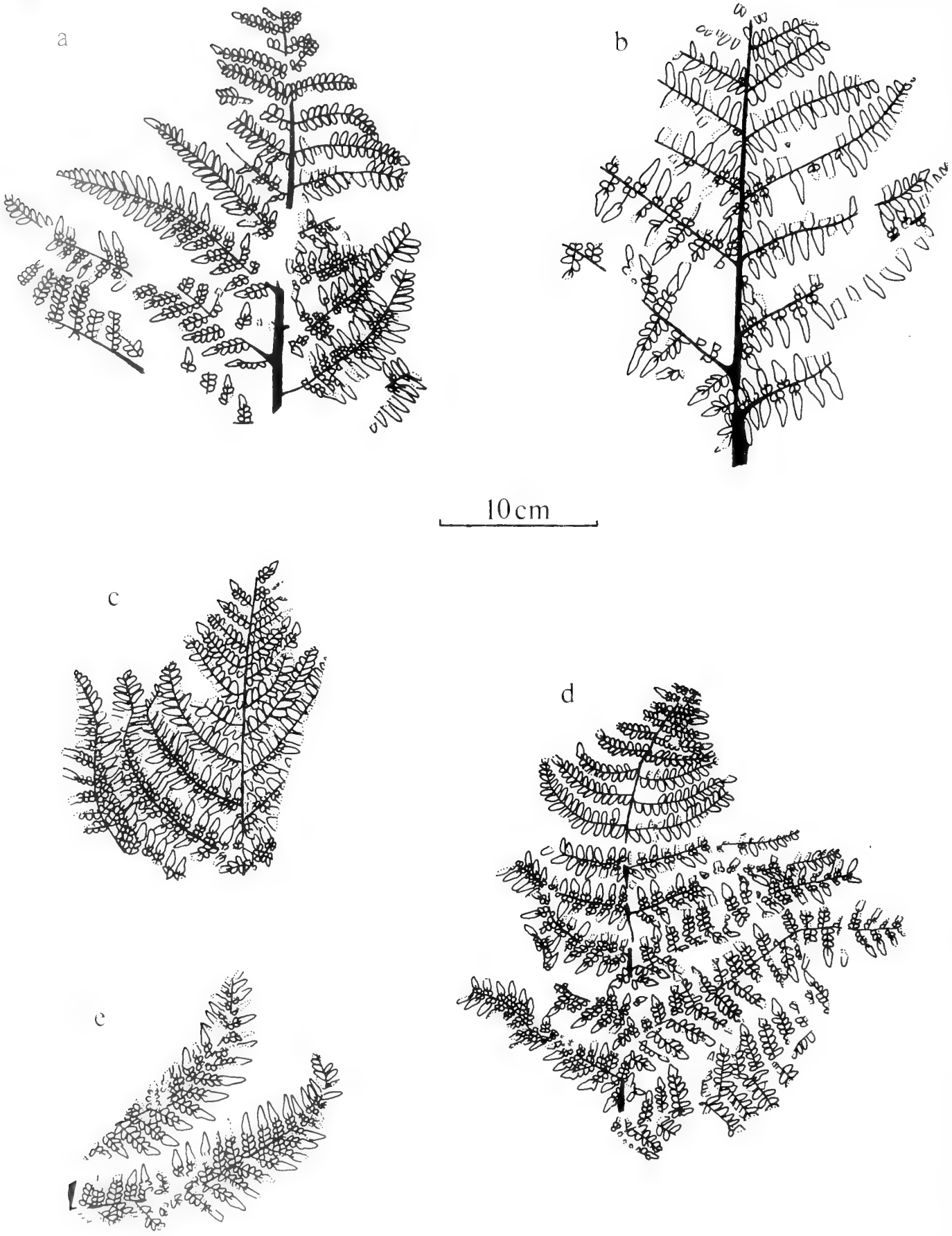
between secondary racheis (SRS) in comparable parts of the frond.

a. The smaller fragment shown in Fig. 27a has PRW and SRS dimensions comparable to a position about 35 cm above the dichotomy in Fig. 26. Consequently, it is also probably from a frond with a DAD of *c.* 1 m.
b. The specimen figured by Zeiller (1886: pl. 44) and Laveine (1967: pl. M, fig. 1) also has PRW and SAS dimensions similar to that in our Fig. 26. Its DAD is therefore again estimated to be *c.* 1 m.
c. The specimen figured by Brongniart (1831: pl. 71) has a PRW immediately below the dichotomy of 1·4 cm, and a SAS on the outward-facing side of the frond just above the dichotomy of 4–5 cm. These dimensions are about half those in Fig. 26, and so the DAD is estimated as *c.* 0·5 m.
d. Fig. 27b shows a curved primary rachis with a PRW 1·5–1·0 cm and a SAS of *c.* 6 cm. If this was the proximal part of a primary pinna branch, then the PRW is approximately twice that in Fig. 26, and consequently the DAD would be *c.* 2 m. It is true that Fig. 27b does not show the alternating long and short secondary pinnae normally characterizing the proximal part of the frond, but this may simply be because the secondary pinnae were more widely spaced, reducing the competition for space in this part of the frond. The only alternative position for such a specimen would be below the dichotomy, but the marked tapering of the primary rachis, and the presence of bipinnate secondary pinnae (only monopinnate secondaries have been otherwise found in this part of the frond) tend to argue against this.

From the above evidence, it appears that the DAD of the fronds was normally 0·5–1·0 metres, possibly sometimes reaching 2·0 metres. To translate this into an estimate of the total length of the foliage-bearing part of the frond, it would be necessary to know how far the foliage extended below the dichotomy. There is little unequivocal evidence on this. The specimen figured by Brongniart (1831: pl. 71) shows 4 cm of frond below the dichotomy. However, if the specimen figured by Crookall (1959: pl. 33, fig. 2) has been correctly interpreted as part of a primary rachis below the dichotomy (see p. 166), then there was at least 13 cm of foliage below the dichotomy in a small frond. This suggests that there may have been at least 30 cm of foliage below the dichotomy in one of the fronds with a DAD of 1 metre, and perhaps 60 cm or more in the largest fronds. Combining this evidence, we suggest that the overall length of the foliage-bearing part of the frond may have varied from 0·7 m to 2·6 m, the most commonly found probably being about 1·3 m long. There is no evidence available as to the length of the petioles, and so it is impossible to estimate the complete length of the frond, from its point of attachment to the stem to the apex.

No complete outward-facing secondary pinnae are preserved, so the width of the frond cannot be determined. Fig. 26 shows a width of 0·6 m, but the secondary pinnae are clearly very incomplete, and the total frond width may have been 1·0 m or more. If this estimate is correct, then that part of the frond lying above the primary pinna dichotomy must have been as wide as it was long.

General comments on frond architecture. The type of bipartite frond reconstructed in Fig. 29 broadly reflects the


a
b
10 cm
c
d
e

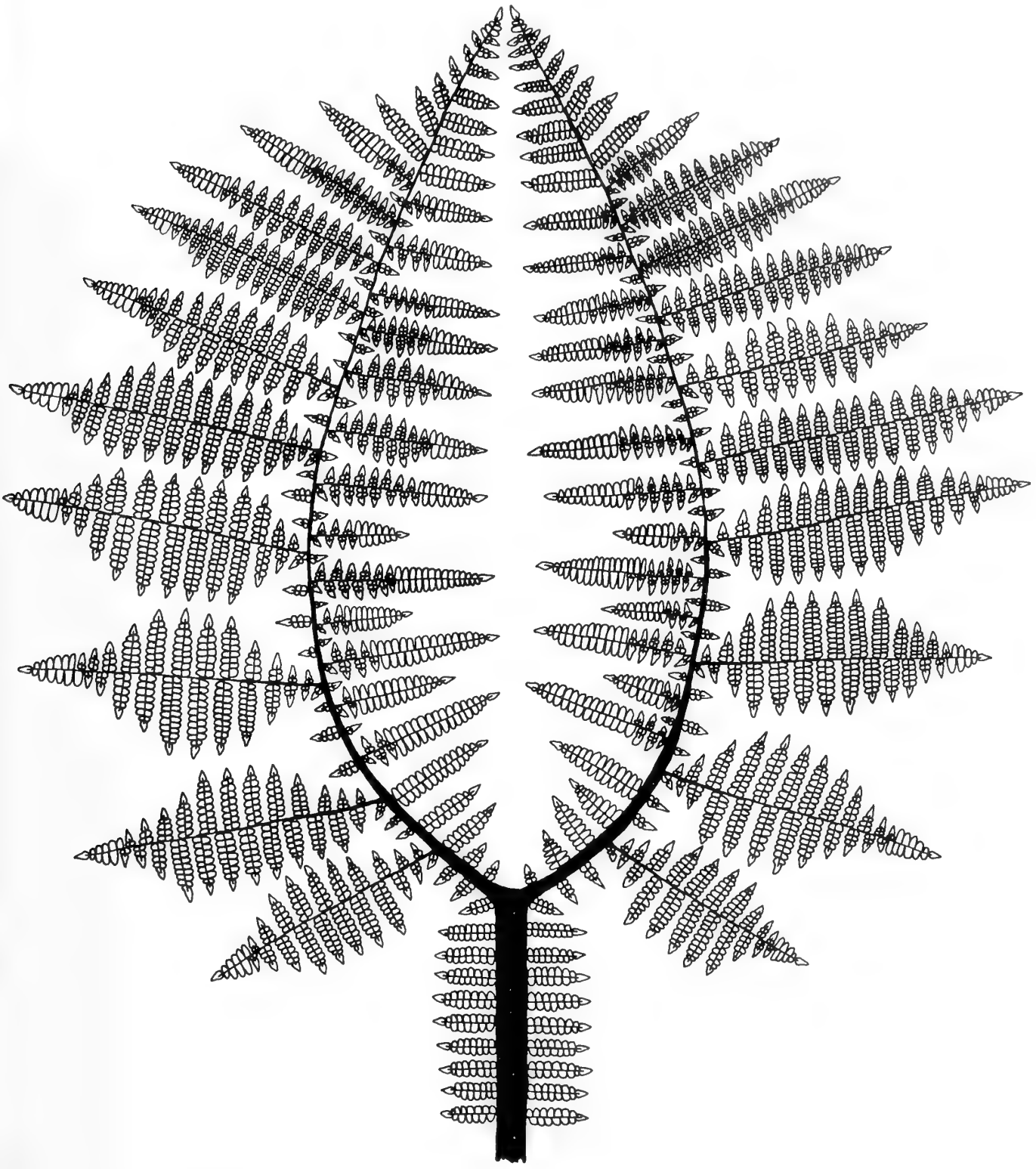


Fig. 29 *Neuropteris heterophylla.* Proposed reconstruction of average-sized frond. About one seventh natural size.

Fig. 28 *Neuropteris heterophylla.* Drawings of specimens shown in Figs 4–8, showing near terminal parts of primary pinnae. Fig. 28a, V.2727. Fig. 28b, V.1868. Fig. 28c, V.1867. Fig. 28d, V.63153. Fig. 28e, V.1871. All × 0.3.

structure envisaged by Gothan (1941) for *Neuropteris* (syn. *Imparipteris*), except for the absence of orbicular cyclopterid pinnules at the base. Although varying in detail, such a bipartite structure is extremely common in Palaeozoic pteridosperm fronds, occurring in the Calamopityales, Callistophytales and Lyginopteridales, as well as the Trigonocarpales (Daber 1980, Gastaldo 1988); only the Peltaspermales fronds are normally characterized by exclusively pinnate branching (Kerp 1986). It thus occurs in both classes of Palaeozoic pteridosperms (the Ginkgoopsida and Cycadopsida *sensu* Meyen, 1987), which are believed to have evolved independently from the progymnosperms. Consequently, the bipartite frond structure also probably developed independently in the two classes. Its function is at present unclear, but may have maximized the width of each frond without developing excessively long racheis, particularly those of the second order. For structural reasons, the longer a rachis becomes, the wider it must be, particularly in its proximal part. Since the racheis probably had no photosynthetic function (they show no evidence of stomata), minimizing the rachis:lamina bulk ratio would help increase the efficiency of the frond as a whole.

Significance of epidermal structures

Based mainly on cuticle evidence, Cleal & Zodrow (1989) divided *Neuropteris* into four main groups. Elucidating the epidermal structure of *N. heterophylla* has had important consequences for the nomenclature of this group of foliage, since it has allowed the four groups to be made the basis of a formal taxonomy. Full details of the revised nomenclature are presented by Cleal *et al.* (1990), but the results may be summarized as follows.

Group 1 = *Laveineopteris* Cleal, Shute & Zodrow 1990
Group 2 = *Neuropteris* (Brongniart) Sternberg *emend.* Cleal, Shute & Zodrow 1990
Group 3 = *Macroneuropteris* Cleal, Shute & Zodrow 1990
Group 4 = *Neurocallipteris* Sterzel *emend.* Cleal, Shute & Zodrow 1990

From the preconceptions of earlier authors (e.g. Bertrand, 1930) *N. heterophylla* might be expected to fall into Group 1 of this classification (i.e. with *'N.' loshii, 'N.' tenuifolia* and *'N.' rarinervis*). However, the epidermal characters found in the present study place it clearly in Group 2 (i.e. with *N. ovata* and *N. flexuosa*). These are: the cell structure in the costal and intercostal fields are clearly differentiated on the adaxial surface; the stomata are anomocytic; cell structure is clearly visible on the abaxial cuticle; and there are both papillae and multicellular trichomes on the abaxial cuticle.

Although multicellular trichomes are present in other neuropteroid species (Barthel 1961, 1962, Cleal & Zodrow 1989), this is the only one reported to have glandular-tipped hairs. In some of the specimens, what appear to be the remains of the exudate produced by the glands are preserved. To the best of our knowledge, this is the oldest evidence of *in situ* exudate preserved in the fossil record. It seems to have been a sticky, resinous substance, which also covered at least part of the abaxial surface of the frond, causing numerous miospores to adhere to it. Whether this condition was the result of taphonomic breakdown of the glandular tips, causing the exudate to become spread over the frond surface, or whether the exudate covered the frond surface in life, is not clear. Its function is also not certain, although a protective role against herbivorous insect attack would seem possible. It has been noted elsewhere that there is little direct evidence of insect attack in medullosan foliage and that they must have had some defence against it (Cleal & Laveine 1988, Cleal & Zodrow 1989). The sticky exudate produced by the hairs of *N. heterophylla* could well have been a deterrent to such attack, although it seems strange that this is the only neuropterid known to adopt such a strategy. On the other hand, Beerbower *et al.* (1987) argued that herbivory was not a significant feeding mode for Carboniferous arthropods, in which case the exudate may have had an alternative, perhaps excretory function.

Taxonomy

Laveine (1967) has reported that the type specimen of *N. heterophylla* figured by Brongniart (1822) is lost. He therefore nominated a specimen figured by Brongniart (1831: pl. 71) as neotype, and illustrated a photograph of it.

In the absence of direct evidence of reproductive organs or stem/rachis anatomy, the taxonomic position of *N. heterophylla* can only be determined from circumstantial evidence. We have provisionally placed it in the pteridosperm order Trigonocarpales Meyen based on its similarity, in both frond architecture and epidermal structure, to *Neuropteris ovata*, which Beeler (1983) has reported attached to *Medullosa noei* Steidtmann stems. As with most species of trigonocarpalean foliage, the identification of *N. heterophylla* has traditionally depended on the shape and nervation of the pinnules, and we have been able to add little to the description of these features given by Laveine (1967). We have, however, been able to add details of its epidermal structure, which require the diagnosis to be enlarged. The taxonomy may be summarized as follows.

Division **PINOPHYTA** Meyen, 1987
Order **TRIGONOCARPALES** Meyen, 1987

Form-genus ***NEUROPTERIS*** (Brongniart) Sternberg *emend.* Cleal *et al.* 1990

Neuropteris heterophylla (Brongniart) Sternberg

1822 *Filicites (Nevropteris) heterophyllus* Brongniart: 239; pl. 2, fig. 6.
1825 *Neuropteris heterophylla* (Brongniart) Sternberg: xvi.
1967 *Neuropteris heterophylla* (Brongniart) Sternberg; Laveine: 140; pl. A; pl. B, fig. 1; pls 11–13 (q.v. for synonymy).
1990 *Neuropteris heterophylla* (Brongniart) Sternberg; Cleal *et al.*: 487.

DIAGNOSIS. Ultimate pinnae oval and imparipinnate. Pinnules oval, sometimes somewhat triangular, generally with round apex. Pinnule base cordiform in proximal part of pinna; towards pinna apex becoming attached to rachis by up to half of its catadromic side. Apical pinnules usually broad with round apex, and length:breadth ratio 1–2; on short pinnae, more elongate with an obtuse apex. Nervation dense. Midvein visible for about half of the pinnule length and rather strong at base. Thick, somewhat flexuous lateral veins arise from midvein at acute angles, dichotomize two to four times, and reach pinnule margin at oblique angles. Adaxial cuticle thicker than abaxial. Adaxial epidermal cells subrhomboidal, more elongate in costal fields. Papillae and

glandular multi-cellular trichomes abundant on abaxial epidermis. Stomata anomocytic, only on intercostal fields of abaxial epidermis; polar axes more or less parallel to veins.

Comparison with other species

Neuropteris heterophylla is most similar to *N. obliqua* (Brongniart) Zeiller and isolated fragments are easily confused. However, the former has rounder lateral pinnules, attached more narrowly to the rachis; and broader, more deltoid apical pinnules with a rounder apex. Also, it does not have the large subtriangular pinnules (known as forma *impar*) that characterize the basal part of the *N. obliqua* frond. The epidermal features of *N. obliqua* are at present unknown (cuticles identified as this species by Barthel, 1962, in fact belong to *Laveineopteris loshii* (Brongniart) Cleal *et al.* – see Laveine, 1967).

Also very similar is the holotype of *Neuropteris grangeri* Brongniart, which originated from the Pennsylvanian of Ohio, USA (Laveine 1967: pl. H, fig. 2). The American specimen has pinnules with a more obtuse apex than is typical for *N. heterophylla*, and lateral veins that meet the pinnule margin at a less oblique angle. However, not enough material has been described from the type area of *N. grangeri* to determine the range of its morphological variation, and so a full comparison with *N. heterophylla* is impossible.

Many of the European records of *N. grangeri* were transferred to *Neuropteris ghayei* Stockmans & Willière by Stockmans & Willière (*in* Pastiels & Willière, 1954). *N. ghayei* is very similar to *N. heterophylla*, but has rather larger, rounder, thicker-limbed pinnules. Furthermore, the midvein of *N. ghayei* is only well developed near the base of the pinnule and the lateral veins are more flexuous, sometimes pseudoanastomosed. It also tends to have more tapered ultimate pinnae. The epidermal structure of *N. ghayei* is unknown.

It can be difficult to distinguish the smaller pinnules of *N. heterophylla* and *Laveineopteris loshii* (Brongniart) Cleal *et al.*, which are more or less oval in both species. However, the larger pinnules of the latter are more linguaeform and have a more prominent midvein extending for at least ⅔ of the pinnule length. Also, *L. loshii* has more broadly arched lateral veins, which meet the pinnule margin at a less oblique angle and are never flexuous. There is also a significant difference in the cuticles. The adaxial epidermal cells of *L. loshii* do not differ significantly between the costal and intercostal fields; the abaxial cuticle shows little evidence of cell structure, other than the stomatal guard cells, and there are neither papillae nor the glandular hairs as found in *N. heterophylla*.

Laveineopteris tenuifolia (Sternberg) Cleal *et al.* could be confused with the larger pinnules of *N. heterophylla*, but are generally more linguaeform, have a more prominent midvein extending for up to ¾ of the pinnule length, and non-flexuous lateral veins. The epidermal structure of *L. tenuifolia*, which is essentially identical to that of *L. loshii*, also serves to distinguish it from *N. heterophylla* (see previous paragraph).

The specimens described by Wills (1914) as *N. heterophylla* are difficult to assess. Only one figured specimen shows features of the gross morphology, and this is a single, small pinnule, probably from a near-terminal position in a pinna. It shows none of the characters necessary to place it in a particular species. The cuticles figured by Wills are quite different from those of *N. heterophylla*, lacking the prominent papillae on the abaxial surface, and having cyclocytic stomata with a ring of significantly thickened subsidiary cells. Based on the epidermal characters, Wills' specimens are closest to *Macroneuropteris scheuchzeri* (Hoffmann) Cleal *et al.*, but it would be difficult to reconcile such an identification with the small size of the pinnules.

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Tertiary Ostracoda from the Lindi area, Tanzania

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CONTENTS

Synopsis. Ostracods from the Upper Eocene–Lower Miocene of the Lindi area of Tanzania, East Africa, are described. 114 species and 2 subspecies are recognized, of which 51 species and 2 subspecies are new. A new genus, *Crenaleya*, is proposed.

The stratigraphical distribution of the ostracod faunas indicates a close relationship with regional geological events, the faunas becoming less diverse during the Oligocene regression and more diverse during the Miocene transgression. The sedimentation rate deduced from valve/carapace ratios shows a higher rate of sedimentation for the Upper Eocene and Lower Miocene than for the Oligocene. The faunas, in general, are indicative of warm shallow shelf-seas with nearby reefs, with temperatures varying between 10°–25° C and water depths of about 50 m. Three ostracod biozones are recognized; the presence of a deep water fauna in the Lower Miocene of the South Mtwero region is also recorded.

The Tanzanian ostracods show affinities with those of India, Pakistan and South Africa; there are a few species in common with the Mediterranean, Caribbean and Indo-Pacific regions.

INTRODUCTION

The fossil ostracods described in this paper come from the Lindi area, which lies in the Southern Province of Tanzania and is bounded by latitudes 9° 50′ S and 10° 05′ S, and longitudes 39° 40′ E and 39° 45′ E. The position of the area relative to the remainder of coastal East Africa is shown in Fig. 1. Cretaceous to Pliocene marine sediments are known from the area, but the present study is concerned only with those ranging from Upper Eocene to Lower Miocene. These Palaeogene beds are in continuity with, or sometimes rest with slight unconformity on, the Upper Cretaceous rocks and have been laid down continuously from late Eocene times into the overlying Oligocene. A small break in deposition during the Chattian was followed by transgression, resulting in widespread deposition of Lower Miocene beds, a wide occurrence recognized by Eames & Kent (1955). The Pliocene is not well known in this area though farther north in the synclinal areas and seaward of the Dar-es-Salaam embayment, post-Miocene sediments amount to thousands of feet in thickness.

The whole succession dips gently to the ENE, the dip not exceeding 10°. According to Eames *et al.* (1962), the late Eocene to early Miocene was a time of low tectonic activity and the region seems to have undergone gentle overall subsidence with no apparent violent movement; the whole sequence of Cretaceous–Tertiary sedimentation seems to have been associated with the various cycles of broad gentle warping. Kent (*in* Burk & Drake 1974) mentions a period of peneplanation, occupying most of the Cretaceous and

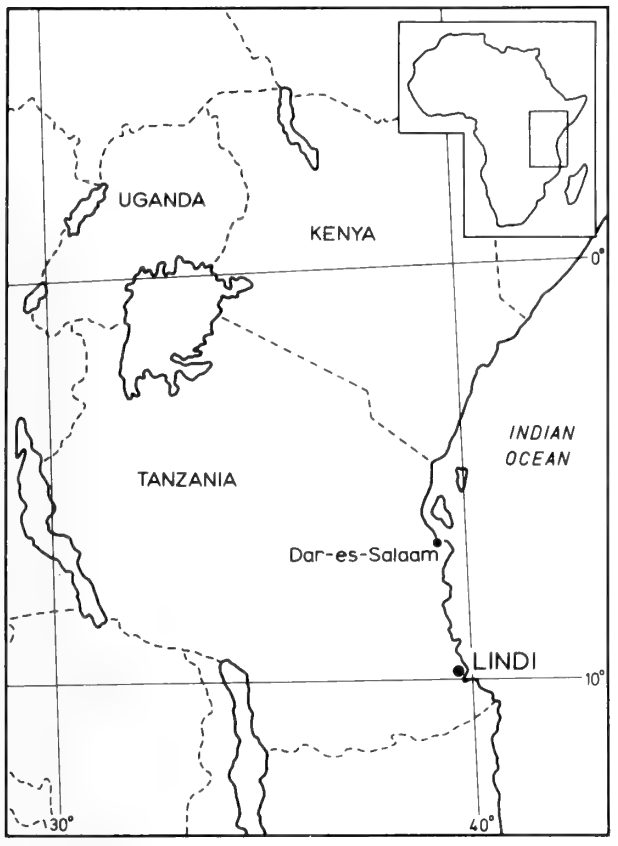


Fig. 1 Map of East Africa, showing the position of Lindi.

Palaeocene, which was disturbed by activation of the Lindi fault system during Oligocene and early Miocene times.

STRATIGRAPHY

The marine Cretaceous succession in the Lindi area consists in general of clay with subordinate sandstones and limestones. There was no break in deposition between the Cretaceous and the Palaeocene but there was a change in environment.

(a) *Palaeocene*. Outcrops of Palaeocene deposits are numerous but small and frequently disturbed. At the base lies brown sandy detrital limestone followed by a chain of reef-knolls, the lithology of which varies considerably. Formation of reef-knolls was followed by a series of silts, clays and impersistent thin limestones.

(b) *Upper Eocene*. Sandy reef limestones with interbedded layers of soft marly clays lie at the base and are overlain by sandy reef limestones in a series of interbedded buff-grey clays, buff siltstones and thin, hard, sometimes siliceous, foraminiferal limestones. The thickness is estimated to be almost 70 m.

(c) *Oligocene*. Distribution of Oligocene deposits is limited, representing a further stage in the early Tertiary regression. The rocks are generally impersistent, being rubbly and silty limestones, soft marly limestones, buff-grey marly clays and buff silts. The estimated thickness is about 80 m.

(d) *Lower Miocene*. The early Lower Miocene is represented by about 5 m of soft buff silty sandstones, which become increasingly calcareous upwards and contain some lenses of gypsiferous clay. In the area immediately to the east of Lindi Town (Kitunda Cliff) the silty sandstones pass upwards into massive reef limestones, but north of Lindi Bay clays and silts appear to replace part of the limestones.

BP-Shell surveys have shown that Lower Miocene beds are brought in on the downthrow side of the Lindi Fault in Lindi Bay, showing evidence of large-scale contemporaneous movement of the fault. At Ras Tapuri a breccia of very large blocks of Miocene limestone is developed 400 m from the easternmost Eocene limestones.

PREVIOUS WORK ON TANZANIAN OSTRACODS

The earliest description of ostracods from Tanzania was given by Sars (1910), who described 29 Recent species belonging to seven genera, all from the fresh-water Lake Tanganyika. Rome (1962) monographed the Lake Tanganyika fauna, establishing two new genera, one new subgenus and 47 new species. Short papers by Vavra, Klie, Lowndes and others also deal with the Recent ostracods of this general area. Ramsay (1968) described three late Cretaceous species of *Cytherelloidea* from the Mikaramu Stream, Tanzania. A year later, Bate (*in* Bate & Bayliss 1969) described 22 new species from Cretaceous sediments and later Bate (1975) described 52 species of which 24 were new, and four new genera, from the Middle Jurassic sediments of Tanzania. The first Tertiary species described from the Lindi area (sample FCRM 1648, Upper Eocene) was *Phalcocythere* cf. *spinosa* Siddiqui, compared with *P. spinosa* Siddiqui 1971 from the Upper Eocene of Pakistan. The only other Tertiary ostracod described from Tanzania, the *Triebelina* cf. *howei* (Stephenson, 1946) of Keij (1976), is from the mid-Oligocene sample FCRM 1576 and is here regarded as identical with *T. howei* from the Caribbean region: see p. 191.

SYSTEMATIC DESCRIPTIONS

All type and figured specimens mentioned in this paper are deposited in the collections of the Palaeontology Department of the British Museum (Natural History); register number prefix OS. Reference is made to other material held at the BP Research Centre, Sunbury-on-Thames.

Subclass **OSTRACODA** Latreille, 1806
Order **PODOCOPIDA** Müller, 1894
Suborder **PLATYCOPA** Sars, 1866
Family **CYTHERELLIDAE** Sars, 1866

Genus ***CYTHERELLA*** Jones, 1849

TYPE SPECIES. *Cytherina ovata* Roemer, 1840.

Cytherella lindiensis sp. nov. Pl. 1, figs 4–9

NAME. After the Lindi area, the type locality in Tanzania.

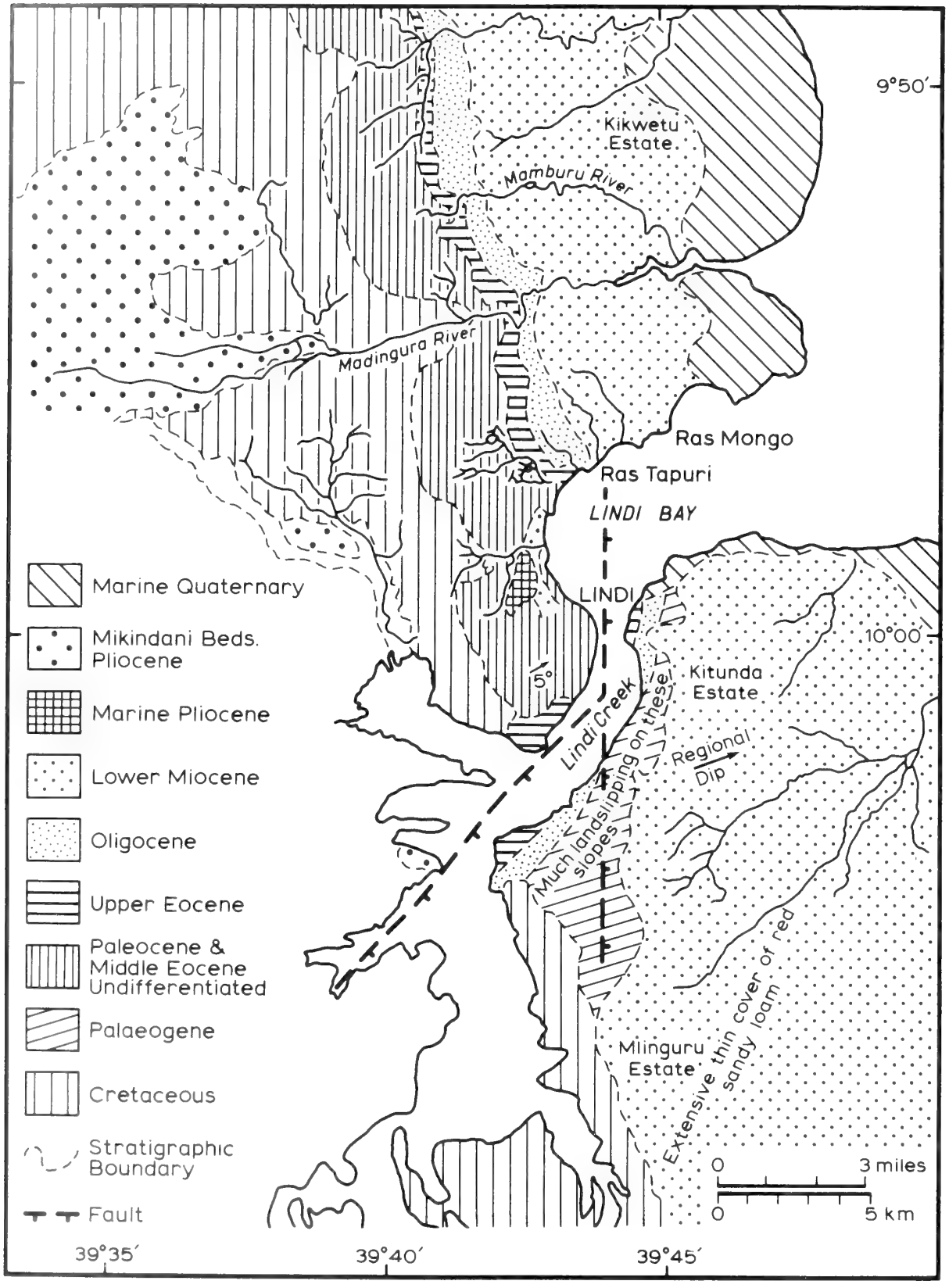


Fig. 2 Geological map of the Lindi area, Tanzania (after Kent *et al.*, 1971).

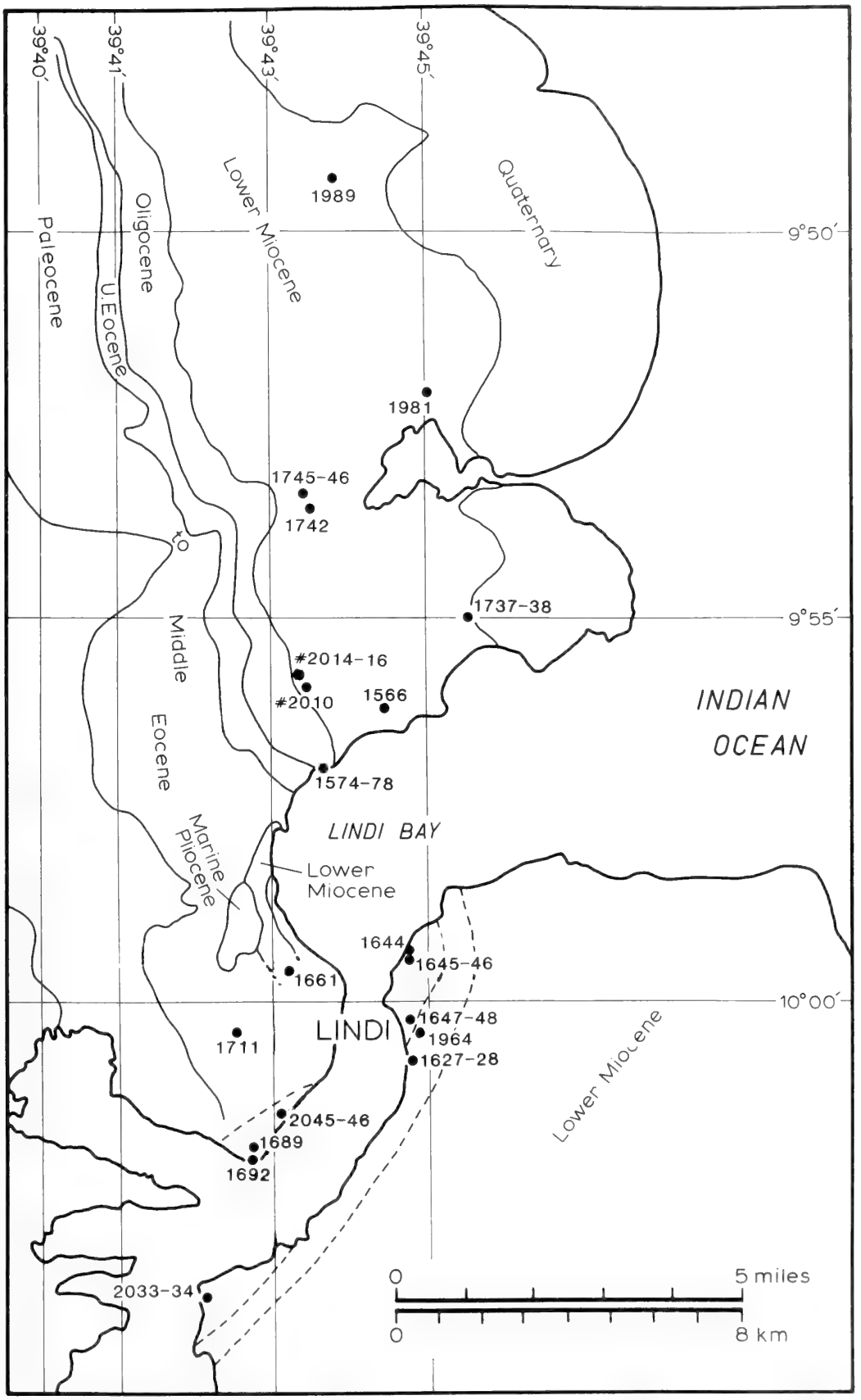


Fig. 3 Sample location map, Lindi, Tanzania. #approx. position only. FCRM 1963 lies off the south-east corner of the map.

DIAGNOSIS. A species of *Cytherella* with females egg-shaped and males subovate in lateral view. Surface completely smooth. Sexual dimorphism pronounced.

HOLOTYPE. A female right valve, OS 8025. Ten paratypes, OS 8026–35. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. 50 specimens, from FCRM 1711, 2033, 2034, 2045.

DESCRIPTION. Carapace medium-sized with greatest width just behind the mid-length and greatest height in the anterior half of the valve. Sexual dimorphism pronounced; presumed females more egg-shaped, males more elongate. Dorsal margin convex, ventral margin slightly concave. Anterior margin broadly rounded, posterior comparatively narrowly rounded. Right valve overlaps left. External lateral surface smooth.

Internally, central muscle scars form a pinnate impression with 14 elongate scars in the anterior row and 10 in the posterior; the axis slopes from dorsal to posteroventral in females and is almost perpendicular to the length in males. The scars are at approximately mid-length in males, posterior to mid-length in females.

DIMENSIONS (μm).	L	H	W
Holotype, female right valve OS 8025	550	370	170
Paratype, male carapace OS 8027	710	415	275
Paratype, male right valve OS 8026	690	410	170

REMARKS. *C. ovata* (Roemer, 1840) and *C. tumidosa* Alexander, 1934 are the closest in shape to *C. lindiensis*. *C. ovata* differs in having the anterior and posterior margins more arched; *C. tumidosa* is larger than *C. lindiensis*, and has the greatest height posterior to the mid-length.

Cytherella mediocalva sp. nov. Pl. 1, figs 1–3

NAME. Latin *medio*, middle + *calvus*, bald; with reference to the smooth central area of the valves.

DIAGNOSIS. Elongate, subquadrate in lateral view. Dorsal margin gently arched, ventral almost straight. Anterior symmetrically rounded, posterior rather narrowly rounded. Carapace strongly pitted except for an inverted T-shaped smooth central area.

HOLOTYPE. A carapace, OS 7994. 10 paratypes, OS 7995–8004. Sample FCRM 1745, Mbanja River; Lower Miocene.

OTHER MATERIAL. 28 specimens, from FCRM 1566 (e.g.

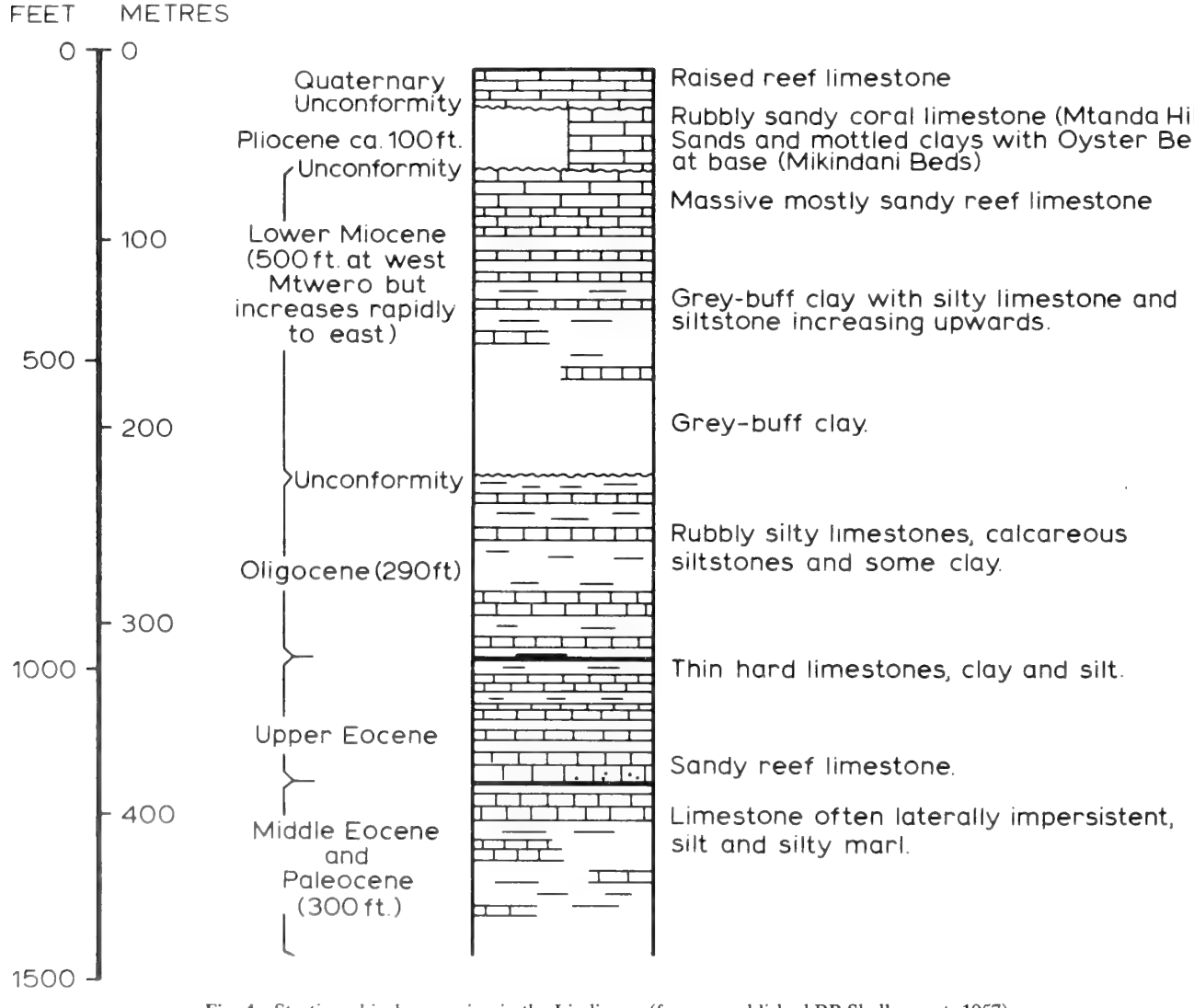


Fig. 4 Stratigraphical succession in the Lindi area (from unpublished BP-Shell report, 1957).

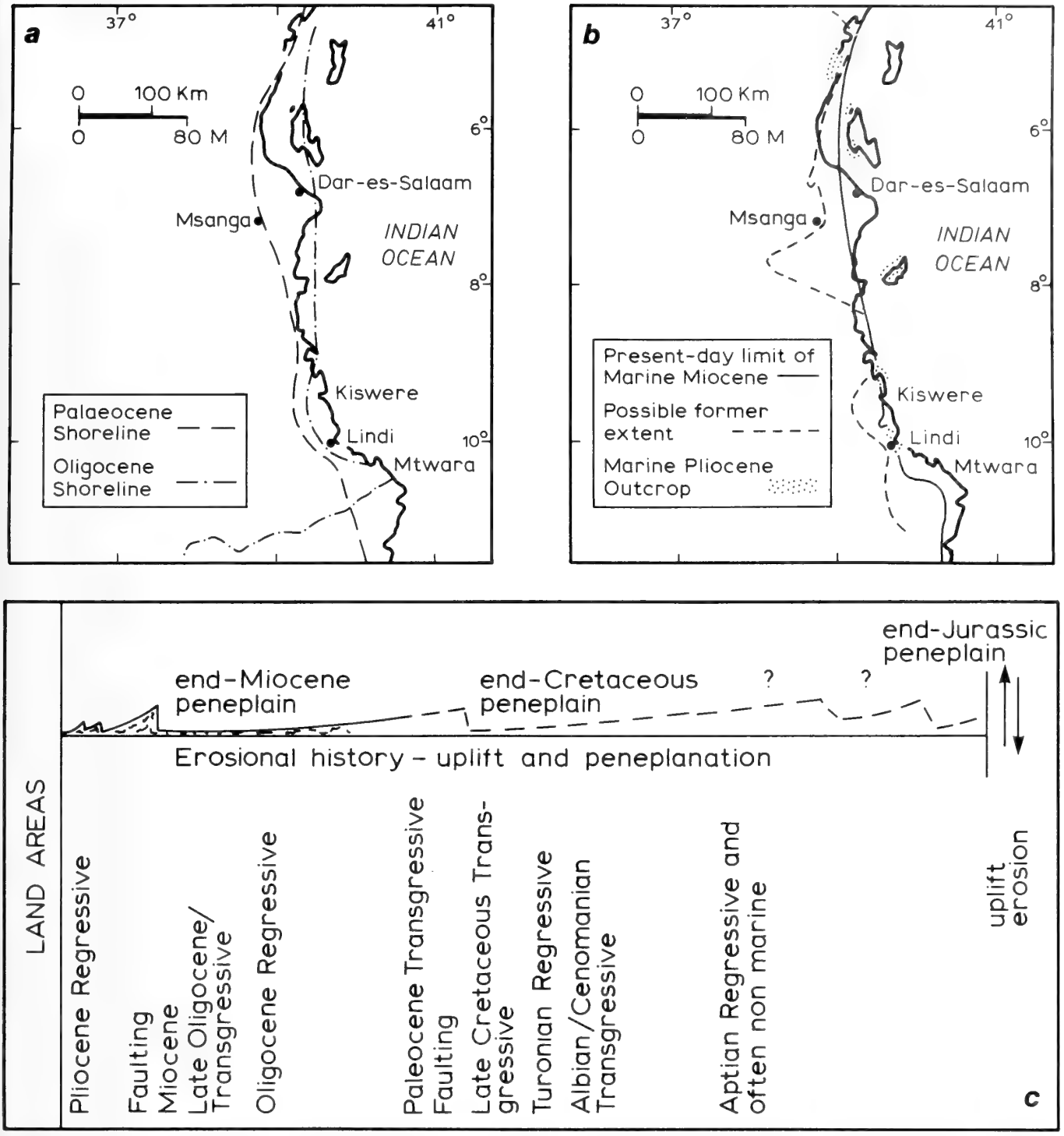


Fig. 5 Tanzania, coastal region. a, positions of early Tertiary shorelines. b, distribution of Neogene rocks. c, geological history of the area. (a, b from Kent *et al.*, 1971; c from Kent, *in* Burke & Drake 1974.)

OS 8005–17), 1746 (e.g. OS 8076–83), 1989 (e.g. OS 8024), 2010 (e.g. OS 8018–24).

DESCRIPTION. Shell medium to thick; shape elongate, subquadrate to subovate, with greatest height in the middle and widest just behind the mid-length. Sexual dimorphism present, presumed males being more elongate than females. Anterior margin symmetrically rounded, posterior comparatively narrower but the carapace is thicker here than at the anterior margin. Dorsal margin arched, passing smoothly into anterior and posterior margins; ventral margin almost straight. Right valve larger than left and overlaps it all round. Surface ornamentation consists of circular pits concentrated in anterior and posterior portions and along ventral

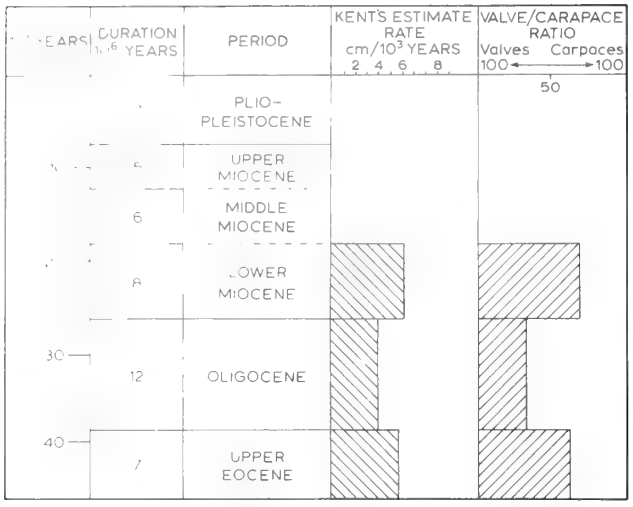


Fig. 6 A comparison of the valve/carapace ratio with the sedimentation rate. (Estimated by Kent *et al.*, 1971.)

margin. There is a smooth central area in the form of an inverted T.

DIMENSIONS (μm).	L	H	W
Holotype, male carapace OS 7994	835	515	360

REMARKS. *C. mediocalva* differs from *C. cretensis* Sissingh 1972 in its dorsal view and in not being pitted over its entire lateral surface. Also, the anterior margin of *C. cretensis* is more conspicuously raised. *C. vandenboldi* Sissingh is more quadrate than *C. mediocalva* and the slope of its postero-dorsal margin is different.

Genus ***CYTHERELLOIDEA*** Alexander, 1929

TYPE SPECIES. *Cythere williamsoniana* Jones, 1849.

Cytherelloidea gemellata sp. nov. Pl. 2, figs 9–10

NAME. 'Paired' or 'double', with reference to the pair of longitudinal ridges on the lateral surface.

DIAGNOSIS. A species of *Cytherelloidea* characterized by a strong marginal ridge and two longitudinal ridges running parallel to the dorsal and ventral margins, from the posterior margin to just behind the anterior margin.

HOLOTYPE. A carapace, OS 8088. A right valve, OS 8089, is a paratype. No other material. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

DESCRIPTION. Carapace medium-sized, subrectangular, with greatest height behind anterior margin and greatest width in posterior half. Anterior margin symmetrically rounded, posterior not so symmetrical, being obliquely inclined towards the ventral margin. Dorsal margin straight in anterior half, then sloping down posteriorly. Ventral margin slightly concave. Right valve overlaps left, the overlap being conspicuous along mid-dorsal and mid-ventral borders. Externally a strong ridge runs along all margins. Two longitudinal ridges, parallel to the dorsal and ventral margins, run from the posterior margin to just before the anterior end. Entire surface finely reticulate.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8088	500	280	160
Paratype, right valve OS 8089	540	300	105

REMARKS. The two lateral ridges in *C. gemellata* are longer than in any other Tanzanian *Cytherelloidea* species. However, the present species resembles *Cytherelloidea* sp. B, and it is possible that *C. gemellata* is the male and *Cytherelloidea* sp. B the female dimorph of the same species. *C. gemellata* also resembles *C. andersoni* and *C. wayensis*, both described by Sexton (1951); however, the upper ridge in *C. andersoni* bends at an obtuse angle just before the mid-length, and that of *C. wayensis* is concave, while the upper ridge of *C. gemellata* is comparatively straight.

Cytherelloidea patagiata sp. nov. Pl. 2, figs 1–4

NAME. 'Ornamented with a border'.

DIAGNOSIS. A species of *Cytherelloidea* with an almost entire marginal ridge. Two short ridges run from the posterior end towards the middle. Two more short ridges originate from the dorsal margin; the anterior one runs more or less parallel to the anterior margin and the median one runs obliquely towards the middle of the anterior margin. Left valve with a distinct hinge tooth.

HOLOTYPE. A male left valve, OS 8085. Two female left valves, OS 8086–7, are paratypes. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene. No other material.

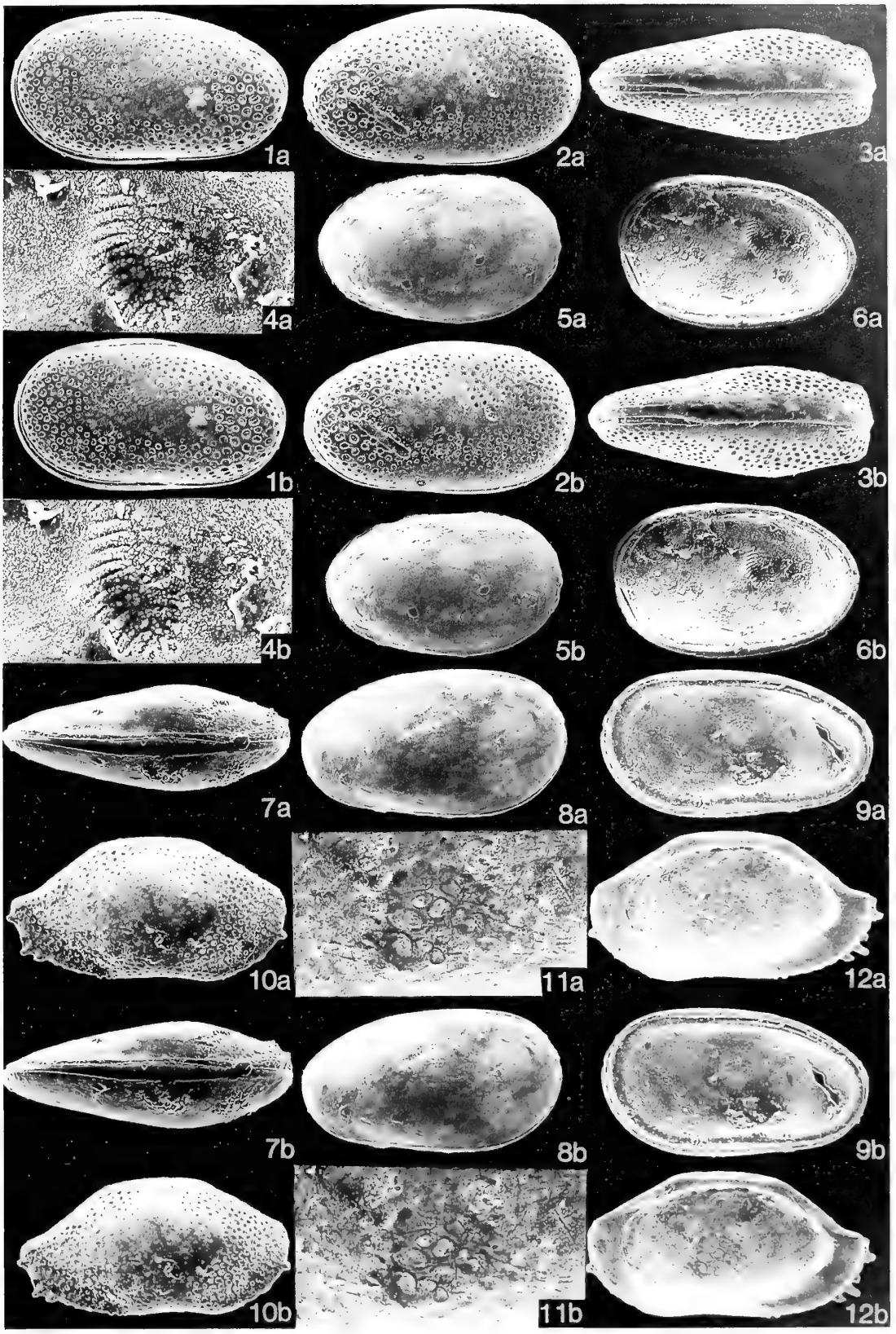
DESCRIPTION. Left valve elongate, subrectangular with greatest height at anterior cardinal angle and greatest width near posterior end. Sexual dimorphism is extremely pronounced, presumed females being swollen ventrolaterally, and males being comparatively slender. Anterior margin symmetrically rounded; posterior rounded in the upper half but obliquely inclined towards ventral border in the lower half. Dorsal margin concave anteriorly but uniformly convex from mid-length to posterior end; ventral margin convex. There are five external ridges; the longest, a strong marginal ridge, runs subperipherally along the anterior margin, becomes peripheral ventrally, is inflated posteriorly and is reduced along the dorsal margin. A short median ridge originates from the inflated posterior end, runs for about one-third of

PLATE 1

Figs 1–3 *Cytherella mediocalva* sp. nov. **Holotype**, male carapace, OS 7994; 1, lateral view from left, ×54; 2, lateral view from right, ×54; 3, dorsal view, ×56.

Figs 4–9 *Cytherella lindiensis* sp. nov. Figs 4–6, **holotype**, female right valve, OS 8025; 4, muscle scars, ×350; 5, external lateral view, ×72; 6, internal lateral view, ×69. Fig.7, paratype, male carapace, OS 8027, ×66. Figs 8, 9, paratype, male right valve, OS 8026; 8, external lateral view, ×62; 9, internal lateral view, ×64.

Figs 10–12 *Paranesidea fracticorallicola* Maddocks, 1969. Right valve, OS 8114; 10, external lateral view, ×57; 11, muscle scar pattern, internal lateral view, ×140; 12, internal lateral view, ×59.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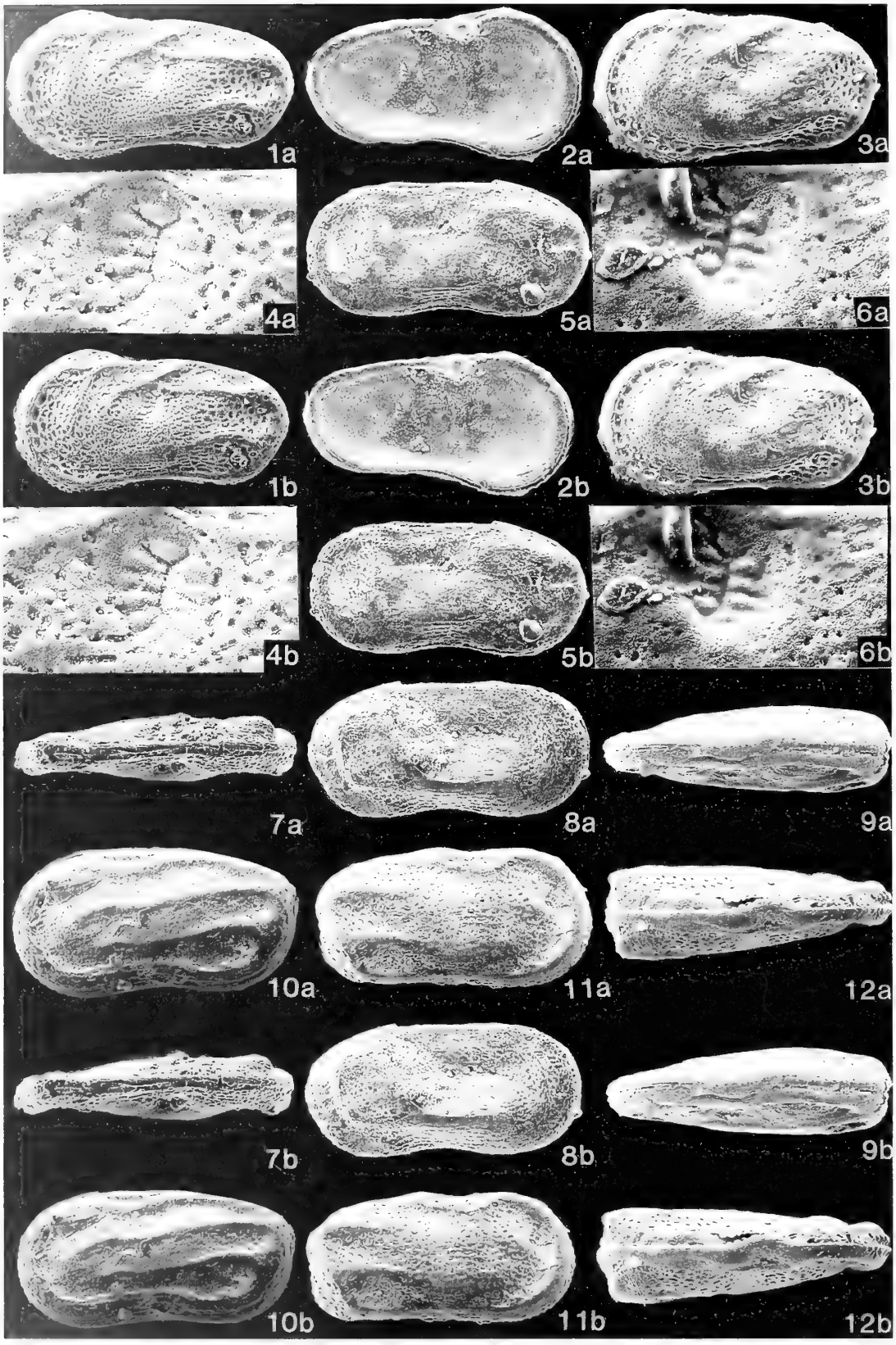
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the length and disappears into the ventral swelling. Above this, a slightly longer ridge runs parallel to the dorsal margin, and ends just above the muscle scars. Starting slightly behind mid-length, another ridge runs obliquely from the dorsal margin to slightly in front of the muscle scar pit. The fifth ridge runs along the anterior part of the dorsal margin for a short distance, then bends almost at a right angle ventrally, where it disappears about the middle of the valve. Entire surface reticulate, most of the fossae being secondarily pitted. Fossae more elongate and larger along the free margins than in the central and dorsal areas. Muscle scars visible externally in a depressed area. Line of concrescence, inner margin and marginal zone cannot be differentiated. Muscle scars raised, forming two rows with a central axis between them, in a feather-shaped pattern. There are five scars anterior to the axis, one at the tip, four posterior to the axis and one at the bottom. Hinge adont as in other *Cytherelloidea* but the selvage of the left valve grows out just behind the anterior end to form a distinct tooth. Keij (1953), van Morkhoven (1963) and Al-Sheikhly (personal discussion) have observed a similar tooth in some Tertiary–Recent species.

DIMENSIONS (μm).	L	H	W
Holotype, male left valve OS 8085	450	260	085
Paratype, female left valve OS 8086	425	250	085

REMARKS. *Cytherelloidea patagiata* is very similar to *C. beckmanni* Barbieto-Gonzales (1971: 262; pl. 2, figs 1c, 2c, 3c; pl. 45, figs 14, 15) first reported from Naxos (Cyclades) and later by Sissingh (1972) from Crete (Calabrian age), the differences between the two being in the degree of development of the ridges. The anterior marginal ridge is stronger in the Tanzanian species, while the lower posterolateral ridge is shorter in *C. patagiata* than in *C. beckmanni*. The outline of the posterior margin also differs slightly.

Cytherelloidea sp. A Pl. 2, figs 5–8

FIGURED SPECIMEN. A carapace, OS 8084. The only specimen, which is not well preserved. Sample FCRM 2034, Lindi Creek, east shore; Upper Eocene.

DESCRIPTION. A *Cytherelloidea* with a strong rim along the anterior and posterior margins; the entire lateral surface is weakly reticulate. Carapace rectangular, compressed, with greatest width just in front of mid-length. Anterior and posterior margins symmetrically rounded, dorsal margin straight to slightly concave, ventral margin convex. A strong marginal ridge occurs along the anterior and posterior margins; another strong short ridge occurs just in front of the posterior end and parallel to it. No interior details could be seen because there were no single valves.

DIMENSIONS (μm).	L	H	W
Carapace OS 8084	730	370	170

REMARKS. The present species differs from all other Tanzanian *Cytherelloidea* in not having any lateral ridges.

Cytherelloidea sp. B Pl. 2, figs 11–12; Pl. 3, fig. 1

FIGURED SPECIMEN. A carapace, OS 8090. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene. The only specimen.

DESCRIPTION. A species of *Cytherelloidea* with a comparatively inflated posterior end, and having a strongly developed marginal rim along the anterior and dorsal margins. Two short parallel ridges run from the posterior to about one-quarter the length; another ridge runs along the mid-dorsal border. Carapace elongate, subrectangular, with greatest height near anterior margin and greatest width near posterior end. Anterior margin symmetrically rounded, with about thirty denticles along the edge; posterior margin inflated. Dorsal margin wavy because of the strong marginal rim, ventral margin straight to very slightly convex. Left valve overlaps right. Surface ornamentation consists of a rounded sub-peripheral ridge running along anterior and dorsal margins. Two short parallel ridges run forward from the inflated posterior margin for about a quarter of the length; another lateral ridge runs along the middle third of the carapace. Entire surface reticulate.

DIMENSIONS (μm).	L	H	W
Carapace OS 8090	540	270	190

REMARKS. In general shape, *Cytherelloidea* sp. B resembles Sexton's (1951) two species *C. wayensis* and *C. andersoni*, from the Miocene and Mid-Oligocene of North America. The only difference is that *Cytherelloidea* sp. B has shorter lateral ridges, which run for only about a third of the length; in fact this feature differentiates this species from all other *Cytherelloidea*. For more discussion see remarks on *C. gemellata*, p. 184.

Suborder **PODOCOPA** Sars, 1866
Superfamily **BAIRDIACEA** Sars, 1888
Family **BAIRDIIDAE** Sars, 1888

Genus ***BAIRDIA*** M^{c}Coy, 1844

TYPE SPECIES. *Bairdia curta* M^{c}Coy, 1844.

Bairdia amygdaloides (Brady) ***oblongata*** van den Bold, 1946 Pl. 3, fig. 12; Pl. 4, figs 1–3

1946 *Bairdia amygdaloides* (Brady) var. *oblongata* van den Bold: 70; pl. 1, fig. 5.

PLATE 2

Figs 1–4 *Cytherelloidea patagiata* sp. nov. Figs 1, 2, **holotype**, male left valve, OS 8085; 1, external lateral view, ×108; 2, internal lateral view, ×105. Figs 3, 4, paratype, female left valve, OS 8086; 3, external lateral view, ×102; 4, muscle scar pattern, external lateral view, ×670.

Figs 5–8 *Cytherelloidea* sp. A. Carapace, OS 8084; 5, lateral view from left, ×62; 6, details of surface ornamentation, ×700; 7, dorsal view, ×62; 8, lateral view from right, ×62.

Figs 9, 10 *Cytherelloidea gemellata* sp. nov. **Holotype**, carapace, OS 8088; 9, dorsal view, ×93; 10, lateral view from left, ×92.

Figs 11, 12 *Cytherelloidea* sp. B. Carapace, OS 8090; 11, lateral view from right, ×82; 12, dorsal view, ×86. See also Pl. 3, fig 1.

FIGURED SPECIMENS. A carapace, OS 7925 (FCRM 1578); a right valve, OS 7927 (FCRM 2033).

LOCALITIES AND HORIZONS. Sample FCRM 1578, 1628, 1711, 2033; Palaeocene to Middle Oligocene.

REMARKS. This species, originally described from the Miocene of Cuba and Guatemala, is widespread in Tanzania. The Tanzanian specimens have a slightly more upturned posterior margin than van den Bold's material but are otherwise very similar. They also resemble some specimens (BM(NH) In.37118) from the Palaeocene of the Salt Range, Pakistan, named by Latham (1938: text-fig. 1) as *Bairdia subdeltoidea* (Münster).

DIMENSIONS (μm).	L	H	W
Carapace OS 7925.	1045	690	520
Right valve OS 7927.	1050	610	350

Bairdia cf. ***attenuata*** Brady, 1880 Pl. 3, fig. 10

cf. 1880 *Bairdia attenuata* Brady: 59; pl. 11, fig. 3a–c.

FIGURED SPECIMEN. A carapace, OS 7934. Sample FCRM 1989, Likonga bridge; Lower Miocene. No other material.

REMARKS. The original locality is given as dredgings at depths of 40 fathoms off the reefs at Honolulu, Hawaii, and 155 fathoms at lat. 11° 35′ S, long. 144° 3′ E, in Torres Strait, between Australia and Papua. The Tanzanian specimens have a more acuminate posterior end and are slightly smoother. In this respect they are closer to *Bairdoppilata planolata* Holden, 1976, but Holden's species has a more upturned and produced posterior margin.

DIMENSIONS (μm).	L	H	W
Carapace OS 7934.	760	490	370

Bairdia cf. ***schulzi*** (Hartmann, 1964) Pl. 4, figs 4, 5

cf. 1964 *Triebelina schulzi* Hartmann: 44; pls 4, 5, figs 14–22.
cf. 1966 Species BA of Maddocks: 47, fig. 2.
cf. 1969 *Neonesidea schulzi* (Hartmann) Maddocks: 20–22.
cf. 1976 *Neonesidea schulzi* (Hartmann); Holden: 12; pl. 7, figs 9–11.

FIGURED SPECIMEN. A carapace, OS 7933. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. 14 carapaces, including juveniles, from samples FCRM 2033 (Upper Eocene) and FCRM 1746, 1792, 1989, 2015 (Lower Miocene).

REMARKS. The Tanzanian specimens are much smaller, but otherwise compare well with *Triebelina schulzi* Hartmann from El Salvador, and sp. BA of Maddocks, 1966, from Madagascar. Holden has described the species from the Lower and Upper Miocene of the Midway area, Hawaiian Islands.

DIMENSIONS (μm).	L	H	W
Carapace OS 7933.	590	370	315

Genus ***PARANESIDEA*** Maddocks 1969

TYPE SPECIES. *Paranesidea fracticorallicola* Maddocks, 1969.

Paranesidea fracticorallicola Maddocks, 1969 Pl. 1, figs 10–12

1969 *Paranesidea fracticorallicola* Maddocks: 43; pl. 1, figs 5, 6; text-figs 16–18.

FIGURED SPECIMEN. A right valve, OS 8114. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene. There is one other specimen from the same sample.

REMARKS. Maddocks' species, from the Recent of Nossi-Bé, Madagascar, is larger than the Tanzanian specimens but they are otherwise identical.

DIMENSIONS (μm).	L	H	W
Right valve OS 8114	795	430	285

Paranesidea nigrescens (Ruggieri, 1962) Pl. 3, figs 6–7

1962 *Bairdia nigrescens* Ruggieri: 11; text-figs 4, 4a; pl. 1, figs 7, 8.
1972 *Neonesidea nigrescens* (Ruggieri) Sissingh: 77; pl. 2, fig. 14.

FIGURED SPECIMEN. A carapace, OS 7923. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene. The only specimen.

DIMENSIONS (μm).	L	H	W
Carapace OS 7923	840	500	480

REMARKS. Ruggieri (1962), who described this species from the Miocene (Tortonian) of central Sicily, placed it in *Bairdia*. Based on his material from the Early Tortonian Tefeli Formation of central Crete, Sissingh (1972) transferred it to *Neonesidea*. As the species is coarsely punctate, rotund, and has a tight spiral muscle scar pattern (as illustrated by Ruggieri), it is here transferred to *Paranesidea*.

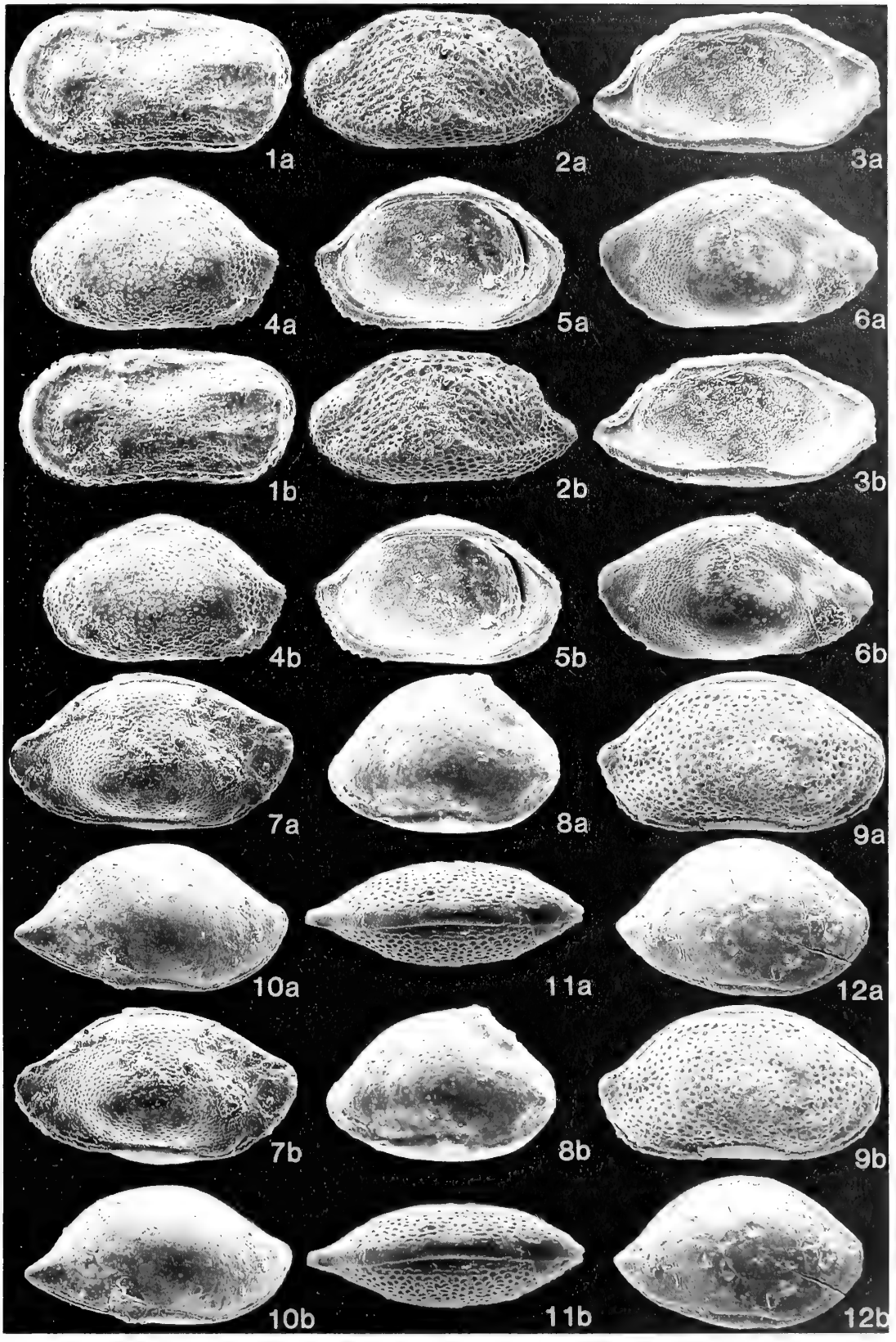
Paranesidea cf. ***fortificata*** (Brady, 1880) Pl. 3, figs 4, 5, 9, 11

cf. 1880 *Bairdia fortificata* Brady: 50.

FIGURED SPECIMENS. A left valve, OS 7953, and a carapace, OS 7951; both from FCRM 1989.

PLATE 3

Fig. 1 *Cytherelloidea* sp. B. Carapace, OS 8090; lateral view from left, ×82. See also Pl. 2, figs 11–12.
Figs 2, 3 *Triebelina howei* (Stephenson, 1946). Left valve, OS 7968; 2, external lateral view, ×72; 3, internal lateral view, ×75.
Figs 4, 5, 9, 11 *Paranesidea* cf. *fortificata* (Brady, 1880). Figs 4, 5, left valve, OS 7953; 4, external lateral view, ×58; 5, internal lateral view, ×58. Figs 9, 11, carapace, OS 7951; 9, lateral view from right, ×79; 11, dorsal view, ×76.
Figs 6, 7 *Paranesidea nigrescens* (Ruggieri, 1962). Carapace, OS 7923; 6, lateral view from left, ×54; 7, lateral view from right, ×55.
Fig. 8 *Paranesidea* sp. A. Carapace, OS 7924; lateral view from right, ×60.
Fig. 10 *Bairdia* cf. *attenuata* Brady, 1880. Carapace, OS 7934; lateral view from right, ×58.
Fig. 12 *Bairdia amygdaloides* (Brady) *oblongata* van den Bold, 1946. Carapace, OS 7925; lateral view from right, ×39. See also Pl. 4, fig. 1.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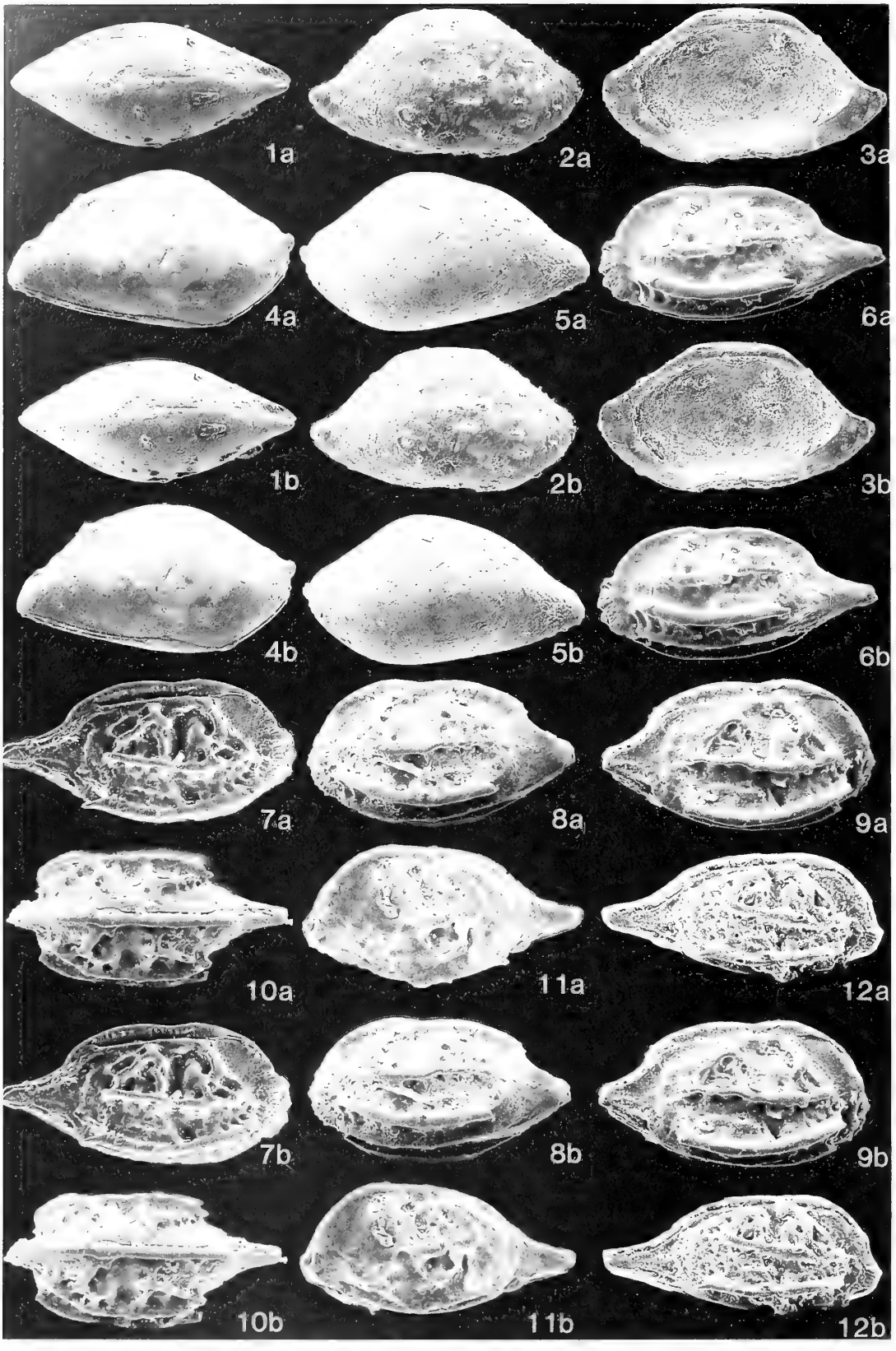
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OTHER MATERIAL. Eight specimens from samples FCRM 1989 (e.g. OS 7951, 7953); 2033, 2046 (e.g. OS 7952); Upper Eocene to Lower Miocene.

DIMENSIONS (μm).	L	H	W
Left valve OS 7953	690	450	190
Carapace OS 7951	590	350	240

REMARKS. The Tanzanian specimens are identical in shape with Brady's from the Recent of Booby Island, south of New Guinea, but are only slightly more than half the size.

Paranesidea sp. A Pl. 3, fig. 8

FIGURED SPECIMEN. A carapace, OS 7924. Sample FCRM 1711, east flank of Kitulo Hill; probably Palaeocene. The only specimen.

DESCRIPTION. Carapace subovoid, with the greatest height slightly more than two-thirds of the greatest length. The greatest height lies almost at mid-length whilst the greatest length is subventral. Dorsal margin strongly arched, sloping steeply towards both anterior and posterior margins; ventral margin concave in the middle with convex anteroventral and posteroventral ends. Left valve larger than right and overlaps it all round. Lateral surface finely punctate in the centre to almost smooth along the margins.

DIMENSIONS (μm).	L	H	W
Carapace OS 7924	620	460	360

REMARKS. The Tanzanian specimen strongly resembles *Bairdia subdeltoidea* (Münster) var. *rotunda* Alexander, 1927, but the anterior margin is higher and the posterior more produced in that species.

Genus ***TRIEBELINA*** van den Bold, 1946

TYPE SPECIES. *Triebelina indopacifica* van den Bold, 1946.

Triebelina howei (Stephenson, 1946) Pl. 3, figs 2, 3

1946 *Glyptobairdia howei* Stephenson: 347; pl. 42, figs 5–6; text-figs 1–2.
1947 *Triebelina howei* (Stephenson) Stephenson: 578.
1974 *Triebelina howei* (Stephenson); Poag: 42; pl. 1, fig. 3.
cf. 1976 *Triebelina howei* (Stephenson); Keij: 41–42; pl. 2, figs 8–9.

FIGURED SPECIMEN. A left valve, OS 7968. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. A specimen from sample FCRM 1576.

DIMENSIONS (μm).	L	H	W
Left valve OS 7968	620	325	180

REMARKS. Keij (1976) also found six valves of this species in sample FCRM 1576, from approximately the same locality as 1578. While comparing his specimens with *T. howei*, he remarked that the two are practically identical except that the East African specimens have a much weaker ornamentation. He mentions that, while the ornamentation of the right valves is very similar, there are major differences in the ornamentation of the left valves. The semicircular dorsal carina of the nominal species is absent in his African specimens, except for weak indications of its ends; also, the ventrolateral carina with the flattened triangular area around its mid-length is barely indicated in the African specimens though well developed in those from the Caribbean. He also noted that the length/height ratio was 1·75 for the Caribbean form and 2·0 for the East African.

Our left valve does not show any of the differences mentioned by Keij; the ornamentation is as strongly developed as in Caribbean specimens, and the length/height ratio is 1·93. Van den Bold's figures (1974: pl. 1, figs 5–6) show the ratio of 1·75 for the left valve to 2·0 for the right valve, almost the same as we calculated from Keij's figures (1976: 41).

Keij's suggestion that the African forms may be older than the American, and have weaker ornamentation because they are closer to the supposed ancestral genus *Paranesidea,* is therefore not supported. His other conclusion, that Tanzanian specimens demonstrate that Tertiary to Recent shallow-water tropical marine ostracods sometimes had, and have, a wide geographical distribution, remains valid.

Superfamily **CYTHERACEA** Baird, 1850
Family **CYTHERIDAE** Baird, 1850
Subfamily **CYTHERINAE** Baird, 1850
Tribe **PAIJENBORCHELLINI** Deroo, 1966

Genus ***PAIJENBORCHELLA*** Kingma, 1948

TYPE SPECIES. *Paijenborchella iocosa* Kingma, 1948.

The genus comprises two subgenera, *Paijenborchella* s. str. and *Eopaijenborchella* Keij, 1966.

Subgenus ***PAIJENBORCHELLA*** Kingma, 1948

Paijenborchella* (*Paijenborchella*) cf. *iocosa Kingma, 1948 Pl. 5, fig. 4

cf. 1948 *Paijenborchella iocosa* Kingma: 86; pl. 8, fig. 12.

PLATE 4

Figs 1–3 *Bairdia amygdaloides oblongata* van den Bold, 1946. Fig. 1, carapace, OS 7925; dorsal view, ×43; see also Pl. 3, fig. 12. Figs 2, 3, right valve, OS 7927; 2, external lateral view, ×42; 3, internal lateral view, ×43.

Figs 4, 5 *Bairdia* cf. *schulzi* (Hartmann, 1964). Carapace, OS 7933; 4, lateral view from right, ×72; 5, lateral view from left, ×72.

Figs 6–10 *Paijenborchella* (*Eopaijenborchella*) *quasimalaiensis* sp. nov. Figs 6, 7, paratype, male carapace, OS 7722; 6, lateral view from left, ×83; 7, lateral view from right, ×85. Figs 8–10, **holotype**, female carapace, OS 7721; 8, lateral view from left, ×93; 9, lateral view from right, ×95; 10, dorsal view, ×100.

Figs 11, 12 *Paijenborchella* (*Eopaijenborchella*) *quasimalaiensis dilata* subsp. nov. Female? carapace, OS 7733 (specimen lost); 11, lateral view from left, ×96; 12, lateral view from right, ×97. See also Pl. 5, figs 1, 3.

FIGURED SPECIMEN. A carapace, OS 7740. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

OTHER MATERIAL. Two specimens: samples FCRM 1738 (right valve, specimen lost); FCRM 1989 (left valve, OS 7739).

DIMENSIONS (μm).	L	H	W
Carapace OS 7740	550	210	300

REMARKS. Except for the less developed alar spines, and especially the fact that the upper spine is missing, the Tanzanian specimens agree with *P. iocosa* Kingma. On the other hand, the ventrolateral spine and the lateral, upper, bridge-like ridge are better developed in the Tanzanian specimens than in *P. solitaria* Ruggieri. Probably the Tanzanian specimens represent a form intermediate between the Far Eastern *P. iocosa* and the Italian *P. solitaria*.

Subgenus ***EOPAIJENBORCHELLA*** Keij, 1966

Type species. *Paijenborchella lomata* Triebel, 1949.

Paijenborchella (*Eopaijenborchella*) *quasimalaiensis* sp. nov. Pl. 4, figs 6–10

NAME. Like *malaiensis* Kingma, 1948.

DIAGNOSIS. Species of subgenus *Eopaijenborchella* with three prominent ridges; the lower two lie in the ventral half, the upper one almost at mid-height of the valve. Median sulcus prominent.

HOLOTYPE. A female carapace, OS 7721. Four other specimens, OS 7722–5, are paratypes. Sample FCRM 2034, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Three specimens from samples FCRM 2033 (2) and 2034 (OS 7720).

DESCRIPTION. Carapace subovate to almost pear-shaped in lateral view. Anterior margin slightly modified by a flange, but otherwise rounded; posterior margin produced into a caudal process. Dorsal margin straight to slightly arched, except for a small constriction above the median sulcus. Ventral margin is strongly modified by the ventral ridges and appears convex in lateral view. Sexual dimorphism present, presumed males being more elongate and slightly less wide than females. The difference can be seen most clearly in dorsal view, when females look distinctly bulbous. Left valve overlaps right, the overlap being especially obvious along the dorsal margin. Surface ornament consists of three prominent longitudinal ridges, the most ventral of which is weakly developed and slightly longer than the others. Middle ridge well developed and ends in a short blunt spine; top ridge weakly developed and about the same length as the middle one. Median sulcus well developed, running from the middle ridge to the dorsal margin, with a triangular ridge behind it and a hook-shaped projection in front of it. Inner margin and line of concrescence coincide throughout and run parallel to the outer margin. Marginal pore canals straight, simple and almost equally spaced. Anterior marginal pore canals number about 12; only two could be seen passing through the caudal process. The hinge in the right valve consists of a bifid anterior tooth followed by a coarsely serrated groove terminated by a narrow posterior tooth.

DIMENSIONS (μm).	L	H	W
Holotype female carapace OS 7721	460	280	260
Paratype male carapace OS 7722	550	290	280

REMARKS. *P. malaiensis* Kingma, *P. cymbula* Ruggieri, 1951, and *P. geoffreyi* Anderson, 1964, are all closely related to this Tanzanian species. The most obvious differences are in the patterns of ornamentation, especially the outlines of the small ridges in the dorsal part; also, the caudal process is shorter in the Tanzanian species than in the others. *P. quasimalaiensis* differs from both *P. cymbula* and *P. malaiensis* in not having a well developed secondary ridge running along the median ridge from the sulcus towards the posterior. Unlike any other *Paijenborchella* species from Tanzania, this one has three lateral ridges almost equal in length.

Paijenborchella (*Eopaijenborchella*) *quasimalaiensis dilata* subsp. nov. Pl. 4, figs 11–12; Pl. 5, figs 1–3

NAME. 'Spread, expanded', with reference to the two median ridges broadening out towards the posterior.

HOLOTYPE. A male right valve, OS 7732. A female carapace, OS 7733, is a paratype (lost). Sample FCRM 2014, stream SW of Mtwero; Lower Miocene.

OTHER MATERIAL. One specimen from sample FCRM 1745.

DIMENSIONS (μm).	L	H	W
Holotype, male right valve OS 7732	475	190	120
Female carapace OS 7733 (spec. lost)	465	220	230

REMARKS. The subspecies differs from the typical subspecies in having three subequal longitudinal ridges, the length decreasing from the ventral one to the dorsal. The small kink

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PLATE 5

Figs 1–3 *Paijenborchella* (*Eopaijenborchella*) *quasimalaiensis dilata* subsp. nov. Figs 1, 3, Female? carapace, OS 7733 (specimen lost); 1, dorsal view, ×98; 3, ventral view, ×96; see also Pl. 4, figs 11, 12. Fig. 2, **holotype**, male right valve, OS 7732, external lateral view, ×95.

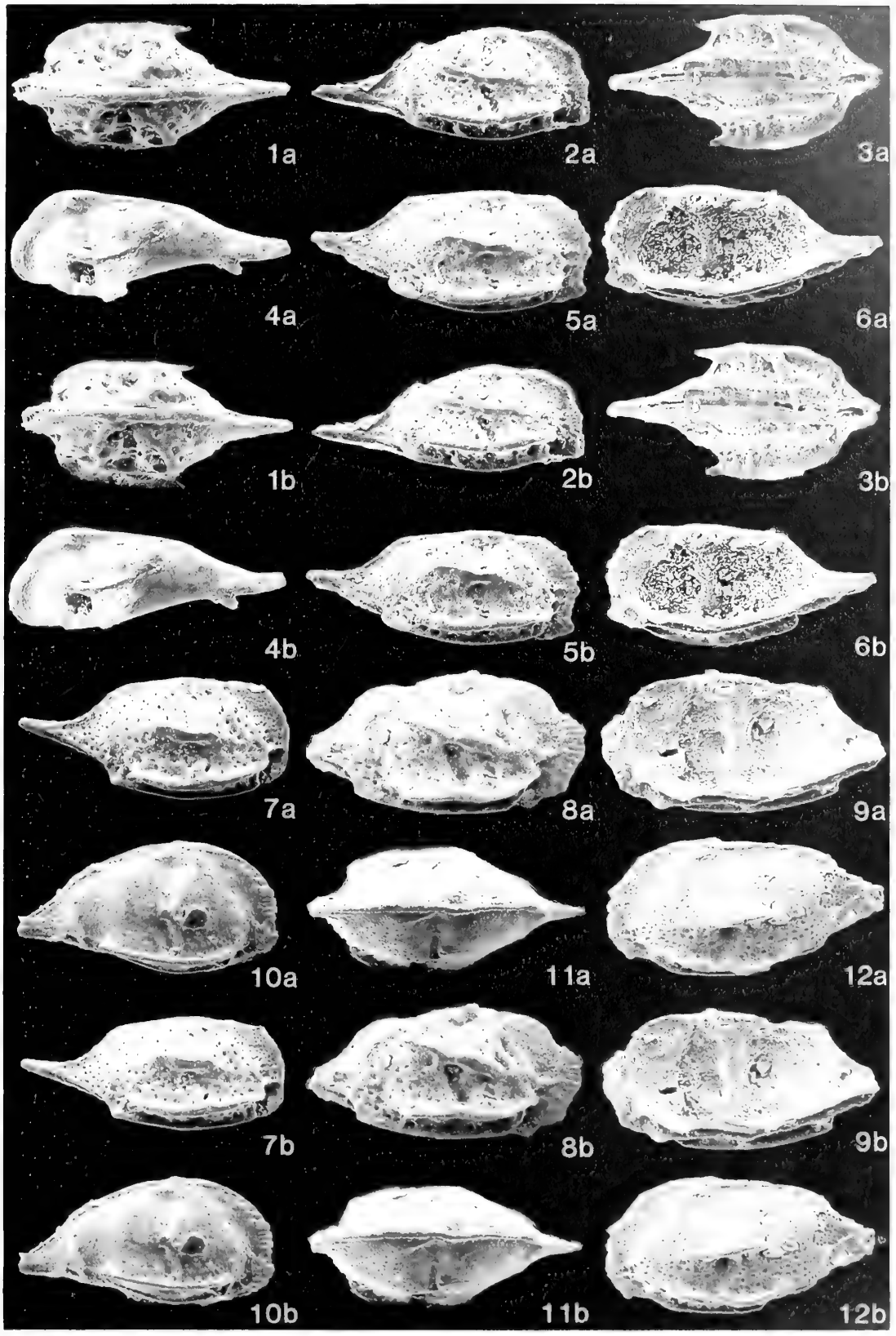
Fig. 4 *Paijenborchella* (*Paijenborchella*) cf. *iocosa* Kingma, 1948. Carapace, OS 7740, slightly oblique lateral view from left, ×83.

Figs 5–7 *Paijenborchella* (*Eopaijenborchella*) *disadunca* sp. nov. Figs 5, 6, **holotype**, male right valve, OS 7727; 5, external lateral view, ×99; 6, internal lateral view, ×100. Fig. 7, paratype, female right valve, OS 7728, external lateral view, ×100.

Figs 8, 9 *Paijenborchella* (*Eopaijenborchella*) *disadunca*, Morphotype A. Right valve, OS 7726; 8, external lateral view, ×108; 9, internal lateral view, ×110.

Figs 10, 11 *Paijenborchella* (*Eopaijenborchella*) *disadunca*, Morphotype D. Carapace (juvenile), OS 7731; 10, lateral view from right, ×105; 11, dorsal view, ×114.

Fig. 12 *Paijenborchella* (*Eopaijenborchella*) *disadunca*, Morphotype B. Carapace OS 7729, lateral view from left, ×114. See also Pl. 6, fig. 1.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in the mid-dorsal margin of *P. quasimalaiensis* s.str. is not present in the subspecies. In dorsal view the males of the subspecies do not widen posteriorly.

Paijenborchella (*Eopaijenborchella*) *disadunca* sp. nov.

Pl. 5, figs 5–7

NAME. 'Not hooked', with reference to the absence of a hook-like ridge in front of the sulcus.

DIAGNOSIS. Species of subgenus *Eopaijenborchella* having a comparatively sharp caudal process and no ridges above the upper longitudinal one.

HOLOTYPE. A male right valve, OS 7727. A female right valve, OS 7728, is a paratype. Sample FCRM 1742, Mbanja River; Lower Miocene.

OTHER MATERIAL. Five specimens, from samples FCRM 1742 and 1745.

DESCRIPTION. Carapace subtriangular to subquadrate in lateral view. Anterior margin symmetrically rounded, posterior produced into a sharp caudal process. Dorsal margin straight, ventral margin obscured by the ventral longitudinal ridge running parallel to it. Surface ornament consists of a subcentral sulcus and three longitudinal ridges. These ridges decrease in length from the ventral to the dorsal one. The upper ridge runs up towards the dorsal margin, the other two run parallel to the long axis. Intercostal areas pitted by numerous pores.

DIMENSIONS (μm).	L	H	W
Holotype, male right valve OS 7727	455	210	130
Paratype, female right valve OS 7728	440	210	130

REMARKS. This species differs from *P. quasimalaiensis* only in not having ridges on the dorsolateral surface and in the caudal process being more acutely pointed. Some specimens differ slightly in the number and distribution of pores, and in the arrangement of the longitudinal ridges; these are grouped as four morphotypes.

Morphotype A

Pl. 5, figs 8–9

FIGURED SPECIMEN. A right valve, OS 7726. Sample FCRM 1738, South Mtwero; Lower Miocene. The only specimen.

DIMENSIONS (μm).	L	H	W
Right valve OS 7726	420	235	145

REMARKS. This differs from typical *P. disadunca* in having the dorsal ridge comparatively strongly developed, diverging away from the lower ridges and ending in a blunt knob.

Morphotype B

Pl. 5, fig. 12; Pl. 6, fig. 1

FIGURED SPECIMEN. A carapace, OS 7719. Sample FCRM 1628, Kitunda; Middle Oligocene. The only specimen.

DIMENSIONS (μm).	L	H	W
Carapace OS 7719	395	200	185

REMARKS. The three lateral ridges are subparallel rather than divergent. Morphotype B is more densely punctate than any of the others.

Morphotype C

Pl. 6, figs 2–3

FIGURED SPECIMENS. A female carapace, OS 7730, and a male left valve, OS 7736. Sample FCRM 1742, Mbanja River; Lower Miocene.

OTHER MATERIAL. Two specimens, from FCRM 1738 and FCRM 2016.

DIMENSIONS (μm).	L	H	W
Female carapace OS 7730	415	230	220
Male left valve OS 7736	460	240	150

REMARKS. The upper lateral ridge is shorter and thicker, the median sulcus is deeper and the anterior margin is more symmetrically rounded than in *P. disadunca* s.str. The pores are concentrically arranged.

Morphotype D

Pl. 5, figs 10–11

FIGURED SPECIMEN. A juvenile carapace, OS 7731. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene. The only specimen.

DIMENSIONS (μm).	L	H	W
Carapace OS 7731	395	220	215

REMARKS. The median ridge of morphotype B is not developed in this form and the caudal process is set lower.

Family **LEPTOCYTHERIDAE** Hanai, 1957*a*

Genus ***LEPTOCYTHERE*** Sars, 1925

TYPE SPECIES. *Cythere pellucida* Baird, 1850.

Leptocythere amoena sp. nov.

Pl. 7, figs 5–11

NAME. 'Delightful, lovely', with reference to its beautiful ornamentation.

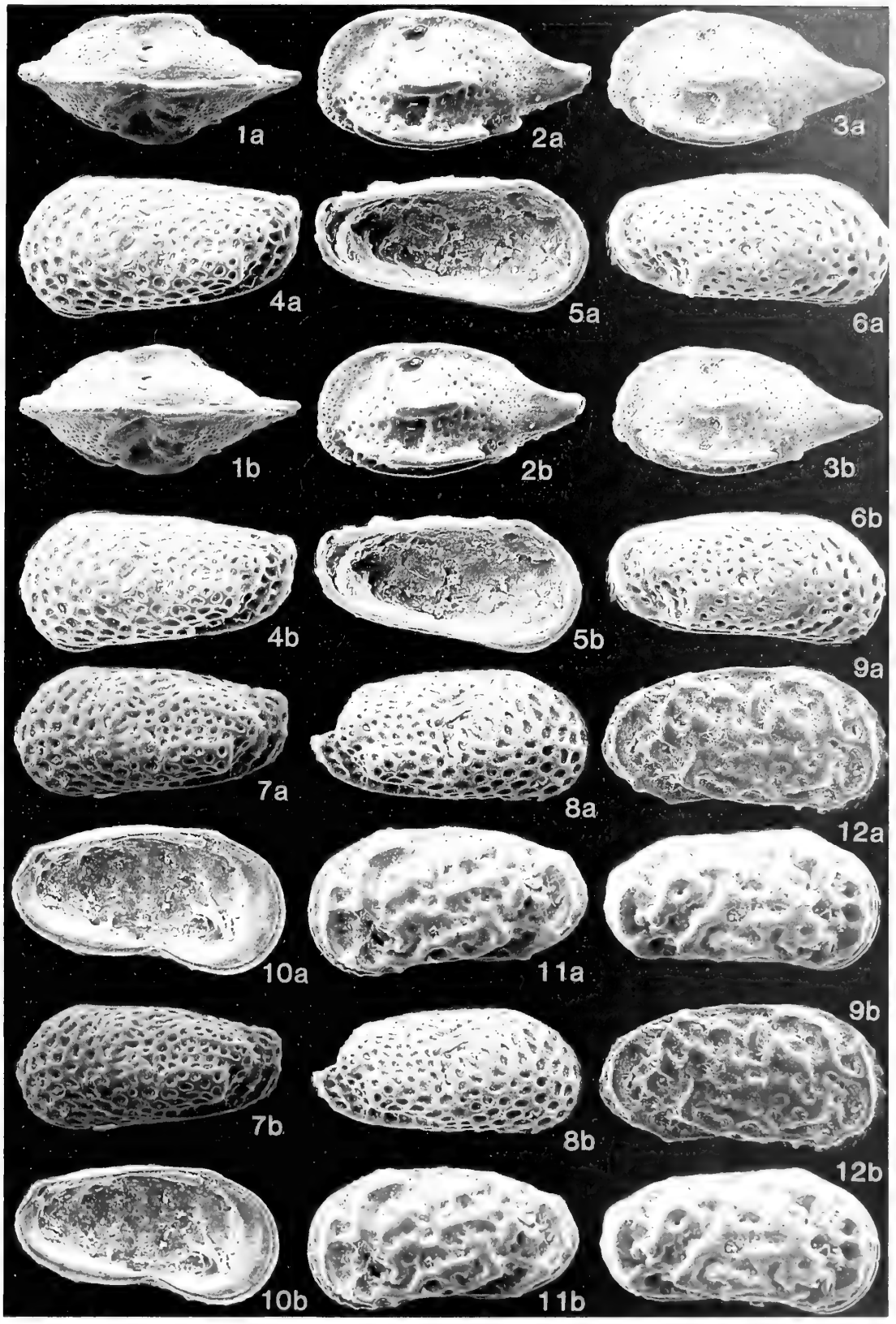
PLATE 6

Fig. 1 *Paijenborchella* (*Eopaijenborchella*) *disadunca*, Morphotype B. Carapace, OS 7729, dorsal view, ×118. See also Pl. 5, fig. 12.

Figs 2, 3 *Paijenborchella* (*Eopaijenborchella*) *disadunca*, Morphotype C. Fig. 2, Female carapace, OS 7730, lateral view from left, ×107. Fig. 3, Male left valve, OS 7736, external lateral view, ×98.

Figs 4–8 *Leptocythere fastigata* sp. nov. Fig. 4, **holotype**, left valve, OS 8132, external lateral view, ×124. Figs 5, 7, paratype, left valve, OS 8134; 5, internal lateral view, ×122; 7, external lateral view, ×120. Fig. 6, paratype, right valve, OS 8133, external lateral view, ×110. Fig. 8, right valve, OS 8136, external lateral view, ×129.

Figs 9–12 *Callistocythere jugosa* sp. nov. Fig. 9, **holotype**, right valve, OS 8140, external lateral view, ×135. Figs 10, 11, paratype, left valve, OS 8141; 10, internal lateral view, ×123; 11, external lateral view, ×125. Fig. 12, paratype, carapace, OS 8138, lateral view from right, ×106; see also Pl. 7, fig. 1.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DIAGNOSIS. Elongate, subrectangular, with a beautiful polygonal reticulation recalling honeycomb. Anterior and posterior with strong marginal rims.

HOLOTYPE. A carapace, OS 8150. Two other right valves, OS 8151–2, are paratypes (OS 8152 is broken). Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene. No other material.

DESCRIPTION. Carapace medium-sized, subrectangular in lateral view with greatest height at the anterior cardinal angle and greatest width in front of the posterior end. Anterior margin rounded, with a marked anterior cardinal angle; posterior margin subrounded and narrower. Dorsal and ventral margins straight and subparallel, converging very slightly posteriorly. External surface with a beautiful reticulation reminiscent of a honeycomb, enclosing a raised central area with a surrounding groove. Along the posterior, anterodorsal and posteroventral margins there are deeper pits, numbering about nine posteriorly and five along the dorsal half of the anterior margin. There are strong anterior and posterior marginal rims. Eye tubercle very reduced and only present as an opaque spot. Duplicature moderately wide; inner margin very regular and slightly separated from the line of concrescence in the dorsal part of the anterior margin, leaving a narrow vestibule. Selvage very strongly developed, running halfway between inner and outer margins in the right valve; in the left valve it runs slightly nearer to the outer margin in the dorsal half and medially in the ventral half of the anterior margin. Marginal pore canals simple, short and parallel; they number 28–30, mostly concentrated in the anterior and anteroventral regions. Muscle scars consist of four adductor scars and a V-shaped frontal scar. Hinge weakly holamphidont. In the right valve, a small anterior tooth placed on an elongate platform, and an adjacent socket joined by a groove to the small conical posterior tooth. Left valve with complementary elements.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8150	745	345	315
Paratype, right valve OS 8151	600	270	135
Paratype, right valve OS 8152	720	355	160

REMARKS. Some specimens of *L. paracastanea* Swain 1955 have somewhat similar ornament, lateral outline and marginal pore canals, but the Tanzanian species can be easily distinguished by the conspicuous slope of its dorsal margin towards the posterior end. In addition, the anterior and posterior marginal rims do not seem to be present in Swain's species, which also has a more complicated hinge. *Leptocythere* (*Amnicythere*) *fallax* Devoto 1965 has a very similar ornament of polygonal meshes and also a similar outline, but it has a different hinge.

Leptocythere fastigata sp. nov. Pl. 6, figs 4–8

NAME. 'Rising to a point', with reference to its tapering to a point posteriorly.

DIAGNOSIS. A small ostracod, subrectangular in side view. Lateral surface coarsely pitted, with a weak posteroventral marginal ridge.

HOLOTYPE. A left valve, OS 8132. Three other valves, OS 8133–5, are paratypes. Sample FCRM 1566, Mongo Stream; Lower Miocene.

OTHER MATERIAL. Two specimens (OS 8126–7) from FCRM 1989, Lower Miocene.

DESCRIPTION. Carapace small, subrectangular, tapering posteriorly; highest at the anterior cardinal angle and widest slightly in front of the posterior end. Anterior margin rounded, posterior subrounded in the right valve and obliquely truncate in the left. Ventral margin almost straight, with a concave indentation anterior of mid-length when seen from inside. Dorsal margin straight, making a distinct cardinal angle at the posterior end. External surface coarsely reticulate, the fossae being larger in the anterior half than in the posterior. A weak marginal ridge is present along posterior and posteroventral margins. Internally, margin very narrow; line of concrescence and inner margin coincide except anteriorly, where there is a very narrow vestibule. Normal pores few, coinciding with the ridges of the reticulate ornament externally. Muscle scars cannot be seen; hinge typical of the genus.

DIMENSIONS (μm).	L	H	W
Holotype, left valve OS 8132	380	180	100
Paratype, left valve OS 8134	370	190	105
Paratype, right valve OS 8133	420	210	115
Right valve OS 8136	360	180	100

REMARKS. The small dimensions of the species, the very narrow duplicature, and the absence of sexual dimorphism suggest that the specimens may not be adult. However, since *Leptocythere* species tend to be small and the Tanzanian ostracods are rather small anyway, it seems more useful to name it than to leave it under open nomenclature. *L. crepidula* Ruggieri 1950 resembles the Tanzanian species somewhat, but the coarser reticulation and straight dorsal and ventral margins of *L. fastigata* easily differentiate the two.

Genus ***CALLISTOCYTHERE*** Ruggieri, 1953

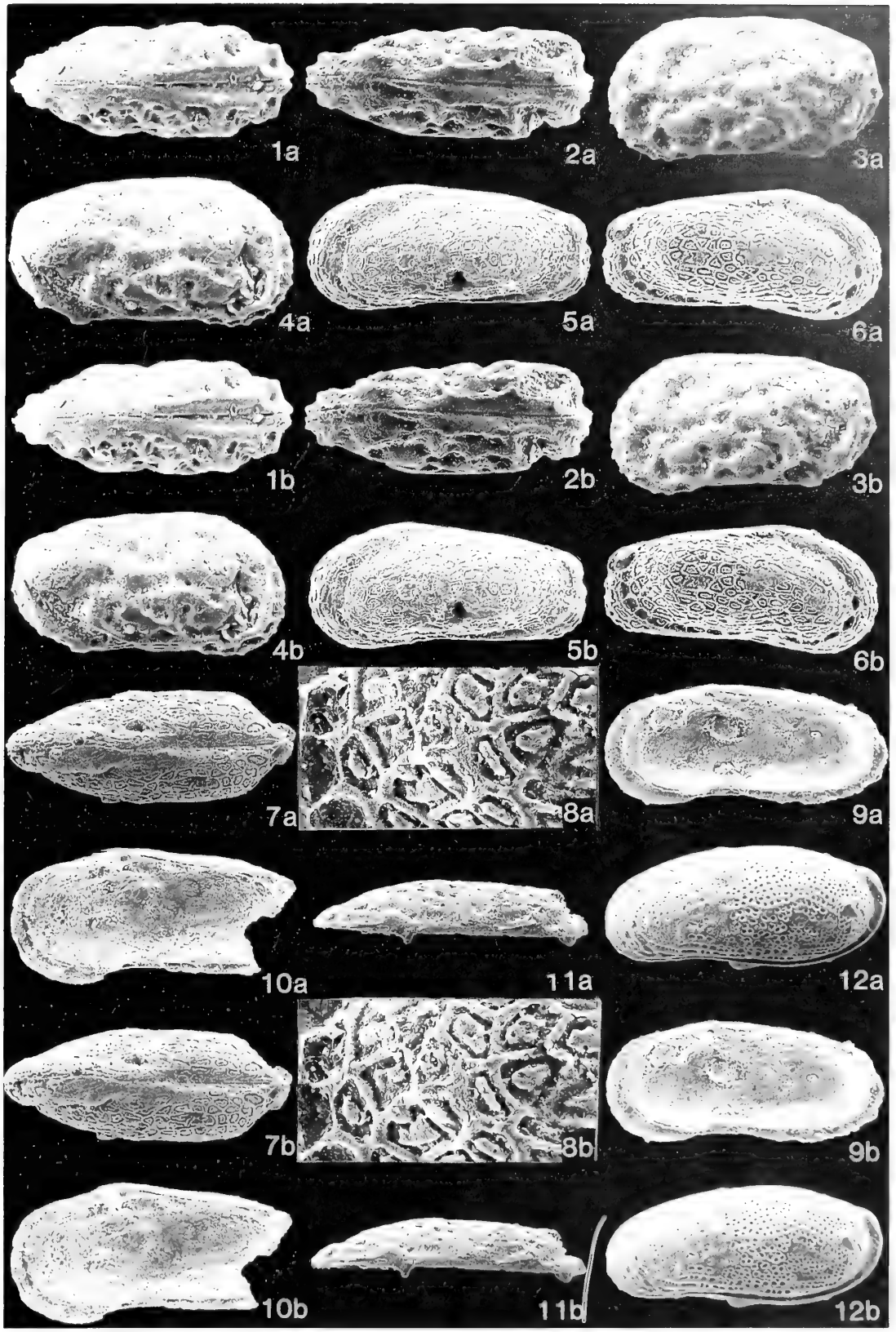
TYPE SPECIES. *Cythere littoralis* Müller, 1894.

PLATE 7

Figs 1–4 *Callistocythere jugosa* sp. nov. Fig. 1, paratype, carapace, OS 8138, dorsal view, ×108; see also Pl. 6, fig. 12. Figs 2–4, carapace, OS 7742; 2, dorsal view, ×129; 3, lateral view from left, ×125; 4, lateral view from right, ×128.

Figs 5–11 *Leptocythere amoena* sp. nov. Figs 5–8, **holotype**, carapace, OS 8150; 5, lateral view from left, ×62; 6, lateral view from right, ×61; 7, dorsal view, ×64; 8, details of surface ornament, ×300. Figs 9, 11, paratype, right valve, OS 8151; 9, internal lateral view, ×77; 11, dorsal view, ×75. Fig. 10, paratype, right valve (broken), OS 8152, internal lateral view, ×65.

Fig. 12 *Tanella* sp. B. Carapace, OS 8126, lateral view from left, ×105.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Callistocythere jugosa sp. nov. Pl. 6, figs 9–12; Pl. 7, figs 1–4

NAME. 'Full of ridges', in reference to the many ridges on the lateral surface.

DIAGNOSIS. A species of *Callistocythere* with the lateral surface covered with undulating ridges; an anteroventral and another posteroventral ridge extend along the margins and slightly modify the lateral outline of the valves.

HOLOTYPE. A right valve, OS 8140. Five paratypes, OS 8141–5. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. Ten specimens, including OS 7742 (FCRM 1575), pl. 7, figs 2–4, and OS 8138–9 (FCRM 1566). The latter are indicated as 'A' in Table 1, p. 260. Also occurs in FCRM 1575.

DESCRIPTION. Carapace small, subquadrate in lateral view, and highest anteriorly. Anterior margin rounded, posterior comparatively narrower. Dorsal margin, modified by the marginal ridge, is straight to slightly arched; ventral margin straight to slightly convex in internal view. In dorsal view, carapace almost lens-shaped. Left valve slightly larger than right but overlap inconspicuous. External surface covered with strong knotty ridges, elongated along the margins. The anteroventral ridge originates near the anterior cardinal angle, follows the anterior margin, then runs along the ventral margin as far as the middle, where it turns upwards and merges into other small posterior ridges. Posterodorsal ridge runs from the posteroventral area towards posterior and dorsal margins, curving slightly behind the anterior margin and ending just above the anteroventral area. The smaller lateral ridges are distributed haphazardly; no particular pattern could be observed. Eye tubercle absent. Duplicature moderately wide along the anterior and posteroventral margins; line of concrescence and inner margin coincide except in upper half of anterior margin, where there is a narrow vestibule. Selvage runs parallel to outer margins except anteriorly, where they coincide. Hinge in left valve consists of an anterior socket, followed by three individual small teeth and a crenulate bar with another socket posteriorly.

DIMENSIONS (μm).	L	H	W
Holotype, right valve OS 8140	340	180	095
Paratype, left valve OS 8141	365	200	080
Carapace OS 8138	425	235	195
Carapace OS 7742	360	200	145

REMARKS. There is a single carapace (OS 7742) from FCRM 1575 (Mid-Oligocene) which is more rectangular and has slightly different ornament, but is morphologically identical with this species. Some other specimens with reduced ridges are classified as Morphotype A. *Leptocythere kiata* Hornibrook 1953 has a very similar outline and ornament, but its truncated posterior margin and slightly different distribution of ridges easily distinguish it. *L. cranekeyensis* Puri 1960 has marginal denticles, a tuberculate posterior rim and very low ridges compared with *C. jugosa*. The Tanzanian species differs from *C. nipponica* Hanai 1957*a* in not having the second marginal rim and in being much smaller.

Genus ***TANELLA*** Kingma, 1948

TYPE SPECIES. *Tanella gracilis* Kingma, 1948.

***Tanella* sp. A** Pl. 8, figs 1–3

FIGURED SPECIMENS. A right valve, OS 8131; a left valve, OS 8127. Sample FCRM 1661, near top of old garnet mine, north Lindi; Lower Miocene. The only material.

DESCRIPTION. Valves small, elongate in side view, ovate with greatest height in the middle. Dorsal margin gently convex, anterior symmetrically rounded, posterior very slightly curved in below. Ventral margin slightly concave before mid-length. External surface reticulate with fossae of varying shapes; muri mostly arranged longitudinally. Reticulation very faint along posterior, posteroventral and anterodorsal margins. Eye spot absent. Duplicature moderately wide; line of concrescence and inner margin separate anteriorly to form a very narrow vestibule. There are four adductor muscle scars and a U-shaped frontal scar. Hinge of right valve consists of a bar thickening at the anterior end to form a low anterior tooth and at the posterior end to give a better-developed posterior tooth. Left valve with complementary elements.

DIMENSIONS (μm).	L	H	W
Right valve OS 8131	380	170	090
Left valve OS 8127	400	205	090

***Tanella* sp. B** Pl. 7, fig. 12

FIGURED SPECIMEN. A carapace, OS 8126. Sample FCRM 1661, near top of old garnet mine, north Lindi; Lower Miocene. The only specimen.

DESCRIPTION. Elongate-ovate in side view, with greatest height in middle. Dorsal margin convex, anterior symmetrically rounded; posterior with marked cardinal angle and rounded posteroventrally; ventral margin concave in anterior half. Surface finely reticulate with low longitudinal ridges. Eye spot absent. No internal features were seen because there were no single valves.

DIMENSIONS (μm).	L	H	W
Carapace OS 8126	435	195	190

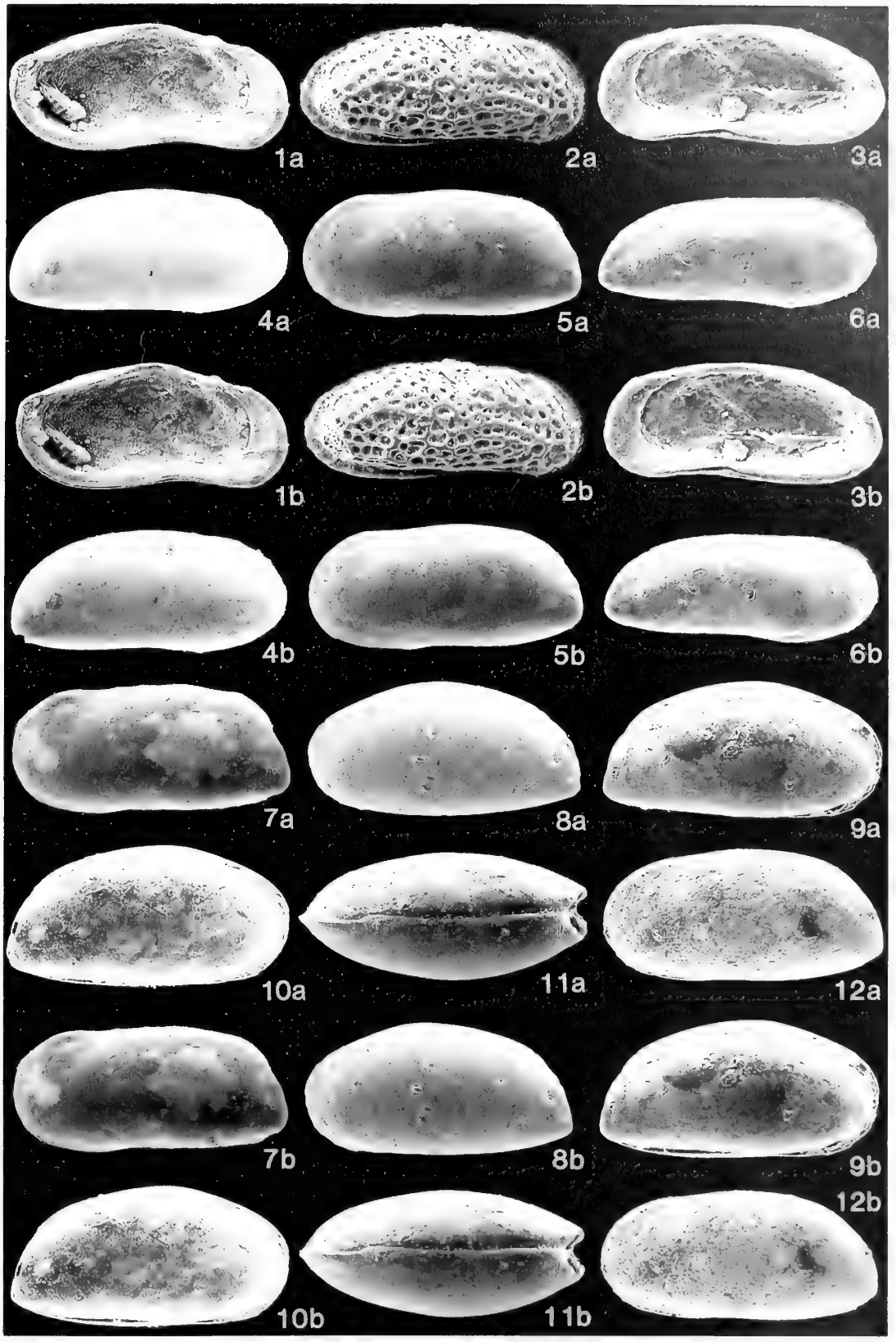
PLATE 8

Figs 1–3 *Tanella* sp. A. Fig. 1, Left valve, OS 8127, internal lateral view, ×113. Figs 2, 3, right valve, OS 8131; 2, external lateral view, ×145; 3, internal lateral view, ×145.

Figs 4–7 *Krithe liebaui* sp. nov. Fig. 4, paratype, female right valve, OS 8161, external lateral view, ×65. Fig. 5, **holotype**, female left valve, OS 8322, external lateral view, ×60. Fig. 6, paratype, male right valve, OS 8323, external lateral view, ×70. Fig. 7, paratype, male left valve, OS 8324, external lateral view, ×60; see also Pl. 9, fig. 9 (slightly more oblique view).

Figs 8–11 *Krithe medioelata* sp. nov. Figs 8, 9, **holotype**, carapace, OS 8166; 8, lateral view from left, ×54; 9, lateral view from right, ×55. Figs 10, 11, paratype, carapace, OS 8167; 10, lateral view from right, ×58; 11, dorsal view, ×59.

Fig. 12 *Krithe burdigalia* sp. nov. Paratype, female carapace, OS 8164, lateral view from left, ×60. See also Pl. 9, fig. 1.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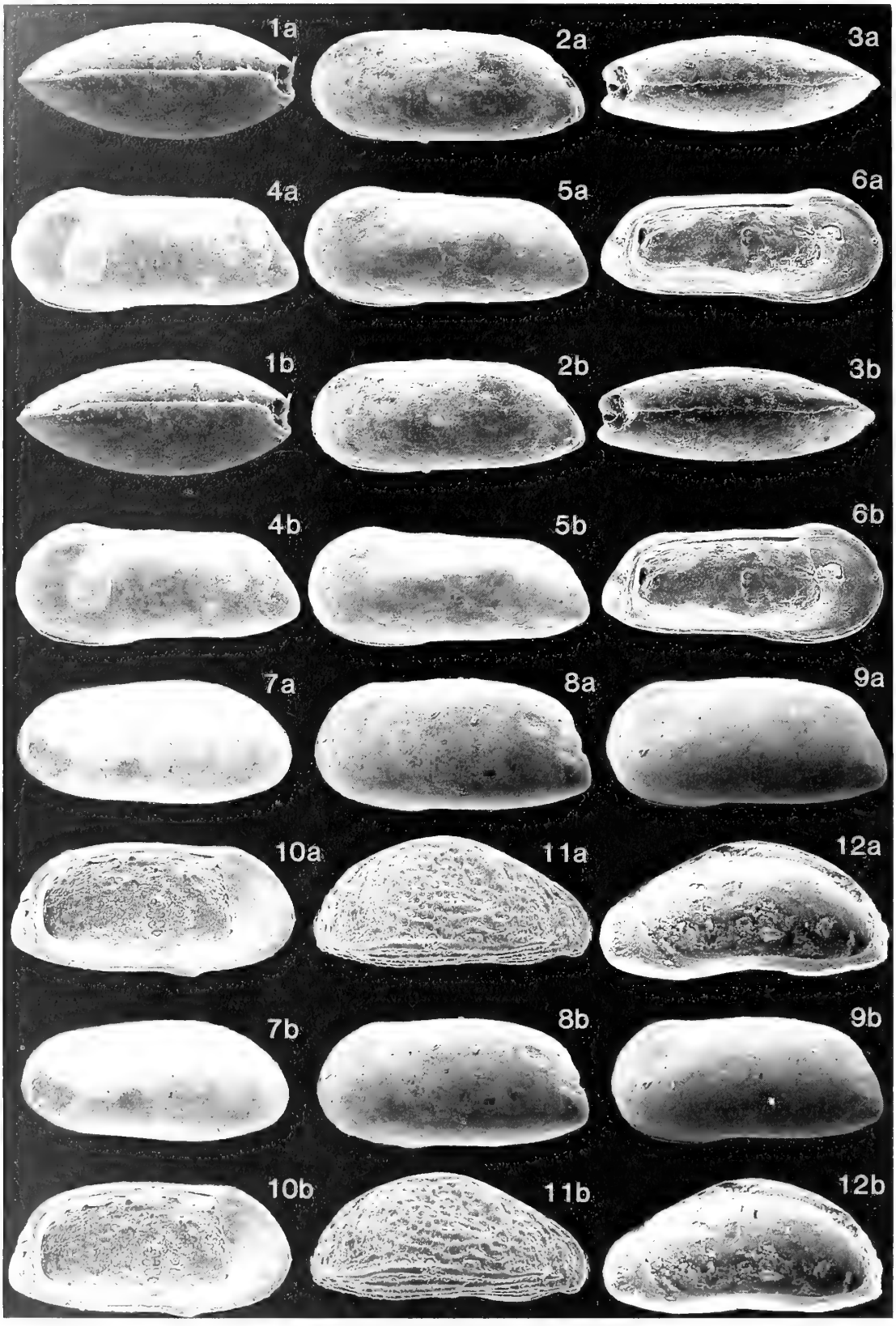
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Family **CYTHERIDEIDAE** Sars, 1925
Subfamily **CYTHERIDEINAE** Sars, 1925

Genus ***CLITHROCYTHERIDEA*** Stephenson, 1936

TYPE SPECIES. *Cytheridea garretti* Howe & Chambers, 1935.

Clithrocytheridea? semiluna sp. nov. Pl. 9, figs 11, 12; Pl. 10, figs 1, 2

NAME. 'Half moon'.

DIAGNOSIS. A more or less egg-shaped species of *Clithrocytheridea*? with carapace inflated ventrally; ventral surface almost flat with four longitudinal ridges in each valve.

HOLOTYPE. A carapace, OS 8154. Four paratypes, OS 8155–8. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Three specimens from the same sample. Also occurs in FCRM 2045.

DESCRIPTION. Carapace egg-shaped in lateral view, with greatest height almost in the middle and greatest width in the mid-ventral half. Anterior and posterior margins almost continuous with dorsal, each junction being marked by a slight angle. Dorsal margin symmetrically and broadly curved in front but sloping and almost straight posteriorly. Ventral margin straight to slightly concave in the middle while the ventrolateral surface is strongly concave. Lateral surface weakly reticulate. A thin, flexuous, sharply defined longitudinal ridge defines the boundary between the lateral and flattened ventral surfaces; the ventral ridge nearest to this is single anteriorly, dividing into two about mid-length; the next is single posteriorly, bifurcating towards the front. There are several more ridges on the ventral surface. Internally, the right hinge consists of crenulate anterior and posterior tooth plates separated by a smooth bar which has a distinct accommodation groove dorsal to it. Other internal features cannot be seen clearly.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8154	405	220	250
Paratype, right valve OS 8155	330	175	130

REMARKS. This Tanzanian species probably does not truly belong to *Clithrocytheridea* and may in fact represent a new genus. It is provisionally placed in it, however, because it resembles that genus in hinge details and general outline. It differs in the outline of its arched dorsal margin and in having ventral ridges; the muscle scars and other internal features are unknown.

Genus ***ROSTROCYTHERIDEA*** Dingle, 1969*a*

TYPE SPECIES. *Rostrocytheridea chapmani* Dingle, 1969*a*.

Rostrocytheridea? sp. Pl. 10, figs 3, 4

FIGURED SPECIMEN. A right valve, OS 7915. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Two valves (e.g. OS 7914) from the same sample.

DESCRIPTION. Right valve subovate to egg-shaped in outline, with greatest height equal to slightly more than half the length. Anterior margin symmetrically rounded, posterior incurved below. Dorsal margin convex, sloping both anteriorly and posteriorly from the greatest height, which is about two-fifths the length from the anterior margin. Ventral margin convex. Lateral surface smooth except for some punctation, mostly concentrated above the centre. Internally, marginal pore canals, muscle scars and hinge are typical of the genus.

DIMENSIONS (μm).	L	H	W
Right valve OS 7915	410	260	140

REMARKS. This Tanzanian species does not belong to *Rostrocytheridea* s. str. but shows an evolutionary intermediate stage between the Cretaceous genus *Rostrocytheridea*, with a pointed posterior margin, and the Miocene–Recent *Cyprideis*, with almost equally rounded posterior and anterior margins.

Family **KRITHIDAE** Brady, Crosskey & Robertson, 1874
Subfamily **KRITHINAE** Mandelstam, 1960

Genus ***KRITHE*** Brady, Crosskey & Robertson, 1874

TYPE SPECIES. *Ilyobates praetexta* Sars, 1866.

Krithe burdigalia sp. nov. Pl. 8, fig. 12; Pl. 9, figs 1–3

NAME. A reference to its occurrence in the Burdigalian (Lower Miocene).

DIAGNOSIS. A species of *Krithe* with marked sexual dimorphism. Presumed males subrectangular in lateral view; females are slightly higher behind the middle.

HOLOTYPE. A male carapace, OS 8163. Two female carapaces, OS 8164–5, are paratypes. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. Four specimens from the same sample.

PLATE 9

Figs 1–3 *Krithe burdigalia* sp. nov. Fig. 1, paratype, female carapace, OS 8164, dorsal view, ×60; see also Pl. 8, fig. 12. Figs 2, 3, **holotype**, male carapace, OS 8163; 2, lateral view from left, ×60; 3, dorsal view, ×61.

Figs 4–6 *Ommatokrithe prolata* Ahmad, 1977*d*. Figs 4, 6, holotype, female left valve, OS 7768; 4, external lateral view, ×59; 6, internal lateral view, ×59. Fig. 5, paratype, male left valve, OS 7769, external lateral view, ×59.

Fig. 7 *Parakrithe cicatricosa* sp. nov. **Holotype**, female left valve, OS 8168, external lateral view, ×86.

Figs 8–10 *Krithe liebaui* sp. nov. Figs 8, 10, paratype, male left valve, OS 8326; 8, external lateral view, ×61; 10, internal lateral view, ×62. Fig. 9, paratype, male left valve, OS 8324, external lateral view, ×61; see also Pl. 8, fig. 7.

Figs 11, 12 *Clithrocytheridea? semiluna* sp. nov. Paratype, right valve, OS 8155; 11, external lateral view, ×136; 12, internal lateral view, ×138.

DESCRIPTION. Sexual dimorphism marked; presumed male almost rectangular, with dorsal and ventral margins parallel, female trapezoidal, being higher and wider behind the middle. Females are also comparatively wider throughout than males. Anterior margin in both sexes symmetrically rounded; posterior margin meets the ventral margin abruptly but is continuous with it and forms part of the posterodorsal curve. Posterior end incised in dorsal view. Left valve overlaps right. Internal features typical of genus; duplicature not well developed and marginal pore canals not easy to see.

DIMENSIONS (μm).	L	H	W
Holotype, male carapace OS 8163	745	320	280
Paratype, female carapace OS 8164	745	375	345

REMARKS. *K. burdigalia* looks very similar to *K. liebaui* but the two can be separated readily; the presumed females of *K. burdigalia* are higher behind mid-length, and the presumed males are not very slender, in both ways being different from *K. liebaui*.

Krithe liebaui sp. nov. Pl. 8, figs 4–7; Pl. 9, figs 8–10; Fig. 7a

NAME. In honour of Dr Alexander Liebau.

DIAGNOSIS. A species of *Krithe* with thirteen marginal pore canals along the anterior and three along the mid-ventral margin. There is marked sexual dimorphism.

HOLOTYPE. A female left valve, OS 8322. Four paratypes, OS 8161, 8323, 8324, 8326. Sample FCRM 1737, South Mtwero; Lower Miocene.

OTHER MATERIAL. Seventeen complete specimens and 15 broken ones, from the same sample. Also occurs in FCRM 1738, 1742.

DESCRIPTION. Shape of carapace depends on sex of specimen; right valves of presumed males slender and subtriangular with greatest height at the anterior cardinal angle. Right valves in females have the greatest height in the middle; female left valves have dorsal and ventral margins almost straight and parallel. Anterior margins rounded in both sexes; posterior margins acutely angled in lateral view and incised in dorsal view. Surface smooth. Internally, duplicature broad; line of concrescence and inner margin separated, forming a comparatively wide anterior vestibule. Inner margin U-shaped and slightly broader towards the front. Selvage runs peripherally except at the posterior margin, where it runs well inside the lateral outline, giving the posterior an indented appearance. Seen from inside, the posterior margin is divided into two compartments. Marginal pore canals, about thirteen anteriorly and three ventrally, are mostly simple and more or less straight; for descriptive purposes they are numbered. MPC 1′ is false and is the only one running in the dorsal half of the anterior margin. MPC 2 and 3 have a common origin and in some specimens do not separate until mid-length.

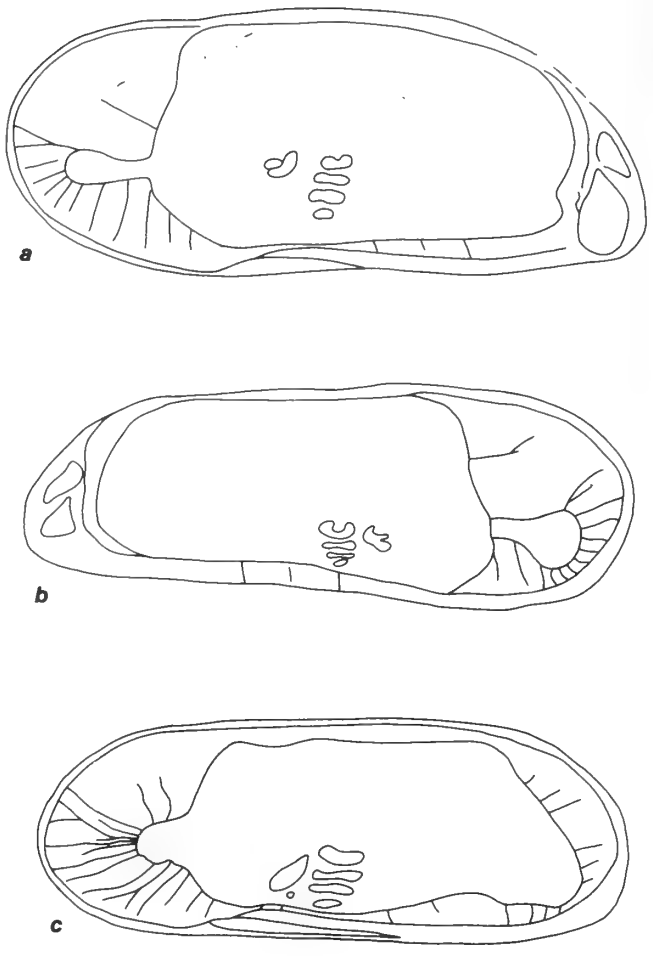


Fig. 7 Krithidae. Internal lateral views showing nature of marginal pore canals and muscle scar patterns. a, *Krithe liebaui* sp. nov. Paratype, ♀ right valve OS 8161. ×120. b, *Ommatokrithe prolata* Ahmad. Holotype, ♀ left valve OS 7768. ×100. c, *Parakrithe cicatricosa* sp. nov. Paratype, ♀ right valve OS 8169. ×150.

DIMENSIONS (μm).	L	H	W
Holotype, female left valve OS 8322	750	375	190
Paratype, male right valve OS 8323	760	320	150
Paratype, male left valve OS 8324	755	370	190
Paratype, male left valve OS 8326	745	380	195
Paratype, female right valve OS 8161	705	345	170

REMARKS. *K. cubensis* van den Bold 1946 has more numerous marginal pore canals in the dorsal half of the anterior margin and along the posterior margin. In general shape and marginal pore canal pattern, *K. dolichodeira* van den Bold 1946, from the Miocene of the Caribbean region, resembles *K. liebaui*, but *K. dolichodeira* has shorter marginal pore canals and is also smaller; it has a length of about 560 μm compared with over 700 μm for *K. liebaui*. *K. hiwanneensis* Howe &

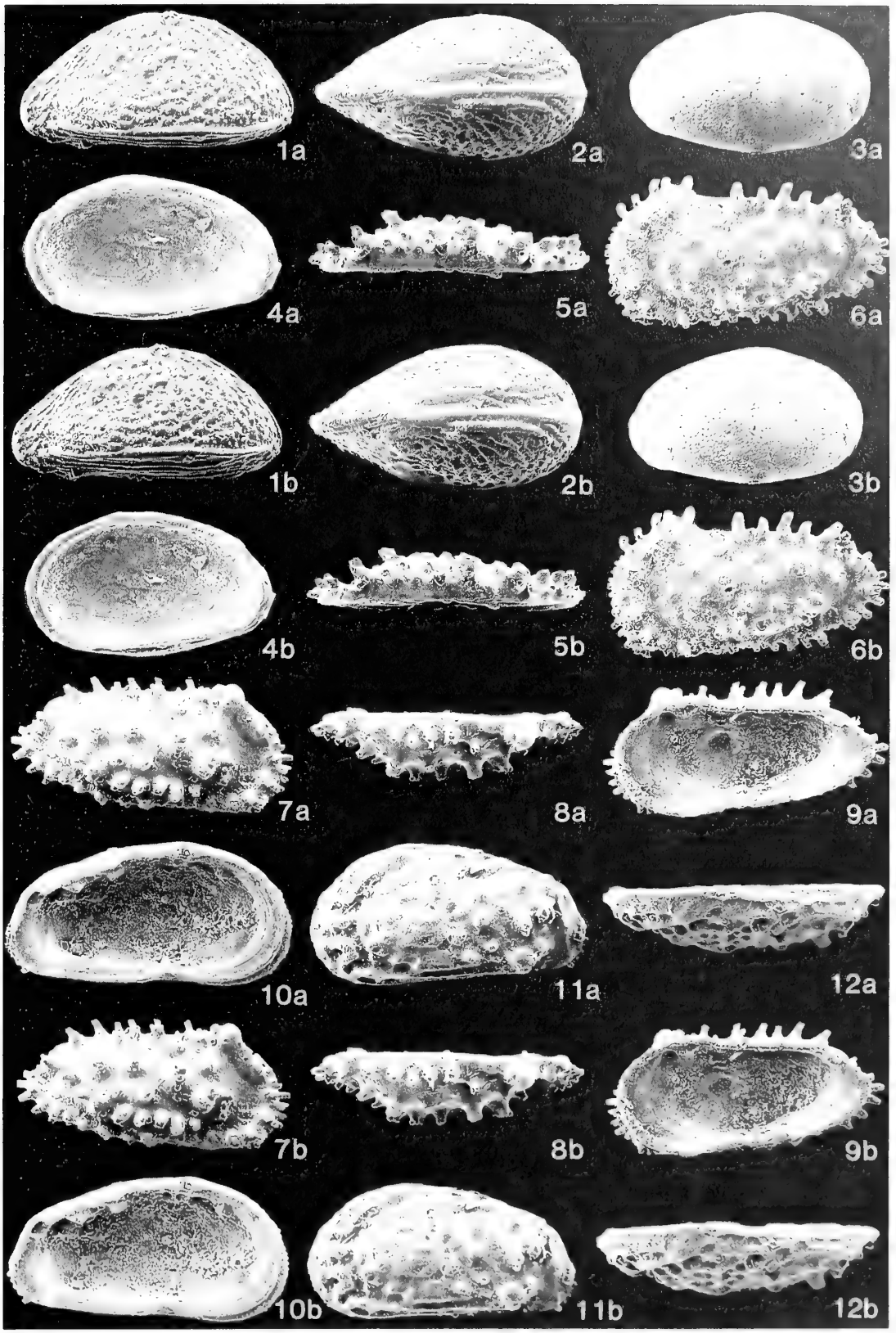
PLATE 10

Figs 1, 2 *Clithrocytheridea? semiluna* sp. nov. **Holotype**, carapace, OS 8154; 1, lateral view from left, ×109; 2, dorsal view, ×109.

Figs 3, 4 *Rostrocytheridea?* sp. Right valve, OS 7915; 3, external lateral view, ×95; 4, internal lateral view, ×100.

Figs 5–9 *Trachyleberis duplex* sp. nov. Figs 5, 6, **holotype**, left valve, OS 7834; 5, dorsal view, ×56; 6, external lateral view, ×56. Figs 7–9, paratype, right valve, OS 7833; 7, external lateral view, ×48; 8, dorsal view, ×47; 9, internal lateral view, ×48.

Figs 10–12 *Gujaratella? tanzaniensis* sp. nov. **Holotype**, left valve, OS 7835; 10, internal lateral view, ×89; 11, external lateral view, ×86; 12, dorsal view, ×88.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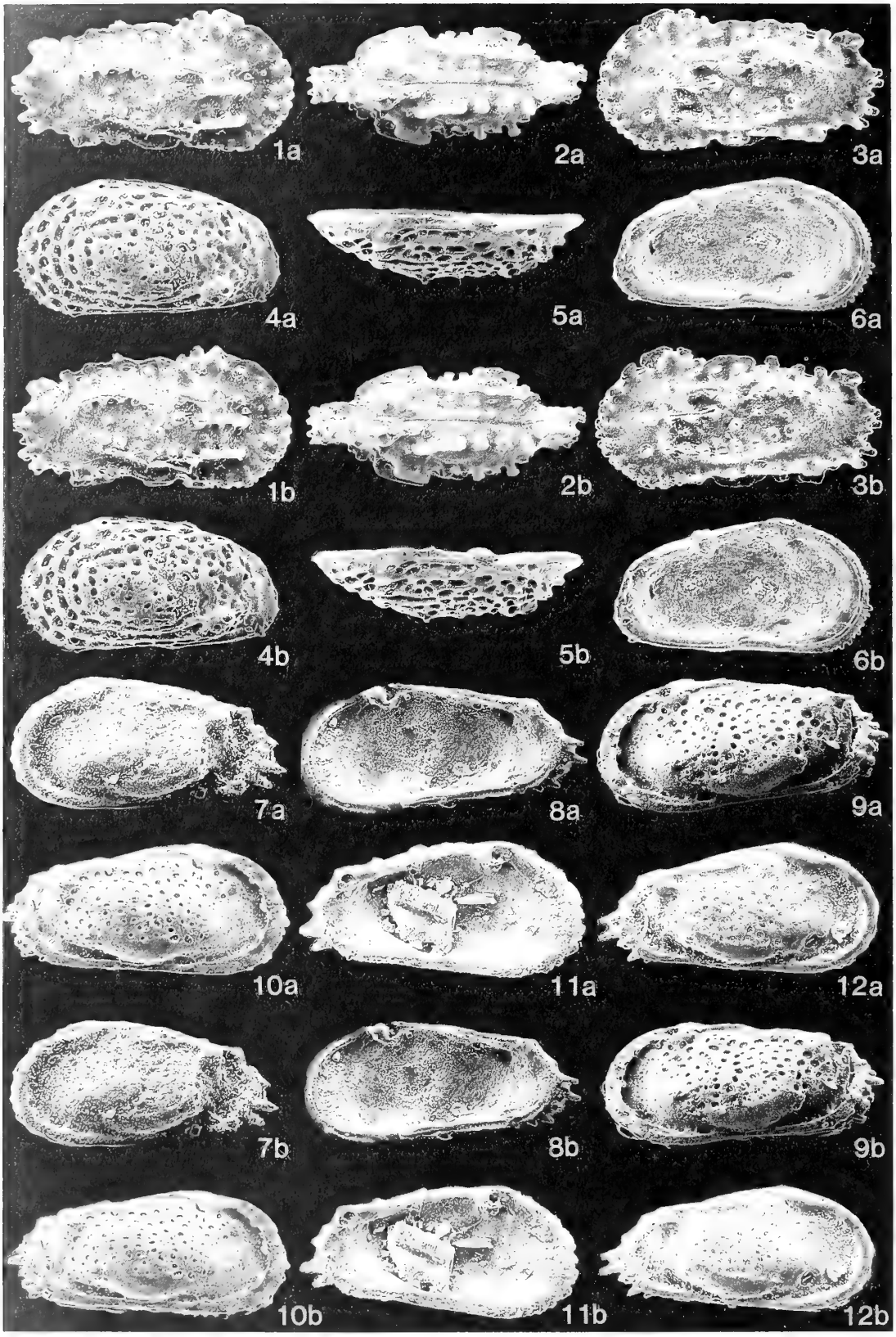
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Lea (*in* Howe & Law 1936) has shorter marginal pore canals. *K. perattica* Alexander 1934 resembles *K. liebaui* in general shape and in having the ends of the marginal pore canals thickened; however, the latter has marginal pore canals concentrated along the anterior margin while the former has them distributed all along the ventral and posterior margins. *K. sawanensis* Hanai 1959, from the Upper Pliocene of Japan, is easily distinguished from the Tanzanian species by its larger size, greater number of false marginal pore canals interspersed between true ones, and less pronounced sexual dimorphism.

Krithe medioelata sp. nov. Pl. 8, figs 8–11

NAME. 'Highest in the middle'.

DIAGNOSIS. A species of *Krithe* with the greatest height in the middle or slightly in front of it. Dorsal margin strongly arched.

HOLOTYPE. A carapace, OS 8166. A carapace, OS 8167, is a paratype. Sample FCRM 2034, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Three specimens from the same sample.

DESCRIPTION. Carapace subovate in lateral view with the greatest height slightly in front of the middle and greatest width almost at mid-length. Anterior margin rounded, dorsal strongly arched, ventral margin almost straight. Carapace lens-shaped in dorsal view, with a strongly incised posterior margin. No sexual dimorphism apparent. Left valve overlaps right. Lateral surface smooth, eye tubercle absent. Internal features typical of the genus; marginal pore canals not visible in the only single valve found intact.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8166	820	435	390
Paratype, carapace OS 8167	790	425	375

REMARKS. *K. echolsae* Esker 1968, from the Danian of Tunisia, has a curved posterodorsal margin compared with the sloping margin of *K. medioelata*. *K. whitecliffensis* Crane 1965, *K. rutoti* Keij 1957, *K. cubensis* van den Bold 1946, *K. contracta* Oertli 1961, *K. langhiana* Oertli 1961, *K. galei* Crouch 1949, and some other species with similar outlines can be distinguished from *K. medioelata* by the fact that their greatest height in lateral view is behind the middle rather than in front of it as in the Tanzanian species.

Genus ***OMMATOKRITHE*** Ahmad, 1977*d*

TYPE SPECIES. *Ommatokrithe prolata* Ahmad, 1977*d*.

Ommatokrithe prolata Ahmad, 1977*d*
Pl. 9, figs 4–6; Fig. 7b

1977*d* *Ommatokrithe prolata* Ahmad: 131–134.

HOLOTYPE. A female left valve, OS 7768. Paratypes, three single valves, OS 7769–71. Sample FCRM 1737, South Mtwero; Lower Miocene.

OTHER MATERIAL. Four single valves from the same sample. Also occurs in FCRM 1738.

DESCRIPTION. Carapace elongate, subrectangular in lateral view, with dorsal and ventral margins straight and parallel; anterior margin rounded, posterior obliquely truncate. Posterior incised in dorsal view; posterior end divided into two compartments internally, behind the selvage. Lateral surface smooth except for a glassy round eye-tubercle just below anterior cardinal angle. Internally, duplicature wide. Inner margin and line of concrescence separated in the mid-anterior region, where there is a moderately wide vestibule. Inner margin extends anteriorly for a considerable distance; marginal pore canals are therefore short; for descriptive purposes they are numbered. MPC 1 occurs in the dorsal half and is long; MPC 2 and 3 bifurcate from a common canal; 4 to 12 are short, straight and parallel; 13 is elongate and curves towards the front; 14 runs along the inner margin; the ventral canals 15 to 17 occur along the midventral margin, MPC 16 being false. Normal pores large, sieve type and regularly distributed. Muscle scar pattern consists of four adductor scars decreasing in size from top to bottom, with a three-fold frontal scar and five to seven dorsal ones. Hinge adont, partly crenulate in the posterior quarter.

DIMENSIONS (μm).	L	H	W
Holotype, female left valve OS 7768	785	375	170
Paratype, male left valve OS 7769	780	365	175

REMARKS. So far, no other Krithidae species with an eye tubercle has been described.

Genus ***PARAKRITHE*** van den Bold, 1958*a*

TYPE SPECIES. *Cytheridea* (*Dolocytheridea*) *vermunti* van den Bold, 1946.

Parakrithe cicatricosa sp. nov. Pl. 9, fig. 7; Fig. 7c

NAME. 'Scarred', in reference to the large number of dorsal muscle scars.

DIAGNOSIS. A species of *Parakrithe* with a large number of dorsal muscle scars, and 16 anterior marginal pore canals, about half of which are false. Sexual dimorphism present.

HOLOTYPE. A female left valve, OS 8168. Paratype a female right valve, OS 8169. Sample FCRM 1737, South Mtwero; Lower Miocene.

OTHER MATERIAL. 48 specimens from samples FCRM 1737, 1738, 1742, 1989, 2014, 2016.

DESCRIPTION. Carapace small, elongate, and subrectangular to subovate in lateral view. Anterior margin symmetrically rounded, posterior subrounded, rather broadly curved in the

PLATE 11

Figs 1–3 *Carinocythereis* sp. Carapace, OS 7991; 1, lateral view from right, ×71; 2, dorsal view, ×70; 3, lateral view from left, ×71.

Figs 4–6 Genus B sp. Left valve, OS 8113; 4, external lateral view, ×74; 5, dorsal view, ×79; 6, internal lateral view, ×74.

Figs 7–12 *Occultocythereis africana* sp. nov. Figs 7, 11, paratype, female left valve, OS 7974; 7, external lateral view, ×89; 11, internal lateral view, ×92. Figs 8, 12, paratype, female right valve, OS 7972; 8, internal lateral view, ×91; 12, external lateral view, ×89. Figs 9, 10, **holotype**, female carapace, OS 7976; 9, lateral view from left, ×107; 10, lateral view from right, ×107.

upper half and narrowly curved in the lower. Sexual dimorphism occurs; dorsal and ventral margins diverge posteriorly in presumed females but are almost parallel in presumed males. Lateral surface smooth and without an eye tubercle. Internally, duplicature moderately wide, with a fairly wide anterior vestibule. About 30 straight marginal pore canals, 16 of them along the anterior margin, where true marginal pore canals are interspersed with false ones. Muscle scar pattern consists of four adductor scars arranged in a vertical row, with an elongate scar in front and seven to eight dorsal scars. Normal pores large, sieve type and widely scattered.

DIMENSIONS (μm).	L	H	W
Holotype, female left valve OS 8168	520	260	140

REMARKS. A large number of carapaces from places other than the type locality are almost identical in outline but it was not possible to see their marginal pore canals. These specimens are tentatively classified as *P. cicatricosa*.

Family **TRACHYLEBERIDIDAE** Syvester-Bradley, 1948
Subfamily **TRACHYLEBERIDINAE** Sylvester-Bradley, 1948
Tribe **TRACHYLEBERIDINI** Sylvester-Bradley, 1948

Genus ***TRACHYLEBERIS*** Brady, 1898

TYPE SPECIES. *Cythere scabrocuneata* Brady, 1880.

Trachyleberis duplex sp. nov. Pl. 10, figs 5–9

NAME. 'Double', with reference to anterior and ventral spines occurring in pairs.

DIAGNOSIS. A species of *Trachyleberis* with a double row of spines along the anterior margin and another along the ventral margin. Anterior cardinal angle well marked.

HOLOTYPE. A female left valve, OS 7834. Paratype a male right valve, OS 7833. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene. No other material.

DESCRIPTION. Carapace elongate in side view, greatest length at mid-height and greatest height at anterior cardinal angle. Anterior margin evenly rounded, a double row of spines following the curve; outer spines smaller and more numerous than inner ones, evenly spaced and well developed. Posterior margin triangular, with spines, mostly bifid. Dorsal margin straight, with a row of spines, also mostly bifid. Ventral margin straight or slightly curved, with a double row of spines. Surface spiny, especially medially, where there is a scattered row, usually arranged in a zigzag way. Eye tubercle with a strong spine just behind it. Inner margin and line of concrescence coincide; hinge holamphidont. Other internal features typical of genus.

DIMENSIONS (μm).	L	H	W
Holotype, female left valve OS 7834	815	465	240
Paratype, male right valve OS 7833	955	475	240

REMARKS. The pattern of ornament is similar to that of *T. pennyi* Neale 1975 from the Santonian of Western Australia, but in side view the Tanzanian species has a more triangular posterior end and strongly projecting anterodorsal margin. It is also larger than *T. pennyi*.

Genus ***GUJARATELLA*** Khosla, 1978

TYPE SPECIES. *Gujaratella boldi* Khosla, 1978.

Gujaratella*? *tanzaniensis sp. nov. Pl. 10, figs 10–12

NAME. 'From Tanzania'.

DIAGNOSIS. A tuberculate species with reduced anterior denticulation and no spines, but with a well developed anterior vestibule.

HOLOTYPE. A female left valve, OS 7835. Paratype a female left valve, OS 7837. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene. The only surviving specimens, but see 'Remarks' below.

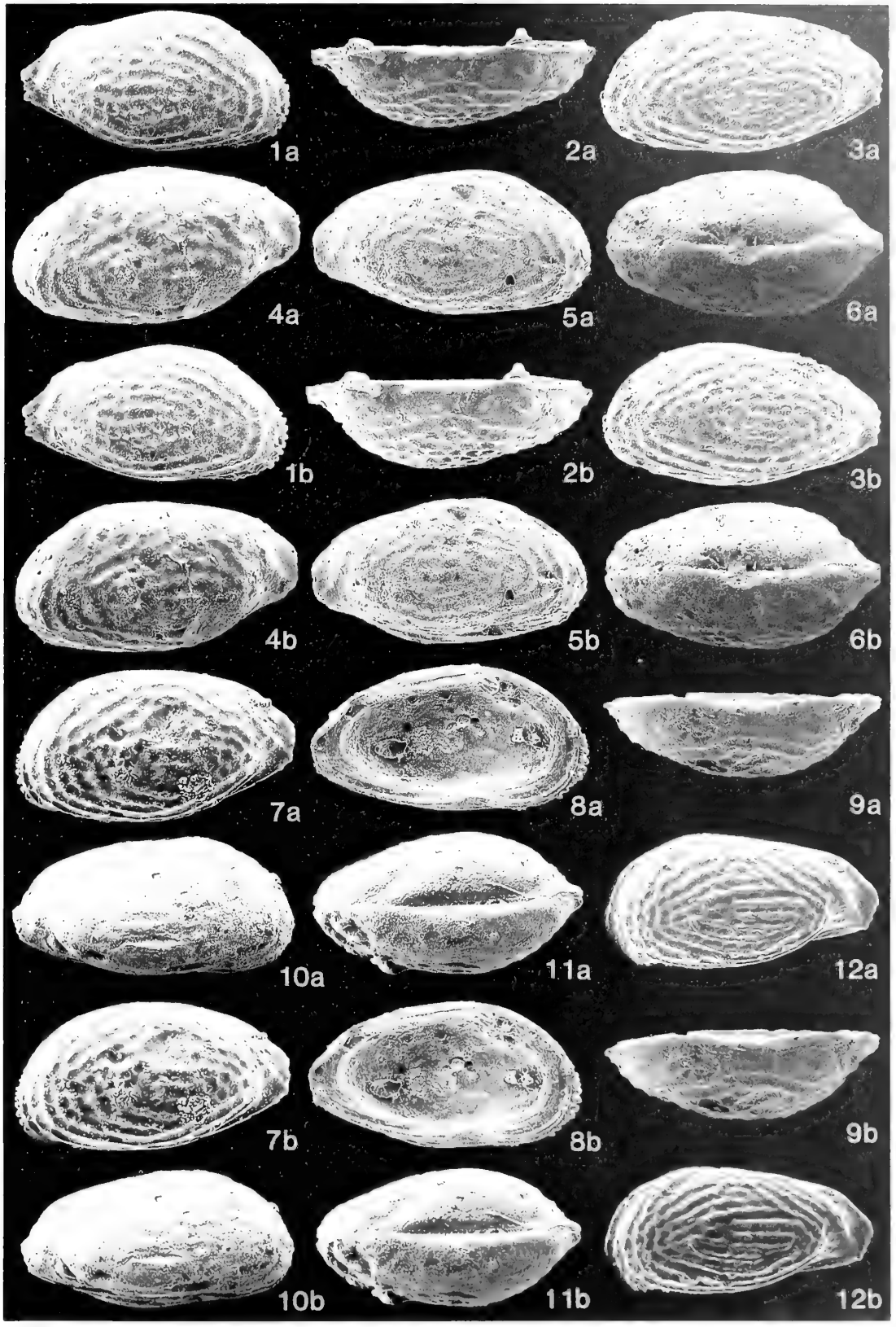
DESCRIPTION. Carapace shape determined by sexual dimorphism; in side view presumed males are elongate, subrectangular, with a straight dorsal margin and a straight or slightly concave ventral margin, these two margins converging posteriorly. Female has dorsal margin slightly arched, subparallel to ventral margin. Anterior margin evenly rounded, posterior rather produced below, and the posterodorsal margin slightly concave. Greatest height at the anterior cardinal angle and greatest length along ventral side. External surface tuberculate. Eye tubercle elongate, running into the anterior marginal rim, which consists of a semicircular double line of tubercular spines joined to each other so as to form semicircular enclosures open towards the front. Subcentral tubercle an elongated swollen boss. Anteroventral complex consists of three or four tubercles joined together and merging into a thin ventral ridge with another thin ridge below. Other ubercles, of various sizes, have normal pore canals opening at their tips. Internally, duplicature moderately wide, inner margin and line of concrescence separate; there is a fairly wide vestibule. Selvage placed almost at the middle of the duplicature, well developed and following a sinuous course along the ventral margin. Muscle scars cannot be seen clearly. Hinge of right valve consists of an anterior tooth with distal part low and proximal part higher; median groove crenulate and posterior tooth slightly elongate and smooth. Immediately below and in front of the anterior hinge tooth there is a prominent ocular sinus. Hinge of left valve complementary to that of right.

DIMENSIONS (μm).	L	H	W
Holotype, female left valve OS 7835	515	285	140

REMARKS. Unfortunately it has not been possible to figure the one male specimen of this species that was found, because of its fragility. The species is provisionally placed in the genus

PLATE 12

Figs 1–12 *Leguminocythereis dinglei* sp. nov. Figs 1, 2, paratype, male carapace, OS 8195; 1, lateral view from right, ×55; 2, dorsal view, ×57. Fig. 3, paratype, male carapace, OS 8196, lateral view from left, ×60. Figs 4–6, **holotype**, female carapace, OS 8194; 4, lateral view from left, ×57; 5, lateral view from right, ×54; 6, dorsal view, ×55. Figs 7–9, paratype, female left valve, OS 8198; 7, external lateral view, ×58; 8, internal lateral view, ×57; 9, dorsal view, ×58. Figs 10, 11, paratype, male carapace, OS 8199; 10, lateral view from right, ×48; 11, dorsal view, ×46. Fig. 12, paratype, juvenile? left valve, OS 8200, external lateral view, ×67.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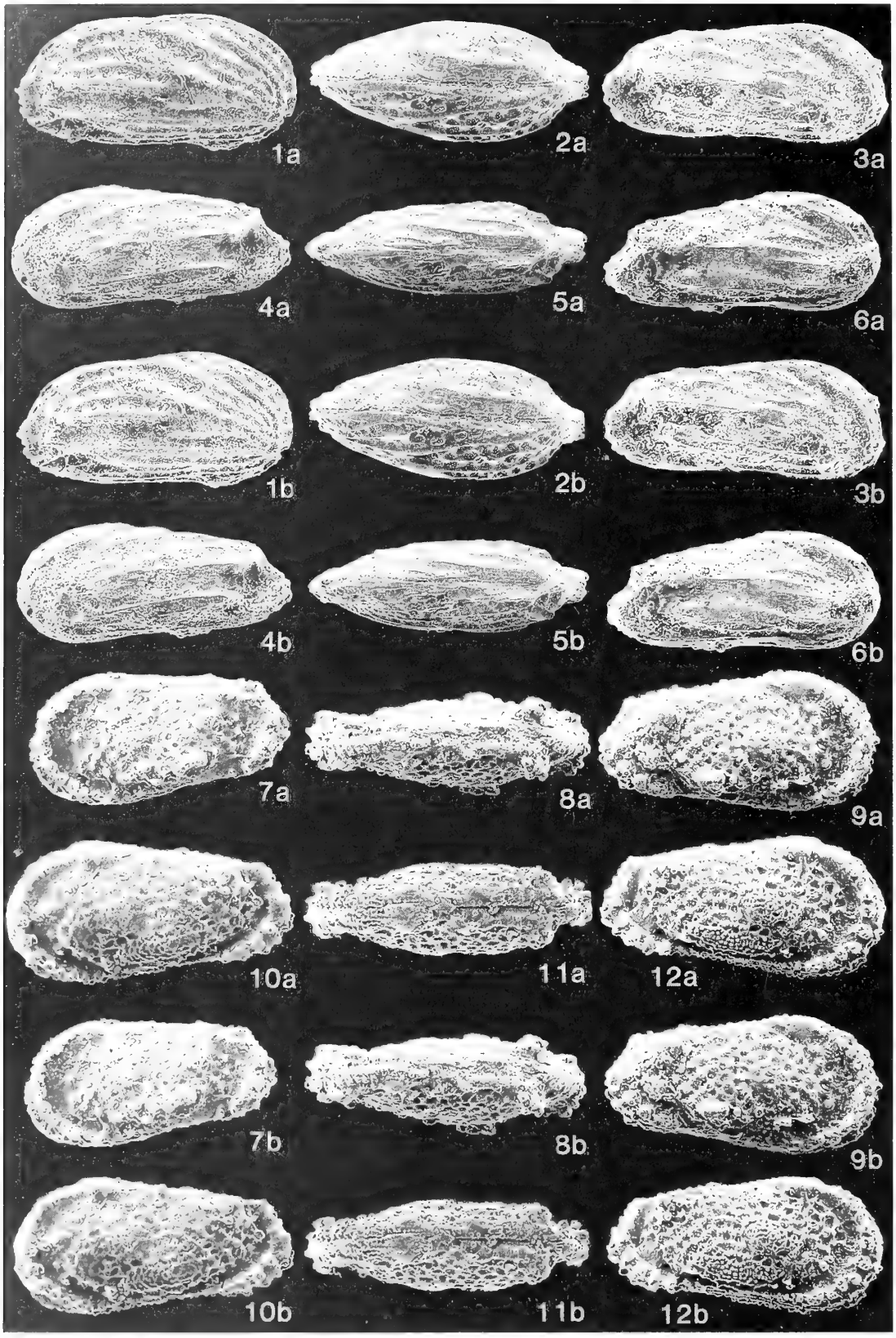
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Gujaratella because of its external appearance, although it has a distinct anterior vestibule not found in that genus. The muscle scars and marginal pore canals were not clearly observed in this material.

Genus ***HAUGHTONILEBERIS*** Dingle, 1969*b*

TYPE SPECIES. *H. haughtoni* Dingle, 1969*b*.

Haughtonileberis radiata Dingle 1976 Pl. 13, figs 1–2

1976 *Haughtonileberis radiatus* (sic, recte *radiata*) Dingle: 46.

1976 *Leguminocythereis*? sp. 1 of Dingle: 44; fig. 6 (a, b); fig. 10 (23).

FIGURED SPECIMEN. A female carapace, OS 8174. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. One right valve (OS 7810), also from FCRM 1578. Also occurs in FCRM 1576.

DIMENSIONS (μm).	L	H	W
Female carapace OS 8174	895	435	380

REMARKS. Originally described from the Upper Oligocene–Upper Eocene of borehole SOEKOR JC-I off the coast of Natal, South Africa. The species described as *Leguminocythereis*? sp. 1 by Dingle in the same paper is, in the present authors' view, a female dimorph of *H. radiata*.

Haughtonileberis rastapuriensis sp. nov. Pl. 13, figs 3–6

NAME. After the type locality, Ras Tapuri.

DIAGNOSIS. A species of *Haughtonileberis* with a prominent dorsal ridge curving towards, but stopping short of, the median ridge, which bifurcates in the anterior half of the valve. There are two ventrolateral ridges joined at their posterior ends, and an ocular ridge along the anterodorsal margin.

HOLOTYPE. A male carapace, OS 7802. Two paratypes, OS 7803, OS 7804. Sample FCRM 1575, shore south-west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Six specimens in the BM(NH) from the same sample, including OS 7807. Another 20 specimens from FCRM 2010, Lower Miocene, are kept at the BP Research Centre, Sunbury-on-Thames. Also occurs in FCRM 1574, 1576 and 1578.

DESCRIPTION. Carapace medium-sized, elongate in side view, tapering posteriorly, with greatest height at anterior cardinal angle. Anterior margin rounded, dorsal margin straight and sloping towards posterior. Ventral margin straight to slightly concave; posteroventral margin convex and posterodorsal concave. Sexes distinct, presumed males being slightly more slender and elongated than presumed females. External ornament consists of a series of ridges. There is a dorsal ridge, slightly concave downward, in the anterior half; a median ridge, bifid in the anterior part and curved dorsally at the posterior end in some specimens; a pair of ventrolateral ridges joined at their posterior ends; and an ocular ridge running along the anterodorsal margin. Two short ridges lie between the dorsal and median ones, and another two lie ventral to the ventrolateral ridges; of these last, one is short and lies in the middle third, while the other, longer, lies in the anterior half of the length. Duplicature fairly wide; marginal pore canals fine, straight and simple; there are 10 or 11 anteriorly and 6 or 7 posteriorly, the latter tending to occur in pairs. There are four adductor muscle scars in a vertical row, decreasing in size from dorsal to ventral; the two uppermost join at their posterior ends; and there is a V-shaped frontal scar which opens upwards. Hinge typical of genus, consisting of an anterior tooth, a small postjacent socket, a crenulate groove in the median section and a round knob-like posterior tooth in the right valve.

DIMENSIONS (μm).	L	H	W
Holotype, male carapace OS 7802	735	305	240
Paratype, female carapace OS 7803	700	310	250

REMARKS. The Lower Miocene specimens (FCRM 2010) are comparatively large (L = 800 μm), and have slightly less ornamentation, but otherwise seem to be the same species as *H. rastapuriensis*; they and the Mid-Oligocene specimens are therefore included in that species. It was difficult to decide whether *H. rastapuriensis* should be a new species, a subspecies or a morphotype of *H. fissilis* Dingle 1969*b*. The two are extremely close in general shape, ornament and other features. However, the Tanzanian species is larger and has two ventrolateral ridges instead of the single ridge of the South African species. The two are also from very different horizons; the South African species is reported from the Upper Senonian (?Upper Cretaceous) of Pondoland, while the Tanzanian species comes from Mid-Oligocene and Lower Miocene samples. For all these reasons, the new species is regarded as distinct from *H. fissilis*. There are some specimens from samples JOZ 889 and JOZ 896, from the Pliocene of the coastal area between Pangani, Tanzania, and Mombasa, Kenya, which are more akin to *H. fissilis*; these are hard to reconcile with the distribution of the present species, which occurs both geologically and geographically between the JOZ specimens and those from South Africa.

Genus ***ACANTHOCYTHEREIS*** Howe, 1963

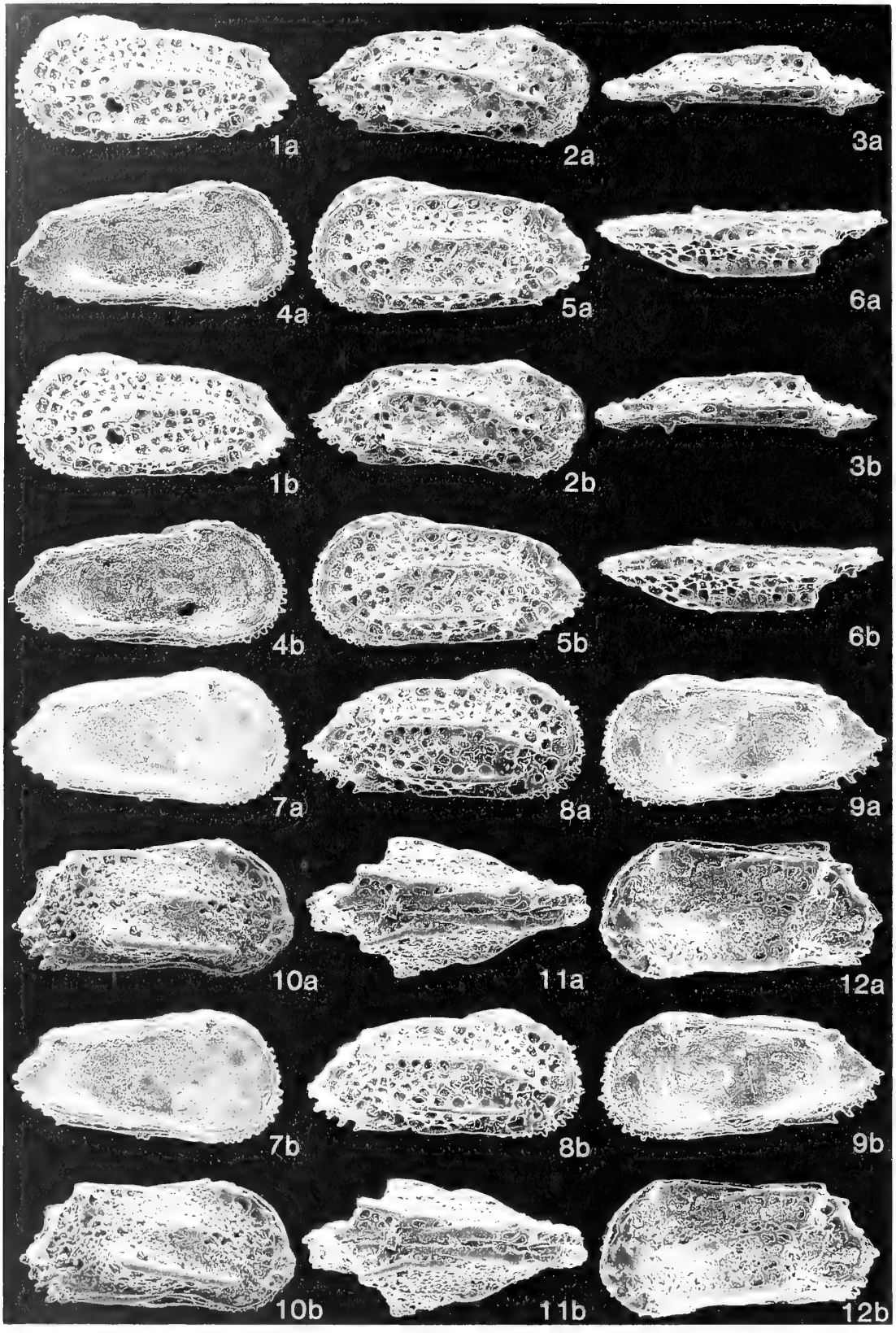
TYPE SPECIES. *Acanthocythereis araneosa* Howe, 1963.

PLATE 13

Figs 1, 2 *Haughtonileberis radiata* Dingle, 1976. Female carapace, OS 8174; 1, lateral view from right, ×51; 2, dorsal view, ×50.

Figs 3–6 *Haughtonileberis rastapuriensis* sp. nov. Figs 3, 5, **holotype**, male carapace, OS 7802; 3, lateral view from right, ×63; 5, dorsal view, ×61. Figs 4, 6, paratype, female carapace, OS 7803; 4, lateral view from left, ×64; 6, lateral view from right, ×64.

Figs 7–12 *Acanthocythereis postcornis* Siddiqui, 1971. Figs 7–9, female carapace, OS 8331; 7, lateral view from left, ×98; 8, dorsal view, ×107; 9, lateral view from right, ×106. Figs 10–12, male carapace, OS 8330; 10, lateral view from left, ×99; 11, dorsal view, ×99; 12, lateral view from right, ×98.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Acanthocythereis postcornis Siddiqui, 1971 Pl. 13, figs 7–12

1971 *Trachyleberis* (*Acanthocythereis*) *postcornis* Siddiqui: 82; pl. 41, figs 9, 10; pl. 42, figs 1, 2, 7, 10.

FIGURED SPECIMENS. Two carapaces, a male OS 8330, and a female OS 8331. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Three carapaces (OS 8332–4) from sample FCRM 1575. Also occurs in FCRM 1578.

DIMENSIONS (μm).	L	H	W
Male carapace OS 8330	460	240	160
Female carapace OS 8331	420	230	160

REMARKS. The Tanzanian specimens differ slightly from the holotype of this species, showing characters reminiscent of *Acanthocythereis procapsus* (Siddiqui 1971); they could be placed in either species. However, because of their size and distinctive posterodorsal process, they appear closer to *A. postcornis* and are so classified here.

Genus ***FALSOCYTHERE*** Ruggieri, 1972

TYPE SPECIES. *Occultocythereis? maccagnoi* Ciampo, 1971.

Falsocythere maccagnoi (Ciampo, 1971) Pl. 17, figs 4–6

1971 *Occultocythereis? maccagnoi* Ciampo: 27; pl. 2, figs 7–9; pl. 3, fig. 1; pl. 7, fig. 1.
1972 *Falsocythere maccagnoi* (Ciampo) Ruggieri: 91.
1975 *Falsocythere maccagnoi* (Ciampo); Bonaduce, Ciampo & Masoli: 51; pl. 26, figs 6–7.

FIGURED SPECIMEN. A left valve, OS 7820. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene. The only specimen.

DIMENSIONS (μm).	L	H	W
Left valve OS 7820	480	240	130

REMARKS. The Tanzanian specimen has a slightly more concave posterodorsal margin than Ciampo's species, but this is the only apparent difference.

Tribe **COSTAINI** Hartmann & Puri, 1974

Genus ***CARINOCYTHEREIS*** Ruggieri, 1956

TYPE SPECIES. *Cytherina carinata* Roemer, 1838.

Carinocythereis sp. Pl. 11, figs 1–3

FIGURED SPECIMEN. A carapace, OS 7991. Sample FCRM 1575, shore south-west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Two specimens from Sample FCRM 1578 (OS 8335–6). Also occurs in FCRM 1576, 1578.

DESCRIPTION. Carapace subrectangular with greatest height at anterior cardinal angle; valves very slightly tapering behind. Anterior margin symmetrically rounded, posterior truncate to somewhat rounded, both margins being denticulate. Dorsal and ventral margins modified by marginal ridges; these appear straight, subparallel, and slightly converging behind. Anterodorsal margin protrudes above prominent glassy eye tubercle. Surface ornamentation consists of an anterior peripheral rim joined to a ventral ridge which continues along the posterior margin. There are four other ridges, all with contiguous undercut clavae in the anterior third and with spines in the posterior two-thirds. Except for occasional spines and/or tubercles between the ridges, the lateral surface is smooth.

DIMENSIONS (μm).	L	H	W
Carapace OS 7991	645	350	300

REMARKS. The Tanzanian specimens have carapaces intermediate in shape between the European *Carinocythereis* and the Indo-Pacific *Ponticocythereis*. Unfortunately only three specimens were found, one of which was not well preserved, and no detailed work was possible.

Genus ***COSTA*** Neviani, 1928

TYPE SPECIES. *Cytherina edwardsi* Roemer, 1838 (subsequent designation, Howe 1955).

Costa? hullina sp. nov. Pl. 14, figs 10–12; Pl. 15, figs 1–3

NAME. After the University of Hull, Great Britain.

DIAGNOSIS. A species of *Costa*(?) with a weakly developed median ridge which curves dorsally and joins the better-developed dorsal ridge. Fossae mostly crimped and very variable in shape.

HOLOTYPE. A carapace, OS 7715. Another carapace, OS 7716, a juvenile, is a paratype. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Three specimens from samples FCRM 2033, 2034.

DESCRIPTION. Carapace subquadrate in lateral view, slightly tapering towards posterior margin; greatest height at the anterior angle and greatest width at about one-third of the length from posterior end. Anterior margin broadly rounded, posterior slightly concave above the middle and straight to slightly curved below. Dorsal margin straight, slightly modified by the dorsal ridge, and sloping towards the posterior. Ventral margin straight to slightly concave anteriorly. Right valve overlaps left. Surface ornament consists of three lateral ridges with pitted intercostal areas. Dorsal and ventral ridges strongly developed, former occurring only in posterior half

PLATE 14

Figs 1–9 *Costa trudis* Ahmad, 1977*c*. Figs 1, 4, 6, holotype, male left valve, OS 7692; 1, external lateral view, ×55; 4, internal lateral view, ×54; 6, dorsal view, ×55. Figs 2, 3, paratype, male right valve, OS 7693; 2, external lateral view, ×53; 3, dorsal view, ×53. Figs 5, 7, paratype, female left valve, OS 7694; 5, external lateral view, ×55; 7, internal lateral view, ×54. Figs 8, 9, paratype, female right valve, OS 7695; 8, external lateral view, ×54; 9, internal lateral view, ×55.

Figs 10–12 *Costa? hullina* sp. nov. **Holotype**, carapace, OS 7715; 10, lateral view from right, ×56; 11, dorsal view, ×58; 12, lateral view from left, ×57.

and latter mostly in anterior half; both these ridges curve upwards at the posterior end. Median ridge weakly developed and curves upward to join dorsal ridge at the back. Subcentral tubercle forms part of median ridge just in front of mid-length. Fossae in intercostal areas variable in shape and have crimped margins. Anteroventral and posteroventral margins denticulate, denticles along the posterior margin being fewer and stronger than the anterior ones. Eye tubercle well developed. As no single valves were found no interior details were seen.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 7715	805	390	400
Paratype (juvenile), carapace OS 7716	650	325	260

REMARKS. Except for the weakly developed median ridge, *Costa*? *hullina* could be classified as a subspecies of *Hermanites paijenborchiana* Keij, 1957, from the Eocene of Belgium and France; no *Hermanites* species has a median ridge. The Tanzanian species also differs in having a shorter ventral ridge and a less developed subcentral tubercle. *C.*? *hullina* also differs from the typical *Costa* in that the median ridge is rather more weakly developed and bends upwards rather than downwards at the posterior end. *Hermanites haidingeri* (Reuss) subsp. *rectangularis* Ruggieri, 1962, resembles *C.*? *hullina* in outline and ornament, but has no median ridge and the ventral ridge is longer.

Costa trudis Ahmad, 1977*c* Pl. 14, figs 1–9

1977*c* *Costa trudis* Ahmad: 127–130.

HOLOTYPE. Male left valve, OS 7692. Seventeen paratypes, OS 7693–709. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. Five single valves from samples FCRM 1745, 1989, 2010, 2015.

DESCRIPTION. Carapace elongate, slender, with greatest height at anterior cardinal angle, greatest width in posterior half, and greatest length along median line. Anterior margin symmetrically rounded, posterior pointed, with the point at mid-height; posterodorsal margin straight. Dorsal margin strongly modified in lateral view by dorsal ridge; ventral margin straight to slightly concave. Sexual dimorphism present; presumed females higher anteriorly than the more slender males. Surface ornament consists of three prominent ridges. Dorsal ridge runs from about one-third of the length from anterior end to just in front of posterior margin, where it curves downwards and disappears. Median ridge runs from just behind anterior margin, steps up a short distance further on, whence it runs parallel to dorsal ridge and curves down posteriorly. Ventral ridge subparallel to other two. Ocular ridge prominent, running from eye tubercle along anterior and ventral margins. Areas between ridges are strongly reticulate, the shapes of the fossae varying from triangular to subrectangular and subrounded. Internally, inner margin uniformly wide along free margin; marginal pore canals cannot be seen clearly. Muscle scars and hinge are typical of genus and eye tubercle is invisible from within. Right valve hinge consists of a slightly stepped but strongly produced anterior tooth, a socket, a crenulate bar and a posterior tooth which looks like a smooth knob in lateral view, but is elongate in dorsal view.

DIMENSIONS (μm).	L	H	W
Holotype, male left valve OS 7692	850	385	220
Paratype, male right valve OS 7693	860	370	150
Paratype, female left valve OS 7694	830	430	200
Paratype, female right valve OS 7695	845	390	190

REMARKS. *Costa trudis* can be distinguished from *Costa punctatissima punctatissima* Ruggieri 1961 by its more acuminate posterior and lack of a marginal rim. *Costa variabilicosta muhlemanni* van den Bold 1966 is also closely related, but the three-pronged ridge which runs vertically from the median to the ventral ridge in that species is missing in *C. trudis*; there are other differences in ornamental details.

Genus ***TRACHYLEBERIDEA*** Bowen, 1953

TYPE SPECIES. *Cythereis prestwichiana* Jones & Sherborn, 1889.

Trachyleberidea? ***cirrata*** sp. nov. Pl. 18, figs 6–10

NAME. 'Fringed', with reference to the muri having tufted spines projecting into the fossae.

DIAGNOSIS. A species of *Trachyleberidea* with a low subcentral tubercle, and an internal snap-knob at the mid-ventral margin of the right valve.

HOLOTYPE. A female carapace, OS 7988. Another female carapace, OS 8128, is a paratype. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. Two specimens from samples FCRM 1575 (OS 7993) and 1628 (OS 8129).

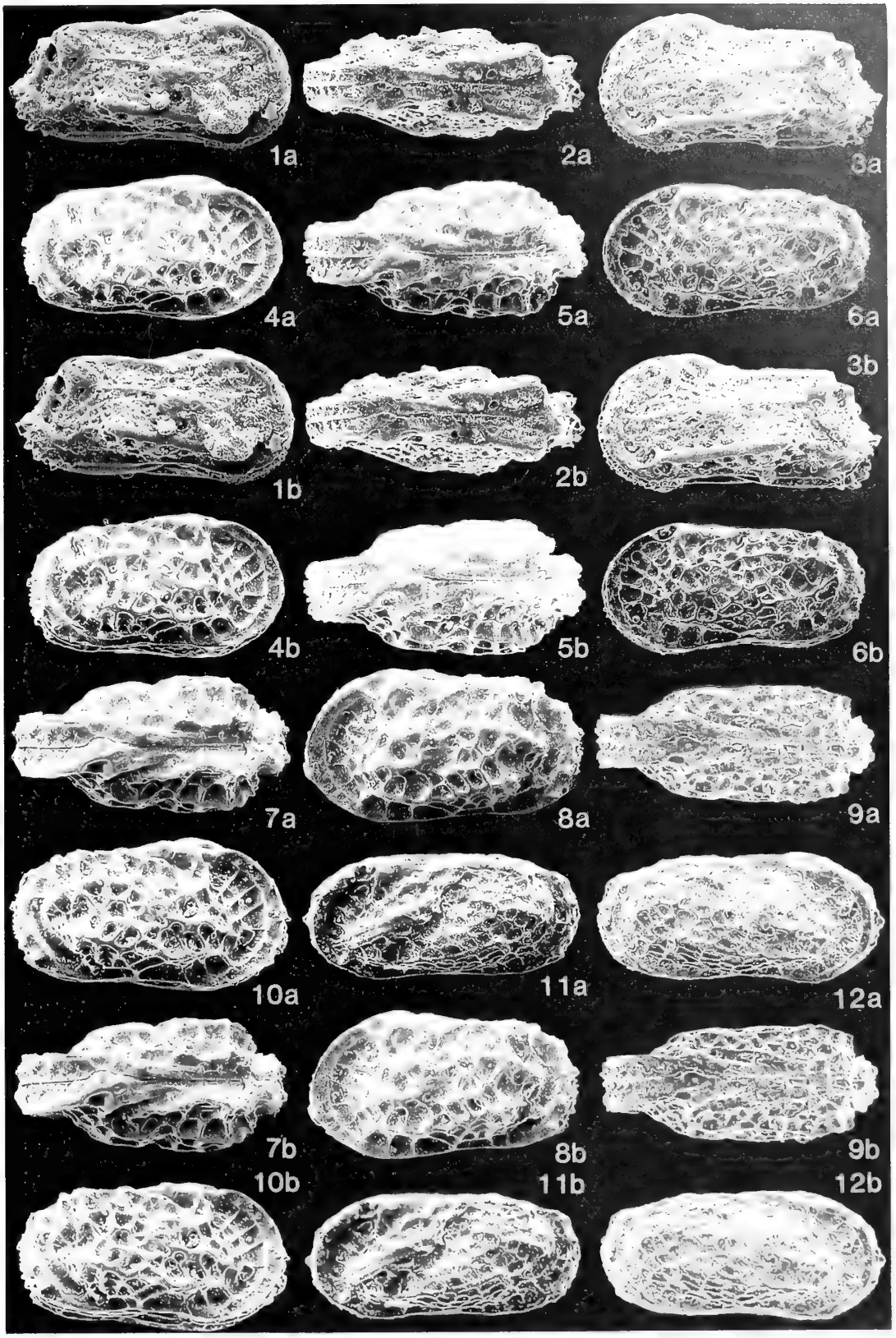
DESCRIPTION. Carapace subtriangular in side view, with greatest height at anterior cardinal angle. Anterior margin symmetrically rounded, posterior end triangular with posterodorsal margin straight to slightly concave. Dorsal margin straight, ventral slightly concave. Sexual dimorphism marked, presumed females being subtriangular compared with subrectangular presumed males; however, see remarks below. Lateral surface reticulate, fossae being concentrically arranged around subcentral tubercle. Muri have short spines which project into the fossae. A prominent thin median longitudinal ridge runs obliquely from subcentral tubercle towards postero-

PLATE 15

Figs 1–3 *Costa*? *hullina* sp. nov. Paratype, juvenile carapace, OS 7716; 1, lateral view from right, ×71; 2, dorsal view, ×69; 3, lateral view from left, ×70.

Figs 4–10 *Stigmatocythere bornhardti* sp. nov. Figs 4, 5, **holotype**, female carapace, OS 8170; 4, lateral view from right, ×76; 5, dorsal view, ×84. Figs 6, 9, paratype, male carapace, OS 8172; 6, lateral view from left, ×70; 9, dorsal view, ×74. Figs 7, 8, 10, paratype, female carapace, OS 8173; 7, dorsal view, ×80; 8, lateral view from left, ×80; 10, lateral view from right, ×80.

Figs 11, 12 *Stigmatocythere intexta* sp. nov. **Holotype**, carapace, OS 8176; 11, lateral view from left, ×83; 12, lateral view from right, ×86.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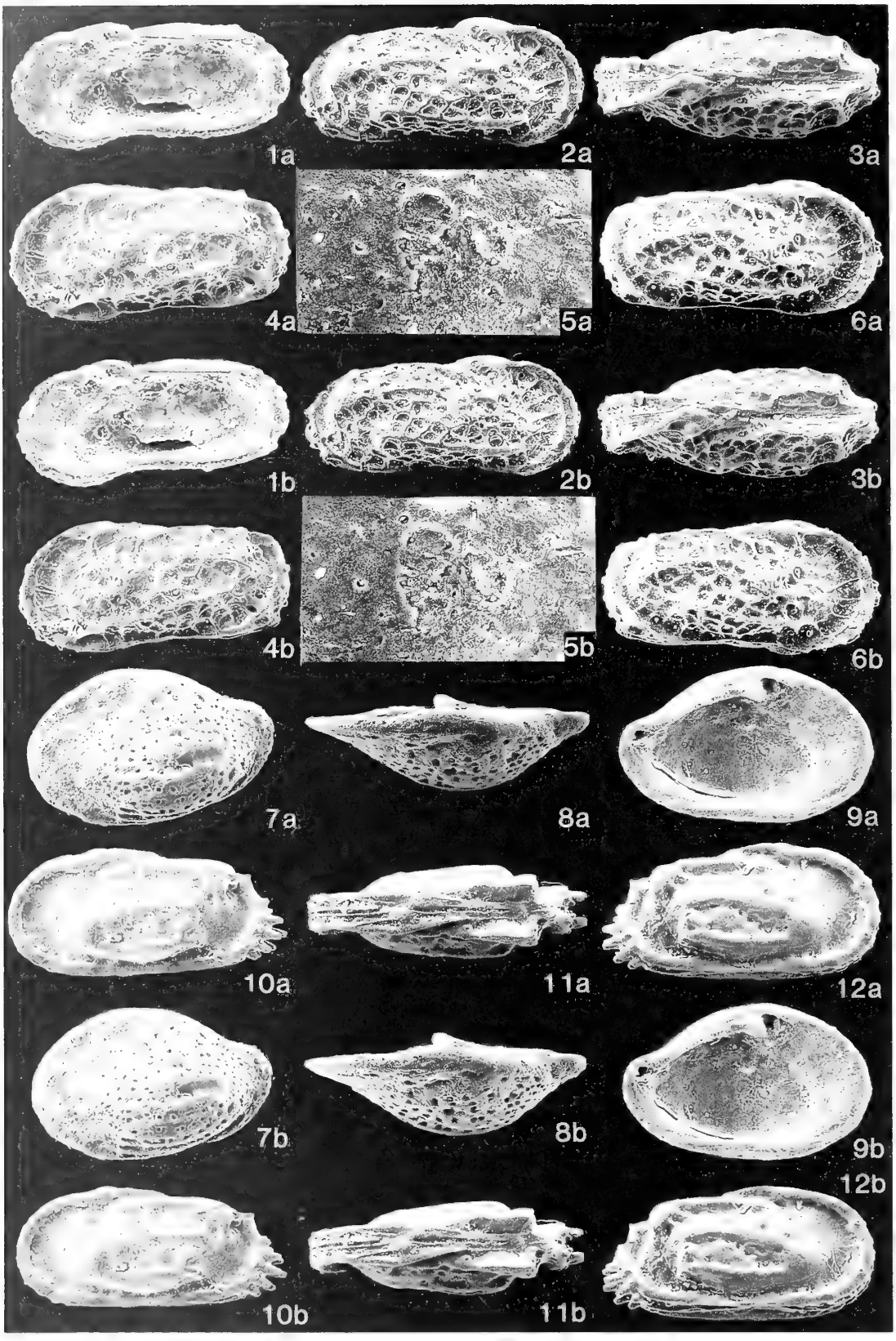
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dorsal margin, curving down at its posterior end. Dorsal ridge not well marked; no ventral ridge. Few internal details visible. Hinge holamphidont, with a rounded knoblike anterior tooth in right valve, a round, slightly stepped tooth posteriorly and a median element consisting of an anterior socket and smooth postjacent groove. Right valve has a midventral snap-knob.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 7988	700	350	265
Paratype, female carapace OS 8128	700	355	290

REMARKS. The two different forms could possibly be regarded as separate species, but as they have the same basic pattern of ornament and occur together, they are taken to be male and female dimorphs of the same species. The generic assignment of this new species is difficult, but it agrees with *Trachyleberidea* in shape and visible internal details; however, none of the other *Trachyleberidea* species so far described has a snap-knob. The Tanzanian species also lacks the distinct ventral ridge of typical *Trachyleberidea*.

Genus ***STIGMATOCYTHERE*** Siddiqui, 1971

TYPE SPECIES. *Stigmatocythere obliqua* Siddiqui, 1971.

Stigmatocythere bornhardti sp. nov. Pl. 15, figs 4–10

NAME. After W. Bornhardt, the German geologist who first established the broad geological outlines of the Lindi area.

DIAGNOSIS. A species of *Stigmatocythere* with strong reticulation and well-marked sexual dimorphism.

HOLOTYPE. A female carapace, OS 8170. A female right valve OS 8171, a male carapace OS 8172, and a female carapace OS 8173, are paratypes. Sample FCRM 1745 (OS 8173 from 1746), Mbanja River; Lower Miocene.

OTHER MATERIAL. Four specimens from samples FCRM 1742 (Lower Miocene) and FCRM 1576, 1578 (Middle Oligocene). Additional specimens are in the collections of the BP Research Centre, Sunbury-on-Thames, from samples FCRM 1647, 1963 and 1964.

DESCRIPTION. Sexual dimorphism pronounced, affecting shape. Carapace of presumed male rectangular in side view; presumed female subquadrate. Anterior margin symmetrically rounded, posterior truncate. Dorsal margin modified by dorsal ridge, ventral margin slightly concave in the middle; these margins converge slightly towards posterior end. A strong ridge runs along dorsal, posterior and ventral margins. Entire surface reticulate, with the fossae arranged in no particular order. Some specimens are less strongly reticulate and in them three longitudinal ridges can be seen. Internal features typical of genus.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8170	550	310	270
Paratype, male carapace OS 8172	610	310	260
Paratype, female carapace OS 8173	560	310	275

REMARKS. *Stigmatocythere bornhardti* is similar in shape to *S. obliqua* Siddiqui 1971, but there are a number of differences in detail; *S. obliqua* has a well developed eye tubercle and a ridge overhanging the ventral margin; *S. bornhardti* has a reduced eye tubercle and no overhanging ventral ridge. Siddiqui's species is smoother in the anterior third, while the Tanzanian species is equally reticulate all over. Sexual dimorphism also differs in the two; the presumed females of Siddiqui's species have strongly converging dorsal and ventral margins while the Tanzanian females are subquadrate. *S. bornhardti* also resembles *S. intexta* sp. nov. (below) but is more strongly reticulate.

Carbonnel's *Stigmatocythere* aff. *obliqua* Siddiqui (Carbonnel 1986: 110, figs 12–15) shows some resemblence to *S. bornhardti* but differs in its accentuated anterodorsal hinge 'ear'. The pattern of ornament, although somewhat similar, is less well developed, although this may be partly a matter of preservation.

Stigmatocythere intexta sp. nov.
Pl. 15, figs 11–12; Pl. 16, figs 1–4, 6

NAME. 'Interlaced', with reference to the ornament.

DIAGNOSIS. A species of *Stigmatocythere* which is almost uniformly reticulate. The ridges are subdued and the fossae shallow.

HOLOTYPE. A carapace, OS 8176. Six paratypes, OS 8177–82. Sample FCRM 2045, Lindi–Mingoyo Road; Upper Eocene.

OTHER MATERIAL. One specimen from the same sample. Also occurs in FCRM 1745, 1575 and 1628.

DESCRIPTION. Carapace medium sized, subrectangular in lateral view. Anterior margin symmetrically rounded, posterior truncate to rounded. Dorsal margin straight, ventral margin slightly concave in the middle. Eye tubercle glassy and well developed. Entire surface reticulate, the fossae being subrectangular, shallow and almost equal in size. The three ridges, dorsal, median and ventral, present but very much reduced; in some specimens ventral ridge almost non-existent. Internal features typical of genus.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8176	530	245	210
Paratype, right valve OS 8177	560	145	130
Paratype, carapace OS 8178	510	250	205

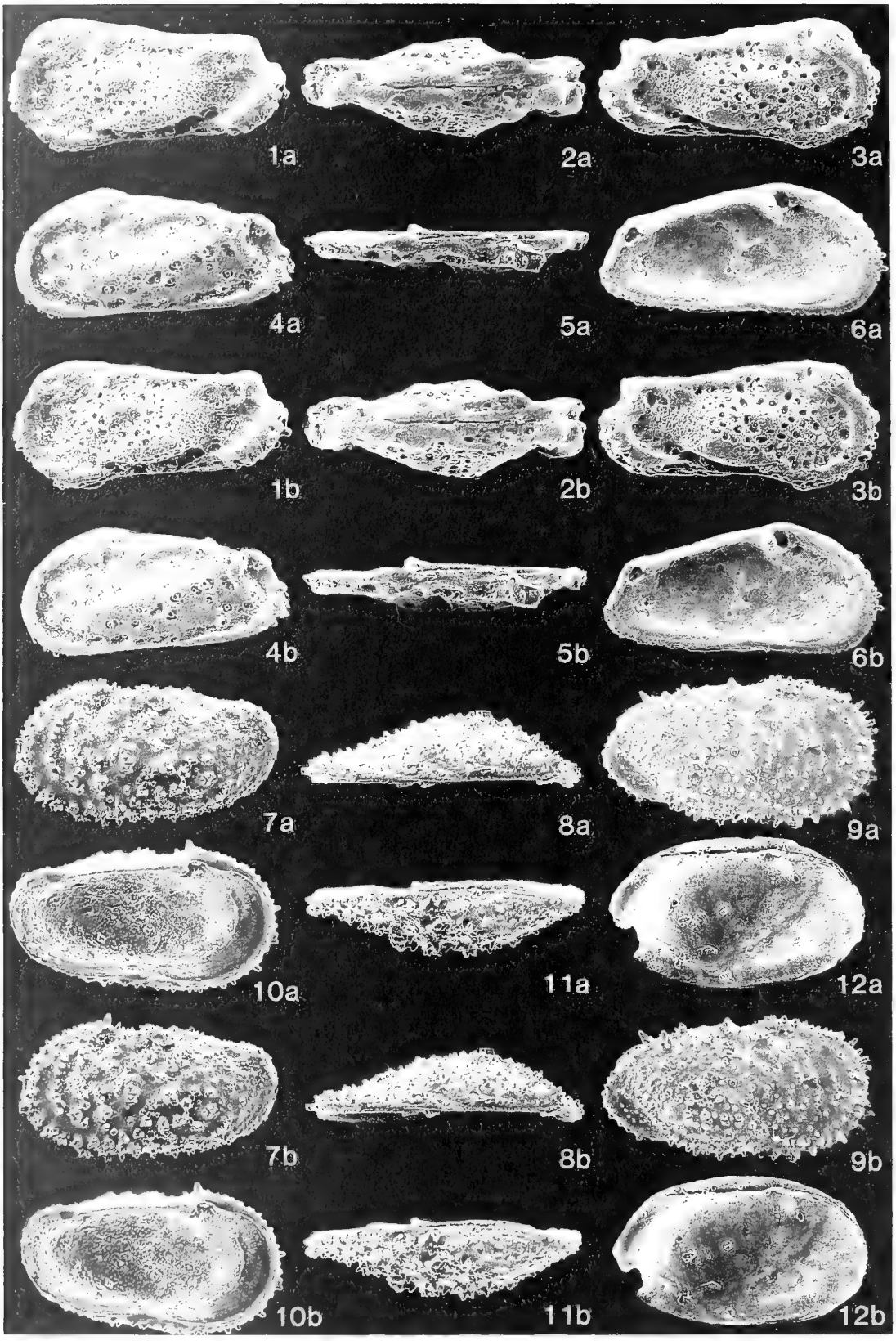
REMARKS. *S. intexta* only differs from *S. bornhardti* sp. nov., above, in having subdued ridges and therefore shallower

PLATE 16

Figs 1–4, 6 *Stigmatocythere intexta* sp. nov. Figs 1, 2, paratype, right valve, OS 8177; 1, internal lateral view, ×80; 2, external lateral view, ×81. Figs 3, 4, 6, paratype, carapace, OS 8178; 3, dorsal view, ×91; 4, lateral view from left, ×89; 6, lateral view from right, ×90.

Figs 5, 7–9 *Buntonia* sp. Left valve, OS 8183; 5, muscle scars, ×450; 7, external lateral view, ×87; 8, dorsal view, ×99; 9, internal lateral view, ×89.

Figs 10–12 *Ambocythere* sp. Carapace, OS 7975; 10, lateral view from left, ×95; 11, dorsal view, ×95; 12, lateral view from right, ×95.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fossae. A number of specimens have intermediate ornamentation, and it is difficult to classify them with certainty in either species.

Tribe **PTERYGOCYTHEREIDINI** Puri, 1957*a*

Genus ***INCONGRUELLINA*** Ruggieri, 1958

TYPE SPECIES. *Incongruellina semispinescens* Ruggieri, 1958.

Incongruellina tonsa sp. nov. Pl. 17, fig. 12; Pl. 18, figs 1–5

NAME. 'Oar', referring to the ventrolateral alae.

DIAGNOSIS. A species of *Incongruellina* with prominent alae which make the valves wider than high. Posteriorly the alae end in spines.

HOLOTYPE. A carapace, OS 7908. Two carapaces, OS 7909, 7910, are paratypes. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. Seven specimens, including OS 7992 from FCRM 1746. Also occurs in FCRM 1745.

DESCRIPTION. Carapace strongly calcified, medium-sized to large; greatest height at anterior cardinal angle, tapering posteriorly. Anterior margin symmetrically rounded, with 10 to 12 marginal denticles. Posterior bluntly produced at the bottom, with posterodorsal margin almost straight. Dorsal margin in left valve gently arched, almost straight in right. Left valve larger than right, overlap being conspicuous along mid-dorsal margin. Externally, ventrolateral marginal keel well developed and almost parallel to ventral margin, ending posteriorly in a spine. Ventral to the keel, two thin ridges run parallel to margin. Except for the glossy eyespot, lateral surface smooth. Internally duplicature moderately wide; line of concrescence and inner margin separated by a narrow vestibule. No marginal pore canals were seen, and a V-shaped frontal scar alone was visible in the muscle scar field.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 7908	780	590	510
Paratype, carapace OS 7910	810	485	495
Paratype, carapace OS 7909	800	450	510

REMARK. *Incongruellina tonsa* is very like *I. semispinescens* Ruggieri 1958, but lacks a long posterior spine in the left valve.

Tribe **ECHINOCYTHEREIDINI** Hazel, 1967

Genus ***HENRYHOWELLA*** Puri, 1957*b*

TYPE SPECIES. *Cythere evax* Ulrich & Bassler, 1904.

Henryhowella sentosa sp. nov. Pl. 17, figs 7–11

NAME. 'Thorny'; with reference to the surface ornamentation.

DIAGNOSIS. A species of *Henryhowella* with spines typically trifid and arranged somewhat concentrically.

HOLOTYPE. A left valve, OS 7985. A juvenile right valve, OS 7986, is a paratype. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. Two specimens from Samples FCRM 2010 and 2016.

DESCRIPTION. Carapace shape typical of genus. In side view, anterior margin evenly rounded; posterior obliquely curved below; posteroventral margin almost straight. Dorsal and ventral margins almost straight and parallel. Eye tubercle indistinct; anterior cardinal angle with a well-developed spine. Surface covered with spines, mostly trifid but sometimes bifid or quadrifid, concentrically arranged in anterior half and posterior third of carapace. Spines very small in posterior and posterodorsal regions, larger in ventral region. Internal features typical of genus except that median element of hinge is not crenulate; frontal scar not visible.

DIMENSIONS (μm).	L	H	W
Holotype, left valve OS 7985	660	410	200
Paratype, juvenile right valve OS 7986	590	350	180

REMARKS. *Henryhowella sentosa* resembles the *Echinocythereis*? sp. of Swain 1971, an immature valve from the Pleistocene of the south-eastern Pacific Ocean, but this does not have the characteristic trifid spines. The ornamentation and shape of the Tanzanian species are very similar to those of *Cythere acanthoderma* Brady from the Gulf of Mexico, but the latter has stronger marginal spines and a more broadly rounded posterior margin. The indistinct eye tubercle and concentrically arranged spines of the Tanzanian species resemble those of *Hystricocythere* Bate 1972, but the hinge is different.

Subfamily **BUNTONIINAE** Apostolescu, 1961

Genus ***BUNTONIA*** Howe & Chambers, 1935

TYPE SPECIES. *Buntonia shubutaenis* Howe & Chambers 1935 (= young of ?*Cythereis israelski* Howe & Chambers, 1935).

Buntonia sp. Pl. 16, figs 5, 7–9

FIGURED SPECIMEN. A left valve, OS 8183. Sample FCRM 1628, Kitunda Jetty road; Middle Oligocene.

OTHER MATERIAL. Three specimens in the collection of the BP Research Centre, Sunbury-on-Thames, from samples FCRM 1645, 1742, and 1745.

DESCRIPTION. Carapace pear-shaped in lateral view, with

PLATE 17

Figs 1–3 *Idiocythere* sp. A. Carapace, OS 8186; 1, lateral view from left, ×85; 2, dorsal view, ×85; 3, lateral view from right, ×85.

Figs 4–6 *Falsocythere maccagnoi* (Ciampo, 1971). Left valve, OS 7820; 4, external lateral view, ×94; 5, dorsal view, ×96; 6, internal lateral view, ×97.

Figs 7–11 *Henryhowella sentosa* sp. nov. Figs 7, 10, 11, **holotype**, left valve, OS 7985; 7, external lateral view, ×65; 10, internal lateral view, ×66; 11, dorsal view, ×69. Figs 8, 9, paratype, juvenile right valve, OS 7986; 8, dorsal view, ×78; 9, external lateral view, ×75.

Fig. 12 *Incongruellina tonsa* sp. nov. **Holotype**, carapace, OS 7908, lateral slightly oblique view from right, ×53. See also Pl. 18, fig. 3.

greatest height at two-fifths of the length, and greatest width about three-fifths of the length from anterior margin. Anterior margin elliptical and narrowly rounded; posterior margin upturned and rounded towards the dorsal. Dorsal margin merges imperceptibly into anterior margin, has an almost straight middle section, and slopes posteriorly, forming a distinct posterior cardinal angle. Ventral margin slightly convex upwards. External surface smooth along anterior margin (possibly a preservation phenomenon), but the rest is covered with small pits. Ventral half has six ridges running almost parallel to ventral margin. Dorsal half, separated from ventral by a longitudinal groove, has two small ridges at an angle to the dorsal margin. Marginal area and pore canals could not be seen because of poor preservation; the specimens in the BP Research Centre collection are better preserved and had 11 anterior marginal pore canals. There are four adductor scars with a V-shaped frontal scar. Hinge holamphidont; in left valve, an anterior socket is followed by a strong knob, a crenulate bar and a posterior socket.

DIMENSIONS (μm).	L	H	W
Left valve OS 8183	460	315	170

Genus ***AMBOCYTHERE*** van den Bold, 1958*b*

TYPE SPECIES. *Ambocythere keiji* van den Bold, 1958*b*.

Ambocythere sp. Pl. 16, figs 10–12

FIGURED SPECIMEN. A carapace, OS 7975. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene. The only specimen.

DESCRIPTION. Carapace small, highest at one-third length from anterior end. Anterior margin symmetrically rounded; posterior end somewhat bluntly produced with posterodorsal part straight to slightly concave and posteroventral part rounded, with six denticles, three strong and three reduced. Dorsal margin strongly modified posteriorly by dorsal ridge; ventral margin almost straight. Dorsal and ventral margins converge posteriorly. Surface ornament consists of a carina-like rim extending from mid-dorsal ridge along anterior margin and continuing along ventral and posterior margins. Three short longitudinal ridges run from mid-length towards the back. The dorsal ridge thickens posteriorly where it curves downwards; the shorter median ridge bifurcates at its posterior end and meets dorsal and ventral ridges; ventral ridge straight, also bifurcating at posterior end. Small rounded pits occur in the central part of the carapace. As there is only a carapace internal details are unknown.

DIMENSIONS (μm).	L	H	W
Carapace OS 7975	495	230	175

REMARKS. This Tanzanian *Ambocythere* is more rectangular and has shorter ridges than any other species so far described.

Genus ***OCCULTOCYTHEREIS*** Howe, 1951

TYPE SPECIES. *Occultocythereis delumbata* Howe, 1951.

Occultocythereis africana sp. nov. Pl. 11, figs 7–12

NAME. 'From Africa'.

DIAGNOSIS. A species of *Occultocythereis* with a prominent anterior marginal ridge; dorsal ridge in the posterior half curving sharply down at the posterior end. A ventrolateral swelling. Surface ornamented with round pits.

HOLOTYPE. A female carapace, OS 7976. Two specimens, OS 7972, 7974, are paratypes. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. One specimen (OS 7978) from sample FCRM 2010.

DESCRIPTION. Carapace small, greatest height at anterior cardinal angle. Anterior end rounded, posterior subrounded below, concave to straight posterodorsally; dorsal and ventral margins almost straight, converging behind. Sexual dimorphism present; presumed males elongate compared with presumed females. Externally, a strong rim runs along free margins. A short dorsal ridge runs in posterior half, curving sharply at posterior end; another rather indistinct ridge, appearing as a ventrolateral swelling, ends in a short spine posteriorly. Five or six elongate marginal spines occur along posteroventral margin and there are a few very short ones at anterior end. Eye tubercle present as an opaque spot. Surface ornamented with round pits except in the anteroventral area, which is almost smooth. Inside, duplicature moderately wide; line of concrescence and inner margin coincide and there is no vestibule. Selvage runs at a short distance from outer margin. Marginal pore canals not clearly visible. Muscle scar pattern consists of four adductor scars in a vertical row with a V-shaped frontal scar. Hinge holamphidont, with a conical anterior tooth and an adjacent socket joined to a posterior tooth in right valve; corresponding elements occur in left.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 7976	435	215	170
Paratype, female left valve OS 7974	500	260	115
Paratype, female right valve OS 7972	500	255	115

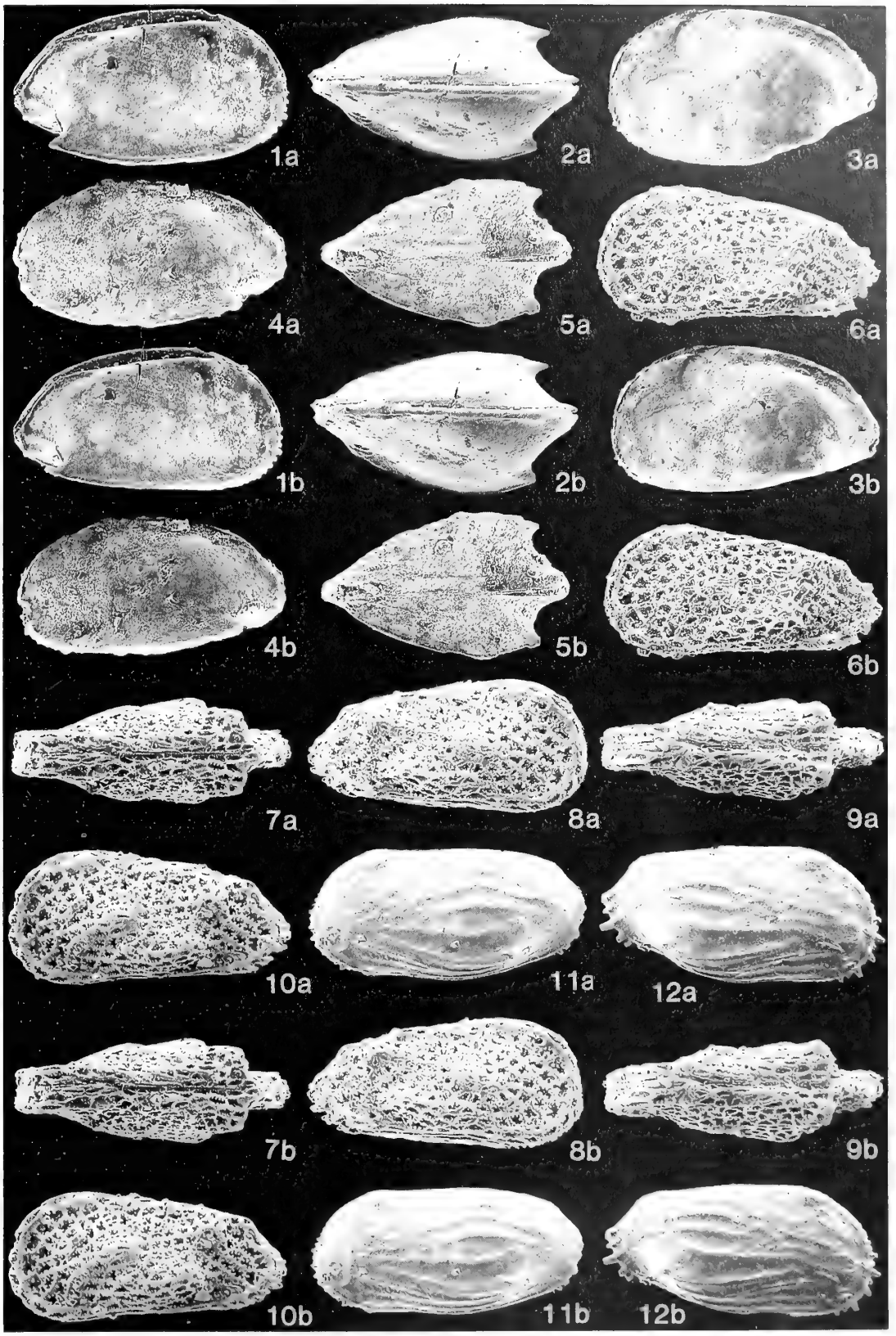
REMARKS. *O. africana* is probably the same as the Gen. Indet. 5 sp. 1 of Dingle, 1976. *Occultocythereis hatraensis* Al-Sheikhly, 1982, shows some resemblance to this species but

PLATE 18

Figs 1–5 *Incongruellina tonsa* sp. nov. Figs 1, 2, paratype, carapace, OS 7910; 1, lateral view from right, ×56; 2, dorsal view, ×54. Fig. 3, **holotype**, carapace, OS 7908, lateral view from left, ×56; see also Pl. 17, fig. 12. Figs 4, 5, paratype, carapace, OS 7909; 4, lateral view from left, ×56; 5, ventral view, ×51.

Figs 6–10 *Trachyleberidea? cirrata* sp. nov. Figs 6, 9, **holotype**, female carapace, OS 7988; 6, lateral view from left, ×66; 9, dorsal view, ×66. Figs 7, 8, 10, paratype, female carapace, OS 8128; 7, dorsal view, ×65; 8, lateral view from right, ×65; 10, lateral view from left, ×65.

Figs 11, 12 *Ruggieria* (*Ruggieria*) *furcilla* sp. nov. Fig. 11, **holotype**, left valve, OS 8201, external lateral view, ×39; see also Pl. 19, fig. 4. Fig. 12, paratype, carapace, OS 8202, lateral view from right, ×42; see also Pl. 19, fig. 3.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differs from it in having a median ridge, a better-developed dorsal ridge and a punctate rather than a pitted surface.

Genus ***IDIOCYTHERE*** Triebel, 1958

TYPE SPECIES. *I. lutetiana* Triebel, 1958.

Idiocythere sp. A Pl. 17, figs 1–3

FIGURED SPECIMEN. A carapace, OS 8186. Sample FCRM 1746, Mbanja River; Lower Miocene. The only specimen.

DESCRIPTION. Carapace subrectangular in side view, with almost straight dorsal and ventral margins. Anterior margin rounded, posterior concave posterodorsally; both ends denticulate. Anterior marginal rim and dorsal and ventral ridges all well developed. Subcentral tubercle prominent; the rest of the surface pitted in the middle and smooth along the margins. No internal features were seen.

DIMENSIONS (μm).	L	H	W
Carapace, OS 8186	535	270	200

Subfamily **CAMPYLOCYTHERINAE** Puri, 1960
Tribe **LEGUMINOCYTHERINI** Howe, 1961

Genus ***LEGUMINOCYTHEREIS*** Howe (*in* Howe & Law, 1936)

TYPE SPECIES. *L. scarabaeus* Howe & Law (*in* Howe & Law, 1936).

Leguminocythereis dinglei sp. nov. Pl. 12, figs 1–12

NAME. In honour of Prof. R.V. Dingle, for his work on the South African ostracod fauna.

DIAGNOSIS. A species of *Leguminocythereis* with obliquely rounded anterior and produced truncated posterior margins. Lateral surface reticulate with coarse striae concentrically arranged at the margins but straight in the middle of the valve.

HOLOTYPE. A female carapace, OS 8194. Six specimens, OS 8195–200, are paratypes. Sample FCRM 1578 (OS 8196, FCRM 1575), coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. 23 specimens from samples FCRM 1574 and 1576.

DESCRIPTION. Carapace medium to large, with greatest width in posterior half. Subtriangular to suboval in side view, tapering towards posterior end. Anterior margin cut away below, with spines along the ventral part; dorsal margin straight to gently arched, posterior end produced and truncate with a straight to concave posterodorsal margin. Ventral margin strongly modified by a swelling which appears convex in side view but is concave in the middle from below or internally. Carapace ovate in dorsal view. Sexual dimorphism present; in dorsal view presumed males less swollen anteriorly than are females. Six longitudinal ridges run along ventrolateral swelling, curving along anterior margin and following dorsal margin. Lateral surface reticulate; fossae rounded, more prominent centrally and almost non-existent along margins. Degree of development of the lateral ridges varies widely; a few specimens have reduced reticulation and may be almost smooth, though the original pattern of reticulation can usually be discerned. However, even when ornamentation is reduced, no other differences are visible, so this is regarded as intraspecific variation. Reduction in ornament may be directly proportional to size of carapace, but this is not an invariable rule. Duplicature fairly wide; line of concrescence and inner margin slightly separated anteriorly, forming a narrow vestibule. Selvage strongly developed along anteroventral and ventral margins. Marginal pore canals obscure due to strong calcification; in some specimens false marginal pore canals visible. Details of muscle scars difficult to see; in most specimens only two adductor scars are visible, with the middle two not apparent and frontal scars placed irregularly. In some specimens there are four adductor scars arranged in a row with two rounded scars in front. Hinge strongly holamphidont; in right valve a sharp anterior tooth projects from a platform the lower side of which has a socket joined to a crenulate groove, followed by a smooth elongate tooth which thickens posteriorly.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8194	830	480	465
Paratype, male carapace OS 8195	800	456	290
Paratype, male carapace OS 8196	765	415	420
Paratype, female left valve OS 8198	790	450	270
Paratype, male carapace OS 8199	950	520	530
Paratype, juvenile(?) left valve OS 8200	665	355	195

REMARKS. The outline of the posterior margin, which is produced and truncate in *L. dinglei*, differentiates this from other species of *Leguminocythereis*; in fact this feature recalls the Mesozoic genera *Neocythere* and *Centrocythere*, which have a completely different hinge.

Genus ***RUGGIERIA*** Keij, 1957
Subgenus ***RUGGIERIA*** Keij, 1957

TYPE SPECIES. *Cythere micheliniana* Bosquet, 1852.

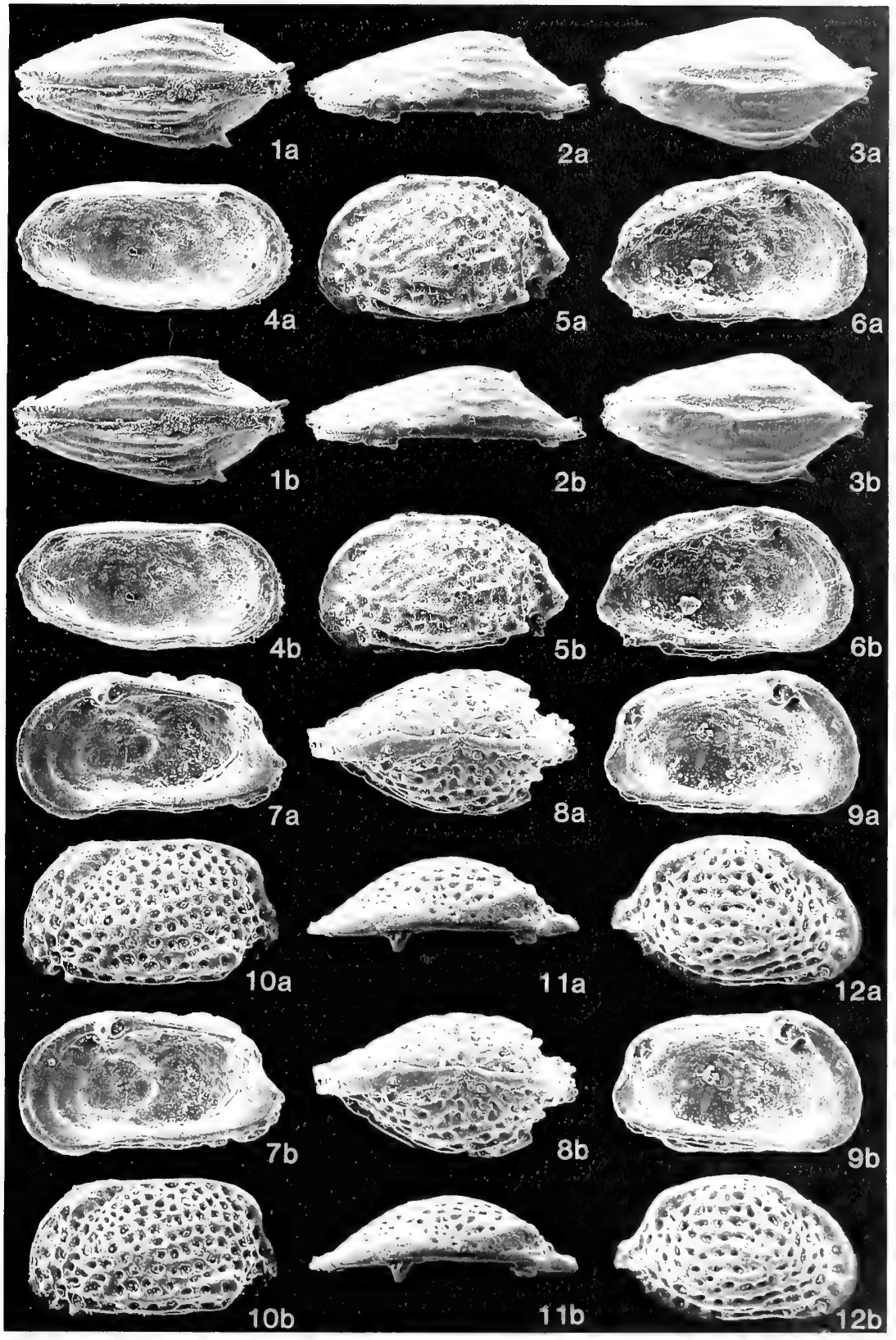
PLATE 19

Figs 1–4 *Ruggieria* (*Ruggieria*) *furcilla* sp. nov. Fig. 1, paratype, carapace, OS 8204, ventral view, ×39. Fig. 2, paratype, right valve, OS 8205, dorsal view, ×44. Fig. 3, paratype, carapace, OS 8202, dorsal view, ×43; see also Pl. 18, fig. 12. Fig. 4, **holotype**, left valve, OS 8201, internal view, ×39; see also Pl. 18, fig. 11.

Figs 5–8 *Procythereis aligera* sp. nov. Figs 5, 6, **holotype**, left valve, OS 8215; 5, external lateral view, ×69; 6, internal lateral view, ×65. Fig. 7, paratype, right valve, OS 8216, internal lateral view, ×73. Fig. 8, paratype, carapace, OS 8217, dorsal view, ×65.

Figs 9, 10 *Procythereis radiata* sp. nov. **Holotype**, left valve, OS 8219; 9, internal lateral view, ×75; 10, external lateral view, ×76.

Figs 11, 12 *Aurila concentrica* sp. nov. **Holotype**, female right valve, OS 8207; 11, dorsal view, ×78; 12, external lateral view, ×70.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Ruggieria (Ruggieria) furcilla sp. nov.

Pl. 18, figs 11–12; Pl. 19, figs 1–4

NAME. 'Little fork', with reference to lateral ridges which form a fork-like pattern.

DIAGNOSIS. A species of *Ruggieria* with ridges which are convex upward in the dorsal part, almost straight in the middle, and concave upward in the ventral part of the lateral surface.

HOLOTYPE. A left valve, OS 8201. Five specimens, OS 8202–6, are paratypes. Sample FCRM 2014, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. 33 specimens from samples FCRM 2014, 2015. Additional specimens are in the collection of the BP Research Centre, Sunbury-on-Thames, from samples FCRM 1745, 1746.

DESCRIPTION. Carapace elongate, oval-shaped in lateral view. Dorsal margin straight; ventral margin strongly modified by ventrolateral swelling, appearing convex in lateral view but from inside concave anteriorly and convex posteriorly. Anterior margin symmetrically rounded; posterior upturned, straight in upper half and gently rounded below. Greatest height behind anterior margin, and greatest width in ventral half, behind mid-length. Eye tubercle prominent. Ornament consists of longitudinal ridges which are curved up in the dorsal half of the carapace, almost straight in the middle of it, and curved down in the ventral half. Intercostal areas smooth. Marginal zone moderately wide except at ventral margin, where it is narrow; inner margin and zone of concrescence coincide except along anteroventral margin, where there is a narrow vestibule. Normal pore canals widely spaced; marginal pore canals straight and wide apart. Muscle scar pattern with four adductor scars with their axis concave towards anterior end; second scar from the top relatively long. Two dorsal scars just above and a V-shaped frontal scar just in front of the adductor scars. Hinge typical of genus; in right valve it consists of a conical anterior tooth, a post-jacent socket which merges into a serrated straight groove, and a smooth ovate posterior tooth. Left valve has corresponding sockets, a conical anterior tooth, and a median crenulate bar.

DIMENSIONS (μm).	L	H	W
Holotype, left valve OS 8201	1140	530	320
Paratype, right valve OS 8205	1050	515	285
Paratype, carapace OS 8204	1175	540	560
Paratype, carapace OS 8202	1035	500	510

REMARKS. *R.* (*R.*) *furcilla* has some affinity with the genus *Keijella* Ruggieri 1967 because of its anteroventral vestibule, but it is placed in *Ruggieria* s. str. because, though a vestibule is present, it is confined to the anteroventral margin; in species of *Keijella* it extends along the entire anterior margin. Also, the hinge is more like that of *Ruggieria* s. str., and the outline of the carapace resembles that of some described species. *R. furcilla* probably represents an intermediate stage in the evolutionary development of *Ruggieria* s. str. into *Keijella*.

Keen (1974) described some *Ruggieria*-like ostracods from the Tertiary and Recent of West Africa. Only his *Ruggieria* sp. from Recent deposits of Sierra Leone shows any resemblence to *R. furcilla*, but differs in shape posteroventrally and in details of ornament, particularly in the ventrolateral region of the shell.

Ruggieria furcilla is closest to *R. triangulata* Omatsola 1972, a Recent species from the western Niger Delta, as figured by Babinot 1981 from the Oligocene of the Cote d'Ivoire, and *R.* aff. *triangulata* Carbonnel 1986 from the Eocene of Senegal. Carbonnel gives good line diagrams of the ornamentation pattern of these forms and the Tanzanian species differs in the detailed rib pattern, especially the four lower costae which swing upwards in the anterior half of their course. Although distinct, the present species is closely allied to the Senegal, Cote d'Ivoire and Niger forms and should be included in the *R. triangulata* species group.

Family **HEMICYTHERIDAE** Puri, 1953
Subfamily **HEMICYTHERINAE** Puri, 1953
Tribe **AURILINI** Puri, 1974

Genus ***AURILA*** Pokorný, 1955

TYPE SPECIES. *Cythere convexa* Baird, 1850.

Aurila concentrica sp. nov.

Pl. 19, figs 11–12, Pl. 20, figs 1–6

NAME. In reference to the concentric arrangement of fossae.

DIAGNOSIS. A medium-sized species of *Aurila*, subovate in lateral view, highest just behind the middle. Anterior and posterior margins together form an arc; posterior produced into a caudal process. Surface strongly reticulate with fossae arranged concentrically.

HOLOTYPE. A female right valve, OS 8207. Five specimens, OS 8208–12, are paratypes. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

OTHER MATERIAL. 106 specimens from samples FCRM 1566 1989, 2010. Additional specimens are in the collection of the BP Research Centre, Sunbury-on-Thames, from samples FCRM 1575, 1576, 1578, 1689, 1692. Also occurs in FCRM 1574, 1737, 1745, 1746 and 2015.

DESCRIPTION. Carapace subovate, almond shaped, with

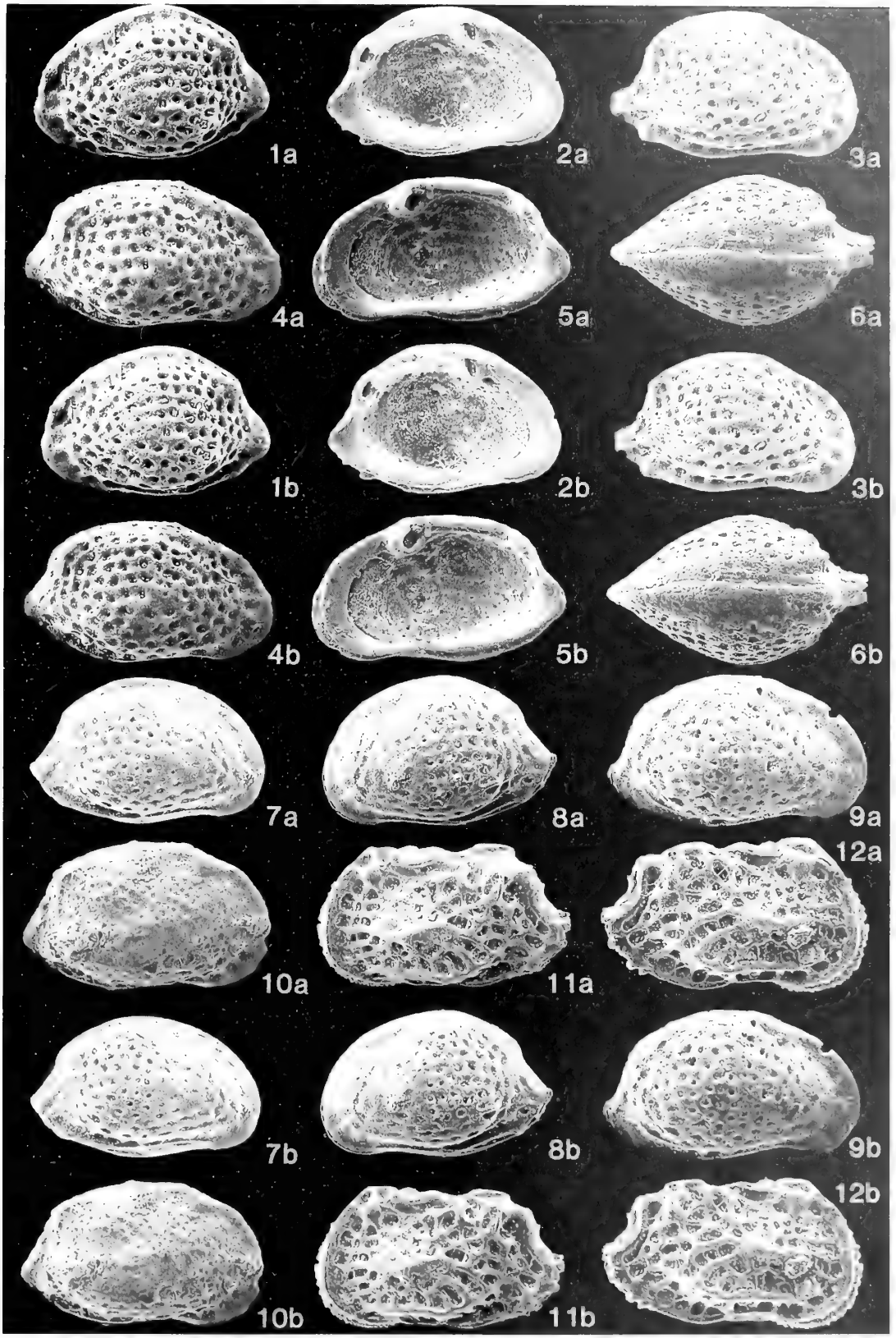
PLATE 20

Figs 1–6 *Aurila concentrica* sp. nov. Fig. 1, paratype, female left valve, OS 8208, external lateral view, ×69. Fig. 2, paratype, female left valve, OS 8210, internal lateral view, ×70. Fig. 3, paratype, female right valve, OS 8209, external lateral view, ×73. Figs 4, 5, paratype, male right valve, OS 8211; 4, external lateral view, ×74; 5, internal lateral view, ×76. Fig. 6, paratype, female carapace, OS 8212, dorsal view, ×62.

Figs 7–9 *Aurila concentrica* sp. nov., Morphotype A. Figs 7, 8, female carapace, OS 8213; 7, lateral view from right, ×58; 8, lateral view from left, ×58. Fig. 9, male right valve, OS 8214, external lateral view, ×62.

Fig. 10 *Aurila concentrica* sp. nov., Morphotype B. Male right valve, OS 8222, external lateral view, ×67.

Figs 11, 12 *Hermanites carchesium* sp. nov. Paratype, male carapace, OS 8224; 11, lateral view from left, ×54; 12, lateral view from right, ×57.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greatest height just behind the middle and greatest width in posterior half. Anterior and dorsal margins almost continuous, forming an arc; posterior margin produced into a caudal process almost at right angles to dorsal margin, joining ventral margin obliquely. Ventral margin slightly concave anteriorly and convex posteriorly. Sexual dimorphism pronounced, presumed females being slightly wider and higher but less elongate than presumed males. Left valve larger than right with a pronounced overlap along dorsal margin. Eye tubercle glassy, elongate. Surface coarsely reticulate, the fossae being subrectangular and arranged concentrically in six rows. Duplicature moderately wide; line of concrescence and inner margin slightly separated anteriorly to give a narrow vestibule. Selvage well developed, running parallel to outer margin. Marginal pore canals straight, mostly simple, including a few false ones. There are 35–40 at the anterior end and 6–8 at the posterior. Muscle scar pattern consisting of four adductor scars, the top three being divided into two, and three frontal scars. Hinge holamphidont; anterior tooth in right valve moderately high and sharp, followed by a socket joined to the elongate incised posterior tooth by a groove. Left valve with complementary hinge elements.

Dimensions (μm).	L	H	W
Holotype, female right valve OS 8207	555	345	210
Paratype, female left valve OS 8208	560	380	240
Paratype, female right valve OS 8209	550	340	175
Paratype, female left valve OS 8210	555	365	185
Paratype, female carapace OS 8212	695	450	405

Remarks. The Tanzanian species is difficult to place firmly in either *Aurila* or *Pokornyella*. While the hinge is more like that of *Aurila*, the number of anterior marginal pore canals is closer to the 20–25 of *Pokornyella* than to the 80 of *Aurila*. This probably represents an intermediate evolutionary stage between the earlier genus *Pokornyella* (Eocene–Oligocene) and the later *Aurila* (Oligocene–Recent).

Two morphotypes are distinguished: see below.

Morphotype A Pl. 20, figs 7–9

Figured specimens. A female carapace, OS 8213 (sample FCRM 1566), and a male right valve, OS 8214 (sample FCRM 1746); Mongo stream and Mbanja river, respectively; Lower Miocene.

Dimensions (μm).	L	H	W
Female carapace OS 8213	660	430	375
Male right valve OS 8214	680	410	220

Remarks. In this morphotype the anterior and dorsal margins together form an arc. The ornamentation is flatter than in the type.

Morphotype B Pl. 20, fig. 10

Figured specimen. A right valve, OS 8222. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene. Also occurs in FCRM 1576.

Dimensions (μm).	L	H	W
Right valve OS 8222	595	370	190

Remarks. The fossae are numerous but smaller and shallower than in typical *Aurila concentrica*. The ridges are almost non-existent, but the eye tubercle is better developed than in the type.

Genus ***PROCYTHEREIS*** Skogsberg, 1928

Type species. *Cythereis* (*Procythereis*) *torquata* Skogsberg, 1928.

Procythereis aligera sp. nov. Pl. 19, figs 5–8

Name. 'Winged', with reference to the ala-like ventrolateral ridge.

Diagnosis. A species of *Procythereis* with an ala-like ridge running along the ventrolateral swelling. Lateral surface reticulate but the fossae not prominent.

Holotype. A left valve, OS 8215. Three specimens, OS 8216–8, are paratypes. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

Other material. Two specimens from the same locality and horizon (OS 8221).

Description. Carapace medium to large, heavily calcified. Subovate in lateral view with greatest height at anterior cardinal angle and greatest width behind mid-length. Anterior margin broadly and obliquely rounded towards venter, posterior produced in ventral half and concave in dorsal half. Dorsal margin almost straight, ventral slightly concave, strongly modified in lateral view by the ventral inflation. Surface irregularly reticulate with poorly developed fossae. Three median ridges run longitudinally from behind anterior margin, bending upwards in front of posterior end. Eye tubercle only moderately developed. The dorsal of the two ventrolateral ridges is ala-like and prominent. Duplicature narrow to moderately wide; line of concrescence and inner margin coincide. Selvage runs along outer margin except at mid-venter, where it stands out prominently. Muscle scar pattern consists of four adductor scars in a vertical row with two frontal scars in front of them. Hinge strongly holamphidont.

Dimensions (μm).	L	H	W
Holotype, left valve OS 8215	660	400	205
Paratype, right valve OS 8216	605	335	225
Paratype, carapace OS 8217	675	415	380

Remarks. *Procythereis aligera* is not a typical *Procythereis* in shape but is assigned to this genus because of its two frontal muscle scars; *Kingmania* and *Nephokirkos* both have only one, though they are more like *P. aligera* in shape. The new species can be distinguished from other *Procythereis* in being more ovate than rectangular and having a less prominent eye tubercle.

Procythereis radiata sp. nov. Pl. 19, figs 9–10

Name. 'Rayed', with reference to the lateral ridges which radiate from the anteroventral region.

Diagnosis. A subrectangular species of *Procythereis* with reticulate ornamentation, the longitudinal ridges radiating from the anteroventral region. Two parallel ridges originate from the eye tubercle and run along the anterior and ventral margins.

Holotype. A left valve, OS 8219. A left valve, OS 8220 (missing), is a paratype. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

OTHER MATERIAL. One specimen from the same locality and horizon.

DESCRIPTION. Carapace subrectangular in lateral view, with ventral region strongly inflated, especially in posterior half. Anterior margin rounded, posterior bluntly produced in ventral half and concave posterodorsally. Dorsal margin straight, ventral hidden by the swelling in lateral view but straight and subparallel internally. Surface reticulate, the fossae being equal-sized and rounded; longitudinal ridges present, radiating from the anteroventral region. Eye tubercle prominent and elongate. Internally, duplicature moderately wide; line of concrescence and inner margin coincide; vestibule absent. Marginal pore canals straight, simple and fairly numerous. Muscle scar pattern consists of four adductor scars and three frontal; one or both of the median adductor scars probably divided but this is hard to see. Hinge strongly holamphidont. In left valve there is an anterior socket with a post-jacent knob-like tooth, followed by a smooth bar with an elongate socket behind.

DIMENSIONS (μm).	L	H	W
Holotype, left valve OS 8219	550	320	225

REMARKS. *Procythereis radiata* has a slightly different hinge from that of the type species, the median bar being smooth instead of crenulate as in *P. torquata* Skogsberg, 1928. So far, very few *Procythereis* species have been described; *P. radiata* can easily be distinguished from any of them by its rectangular shape, symmetrically rounded anterior margin, and the obliquely truncate and ventrally produced outline of the posterior margin.

Subfamily **THAEROCYTHERINAE** Hazel, 1967
Tribe **THAEROCYTHERINI** Hazel, 1967

Genus ***HERMANITES*** Puri, 1955

TYPE SPECIES. *Hermania reticulata* Puri, 1954.

Hermanites carchesium sp. nov.
Pl. 20, figs 11–12; Pl. 21, figs 1–6; Pl. 22, fig. 11

NAME. Latin *carchesium*, a Greek style of cup slightly contracted in the middle; with reference to the slight contraction in the middle of the carapace.

DIAGNOSIS. A strongly reticulate species of *Hermanites* with broadly rounded anterior margin, dorsal margin strongly modified in lateral view by a wavy marginal ridge, and the ventral margin modified by a straight ridge.

HOLOTYPE. A female carapace, OS 8223. Two male carapaces, OS 8224–5, are paratypes. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Eight specimens from the same locality and horizon, including OS 8321 (juvenile), pl. 22, fig. 11.

DESCRIPTION. Carapace subquadrate, with greatest height at anterior end and greatest width in posterior half at about two-thirds the length from anterior margin. Anterior margin symmetrically rounded, with 23 short denticles; posterior produced just below middle; five to seven strong denticles along posteroventral edge. Dorsal margin strongly modified by a wavy dorsal ridge. Posterodorsal margin concave, ventral margin straight to slightly concave in the middle and convex in posterior half. Sexual dimorphism present, presumed females being more quadrate and wider than males. Surface strongly reticulate. Strong anterior marginal ridge present; ventral ridge running from about a quarter to about three-fifths the length from the anterior margin, then curling upwards to form a loop. Subcentral tubercle elongate, not well developed; eye tubercle strongly developed. Fossae vary in shape, being quadrate and subrectangular in some parts and polygonal or triangular in others. Muscle scars and marginal pore canals not seen in the one poorly preserved adult single valve. Other internal features typical of genus.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8223	750	440	370
Paratype, male carapace OS 8224	745	440	345
Paratype, male carapace OS 8225	750	460	400

REMARKS. It is very difficult to place *H. carchesium* in either *Hermanites* or *Quadracythere* solely on the basis of shape and ornamentation. There is a group of species closely allied with *H. carchesium* which could belong to either genus, these genera being distiguished only by the type of frontal scar, which could not be seen in the Tanzanian species. However, *H. carchesium* is most like *Hermanites* in dorsal view , and therefore is here placed in that genus. *H. carchesium* resembles *H. dameriacensis* Keij, 1958 in outline and ornament, differing only in having no pronounced loop connecting the dorsal and ventral ridges in the posterior half.

Hermanites mongoensis sp. nov. Pl. 22, figs 1–2

NAME. After Mongo Stream, the type locality.

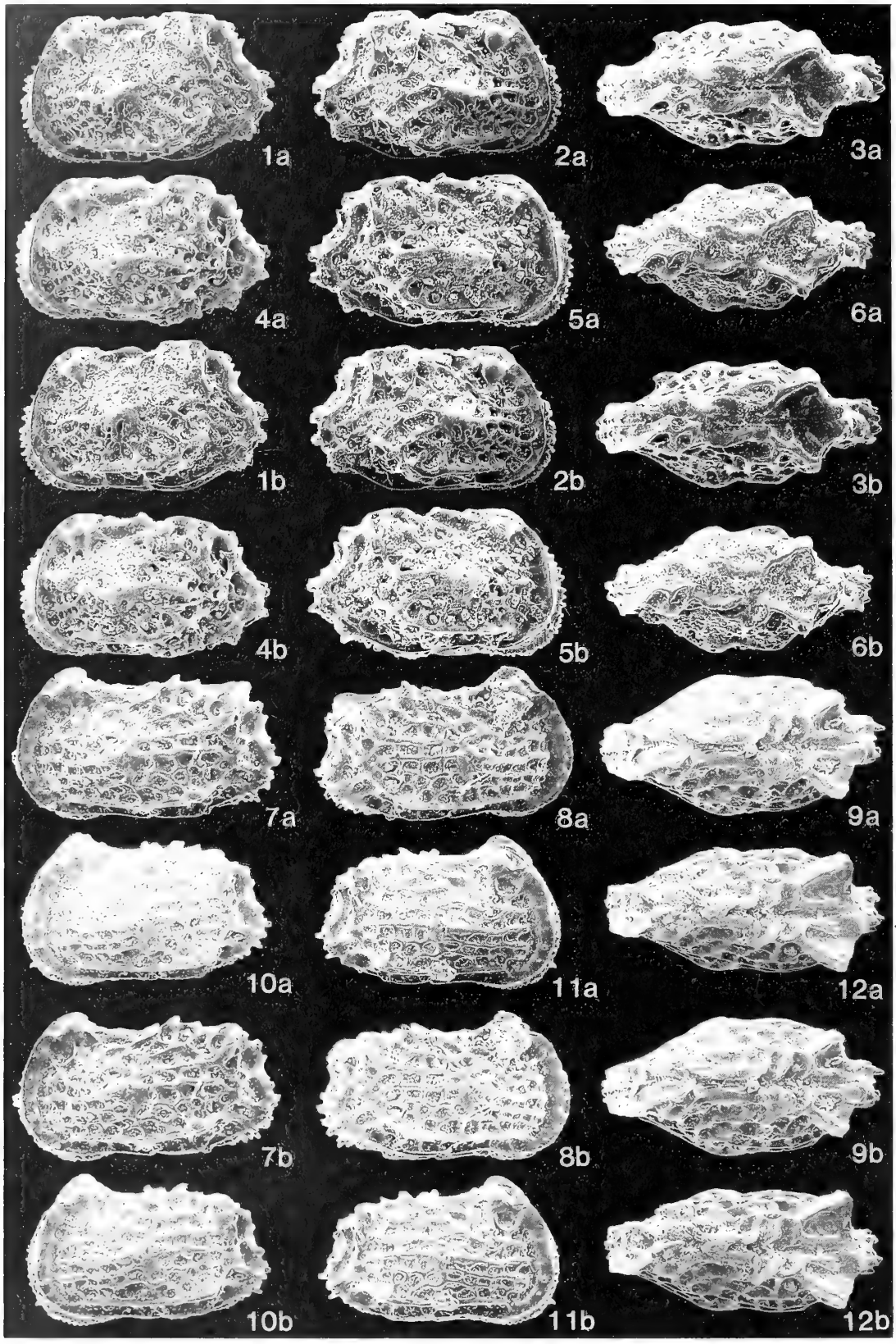
DIAGNOSIS. A species of *Hermanites* with dorsal ridge strongly modified in posterior half by the posterodorsal loop, which joins it to the median ridge; ventrolateral carina strongly developed.

HOLOTYPE. Right valve, OS 8232. Another valve, OS 8233 is a paratype. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

OTHER MATERIAL. Five specimens from the same sample. Also occurs in FCRM 1745 and 2010.

DESCRIPTION. Carapace medium-sized, subquadrate to subrectangular, with greatest height at anterior end, tapering towards posterior. Anterior margin symmetrically rounded, posterior subacuminate and produced subventrally. Dorsal margin, with its marginal ridge, is almost straight and slopes posteriorly; it is strongly modified in posterior half by the posterodorsal loop which joins it to the median ridge. Ventral margin almost straight. Ventrolateral carina well developed, curving upwards near posterior end to join posterodorsal loop. Entire lateral surface reticulate, with broad fossae. Eye tubercle well developed. Duplicature moderately wide; inner margin regular, slightly separated from line of concrescence, leaving a narrow vestibule. Selvage a little distance from anterior margin, continuous along entire free edge. 20–25 marginal pore canals, mainly concentrated along the anteroventral margin, are mostly short, straight and simple. Four adductor muscle scars, located in the deep subcentral pit, are arranged in a vertical row and decrease in size from dorsal to ventral; one crescentic to U-shaped frontal scar. Hinge strongly holamphidont.

DIMENSIONS (μm).	L	H	W
Holotype, right valve OS 8232	680	380	240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REMARKS. Oligocene specimens vary somewhat from the holotype and are distinguished as Morphotypes A and B, below. *H. dameriacensis* Keij 1958 has a similar shape to *H. mongoensis* but differs in its less angular posterodorsal loop, its smooth rounded subcentral tubercle, and in the way the posterodorsal ridge joins the dorsal and ventral ridges; this junction is defined better than in *H. mongoensis*.

Morphotype A

Pl. 22, figs 3–7

FIGURED SPECIMENS. Two female valves, OS 8238–9, and a male left valve, OS 8240. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Seven specimens.

DIMENSIONS (μm).	L	H	W
Female right valve OS 8238	810	450	270
Female left valve OS 8239	745	445	245
Male left valve OS 8240	840	455	280

REMARKS. Morphotype A differs from typical *H. mongoensis* in details of ornamentation; the posterodorsal loop is less sharp and the parts of the median ridge are differently arranged. Morphotype A clearly represents an earlier stage in the evolutionary development of *Hermanites mongoensis*, s. str.

Morphotype B

Pl. 22, figs 8–10

FIGURED SPECIMEN. A male left valve, OS 8242. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene. The only specimen.

DIMENSIONS (μm).	L	H	W
Male left valve OS 8242	710	370	235

REMARKS. Morphotype B is rectangular. In lateral view the ventral margin is strongly modified by the overhanging ventral ridge, which gives it a distinctive shape.

Hermanites percultus sp. nov.

Pl. 21, figs 7–12; Fig. 8

NAME. 'Highly ornamented', with reference to the strongly reticulated surface.

DIAGNOSIS. A species of *Hermanites* with a strongly reticulate lateral surface, a straight, pronounced ventral ridge and a raised posterodorsal tubercle, which gives it a characteristic appearance in dorsal view.

HOLOTYPE. A female carapace, OS 8226. Five carapaces, OS 8227–31, are paratypes. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Two specimens.

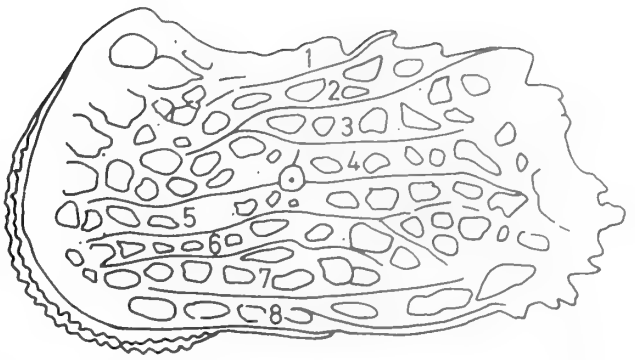


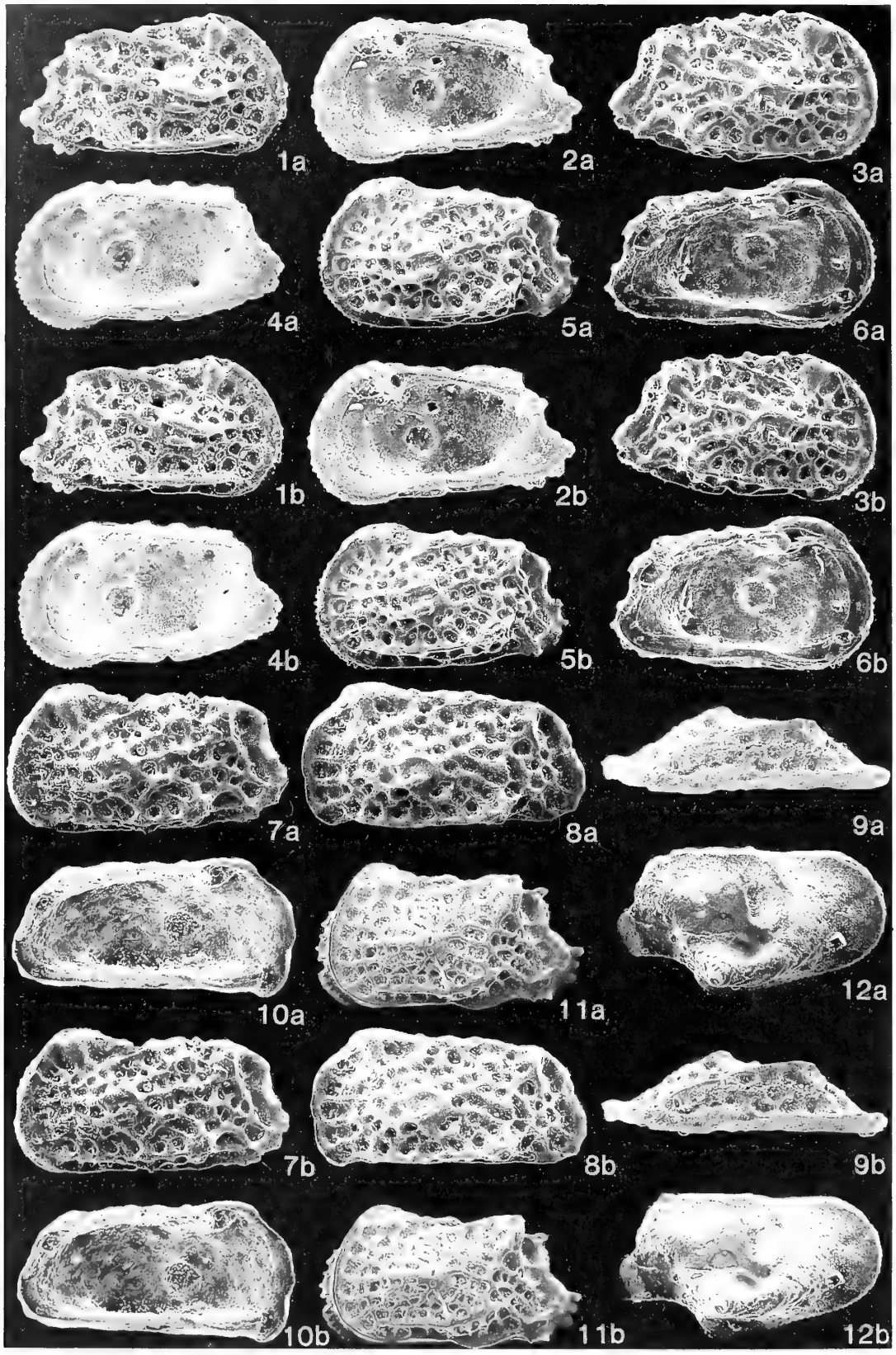
Fig. 8 *Hermanites percultus* sp. nov. Paratype OS 8227. Carapace from left, lateral surface showing the ornament. ×110. 1–8, the ridges described in the text.

DESCRIPTION. Carapace subrectangular in lateral view, with greatest height at anterior cardinal angle. Dorsal and ventral margins straight, converging slightly towards posterior. Anterior margin broadly rounded with a very distinct anterior cardinal angle; it has 18–20 marginal denticles. Posterior margin curving into ventral margin in lower half and concave posterodorsally; it has three to five large, strong marginal denticles. In dorsal view, greatest width in anterior third. Posterodorsal tubercles give carapace a winged appearance. Sexes distinct; while presumed females are more rectangular, with dorsal and ventral margins subparallel, presumed males taper posteriorly. Surface strongly reticulate, fossae being subrectangular. There are eight longitudinal ridges, here numbered from top to bottom for convenience in description. Ridge 1–3 are well developed posteriorly and subparallel forward to mid-length, losing their identities further forward; ridge 4 runs from anterior to posterior and includes the rather small subcentral tubercle; 5 and 6 are subparallel to 4 anteriorly but lose their identities further back; ridge 7 is straight and strong, running parallel to the ventral margin; ridge 8 is a continuation of the anterior marginal rim and runs as far as mid-venter, where it is replaced by another short ridge running parallel to the ventral margin. Duplicature fairly wide, narrowing slightly towards anterodorsal margin. Selvage very well developed, running almost in the middle of marginal zone but curving in mid-ventral region, where it is raised and is concave to outer margin. Normal pore canals few and widely spaced. Marginal pore canals fairly numerous, straight and simple, mostly concentrated along the anterodorsal margin. Muscle scars cannot be seen in any adult specimens, but in the less calcified juveniles the frontal scar is crescentic. Hinge strongly developed, consisting of a strong anterior knob-like tooth, post-jacent socket, a crenulate bar and a very backwardly placed, elongate posterior tooth.

PLATE 21

Figs 1–6 *Hermanites carchesium* sp. nov. Figs 1, 2, paratype, male carapace, OS 8225; 1, lateral view from left, ×55; 2, lateral view from right, ×54. Fig. 3, paratype, male carapace, OS 8224, dorsal view, ×63. Figs 4–6, **holotype**, female carapace, OS 8223; 4, lateral view from left, ×55; 5, lateral view from right, ×57; 6, dorsal view, ×59.

Figs 7–12 *Hermanites percultus* sp. nov. Figs 7–9, paratype, male carapace, OS 8227; 7, lateral view from left, ×57; 8, lateral view from right, ×56; 9, dorsal view, ×61. Figs 10–12, **holotype**, female carapace, OS 8226; 10, lateral view from left, ×59; 11, lateral view from right, ×58; 12, dorsal view, ×65.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DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8226	695	440	340
Paratype, male carapace OS 8227	760	445	350

REMARKS. *H. percultus* is quite distinct from all the other *Hermanites* species described so far, but is tentatively placed in that genus because of some internal details and the pattern of exterior ridges. In general shape it also resembles a number of species described under *Bradleya* Hornibrook 1952, and *Agrenocythere* Benson 1972. *H. percultus* differs from typical *Hermanites* in the following respects:

(i) There is a vestibule, and the line of concrescence and the inner margin do not coincide as in other *Hermanites*.

(ii) The posterior tooth is very backwardly placed in the new species.

(iii) The marginal pores are simple, not thickened in the middle as in most species of *Hermanites*.

(iv) *H. percultus* is rectangular, compared with the usual tapering shape of *Hermanites* species.

(v) The subcentral tubercle is unlike that of typical *Hermanites*, being more like what Benson (1972) called a bridte.

Tribe **BRADLEYINI** Benson, 1972

Genus ***BRADLEYA*** Hornibrook, 1952

TYPE SPECIES. *Cythere arata* Brady, 1880.

Bradleya? sp. A Pl. 23, figs 1–3

FIGURED SPECIMEN. A right valve, OS 8187. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene. The only specimen.

DESCRIPTION. A species of *Bradleya*? with strong ventrolateral carina, posterodorsal loop and subcentral tubercle. Surface smooth with underlying reticular 'ghost' pattern. Carapace subrectangular to suboval in lateral view, with greatest height at anterior cardinal angle; tapering posteriorly. Anterior margin symmetrically rounded, posterior bluntly produced and truncate. Dorsal margin modified by dorsal ridge but otherwise straight; ventral margin straight to slightly concave in the anterior half. Ornament consists of a posterodorsal loop, a ventrolateral carina and a subcentral tubercle. Lateral surface smooth, but with the sort of underlying reticulation termed 'reticular ghosts' by Benson (1972). Duplicature moderately wide; selvage well developed, running almost halfway between inner margin and flange. Flange groove prominent. Marginal pore canals, about 17 anteriorly and 8 posteriorly, mostly simple, short and equally spaced. There are four adductor muscle scars, the second from the top being longest, all arranged in a row behind a divided frontal scar. Hinge strongly holamphidont.

DIMENSIONS (μm).	L	H	W
Right valve OS 8187	820	450	310

REMARKS. *Bradleya lactea pakaurangia* Hornibrook 1952 resembles *Bradleya*? sp. A in general shape but has a strong posterodorsal loop with the median ridge well developed in the posterior half, whereas *Bradleya*? sp. A has no median ridge. The conspicuous normal pores of Hornibrook's species are not present in our African one. *B. semiarata* Hornibrook is also closely allied to *Bradleya*? sp. A but has an almost straight posterior marginal outline compared with the bluntly produced posterior of the latter. The generic placement of *Bradleya*? sp. A is tentative; though it probably belongs to the same genus as *B. lactea pakaurangia*, it is doubtful whether the latter is congeneric with the type species *B. arata* (Brady).

Bradleya? sp. B Pl. 23, figs 4–5

FIGURED SPECIMEN. A carapace, OS 8328. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Four carapaces, including OS 8329, from FCRM 1578.

DESCRIPTION. Carapace subrectangular in side view, with greatest height at anterior cardinal angle, valves tapering posteriorly. Anterior margin denticulate, broadly rounded; posterior margin strongly concave in the posterodorsal half and convex posteroventrally. Dorsal margin strongly modified by dorsal ridges; ventral margin slightly concave in anterior half, to almost straight behind. Ornament consists of a marginal ridge running from well-developed eye tubercle along anterior, ventral and posterior margins and parallel to them. Posterodorsal loop-like ridge prominent; subcentral tubercle well developed. Surface smooth except for small compartments enclosed by low ridges along posterodorsal, anterior and ventral margins. No single valves were found so no internal details were seen.

DIMENSIONS (μm).	L	H	W
Carapace OS 8328	570	315	280

REMARKS. This species is less subrectangular than *Bradleya*? sp. A, and the dorsal ridge is loop-like rather than straight and mostly parallel to the dorsal margin; also, the ghostly ornamentation is absent. The present species resembles *B. lactea pakaurangia* Hornibrook, but the outline of the posterior margin is different and the maximum height is

PLATE 22

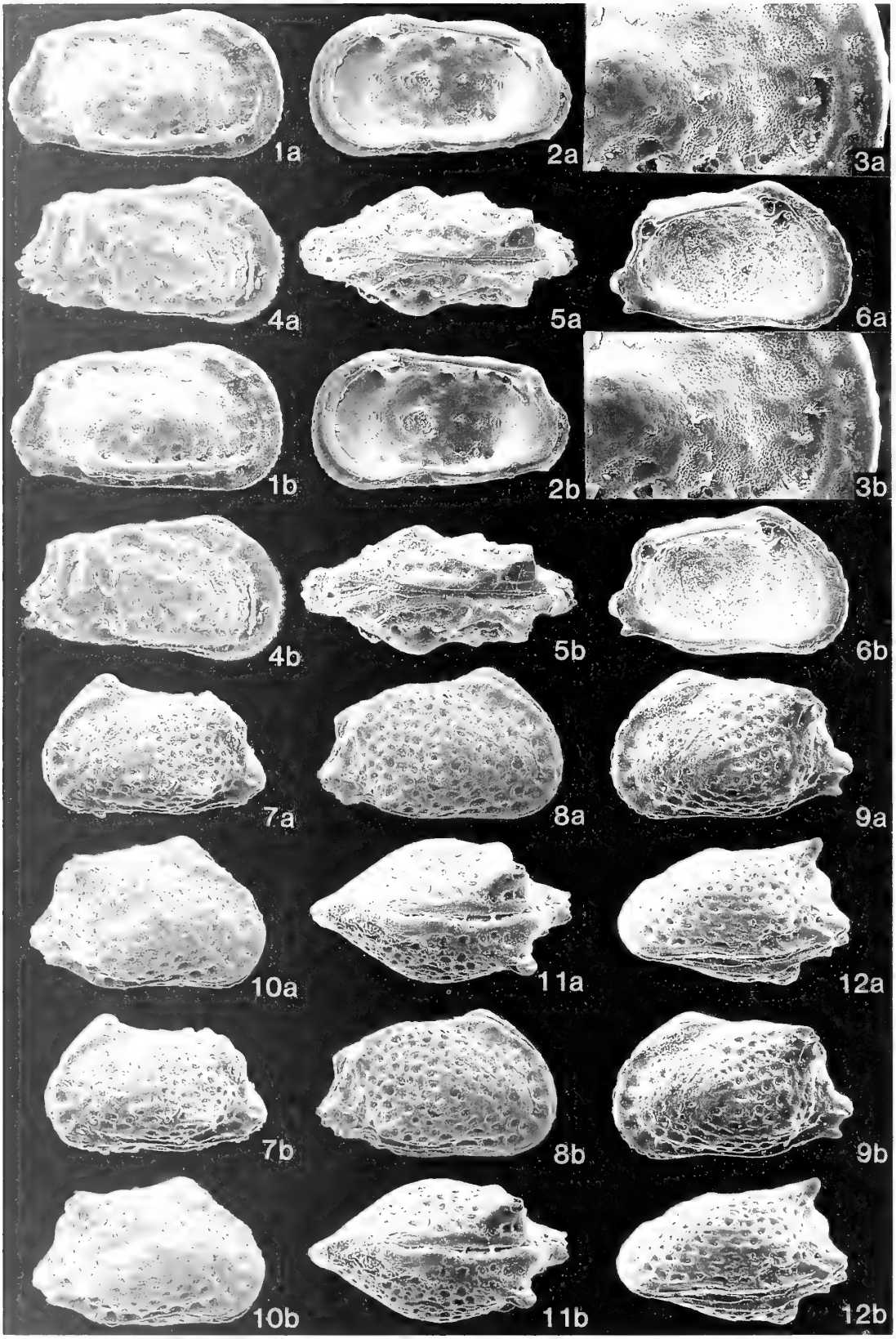
Figs 1, 2 *Hermanites mongoensis* sp. nov. **Holotype**, right valve, OS 8232; 1, external lateral view, ×63; 2, internal lateral view, ×64.

Figs 3–7 *Hermanites mongoensis* sp. nov., Morphotype A. Figs 3, 4, female right valve, OS 8238; 3, external lateral view, ×54; 4, internal lateral view, ×54. Figs 5, 6, female left valve, OS 8239; 5, external lateral view, ×56; 6, internal lateral view, ×59. Fig. 7, male left valve, OS 8240, external lateral view, ×54.

Figs 8–10 *Hermanites mongoensis* sp. nov., Morphotype B. Female left valve, OS 8242; 8, external lateral view, ×65; 9, ventral view, ×65; 10, internal lateral view, ×64.

Fig. 11 *Hermanites carchesium* sp. nov. Juvenile left valve, OS 8321, external lateral view, ×72.

Fig. 12 *Bythoceratina* sp. A. Right valve, OS 8317, external lateral view, ×75.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subventral rather than at mid-height as in Hornibrook's species.

Genus ***QUADRACYTHERE*** Hornibrook, 1952

TYPE SPECIES. *Cythere truncula* Brady, 1898.

Quadracythere arcana (Lubimova & Guha, 1960)

1960 *Cythereis arcanus* (sic, recte *C. arcana*) Lubimova & Guha (in Lubimova *et al.*): 33; pl. 34, figs 3–5.
1971 *Quadracythere* (*Hornibrookella*) *arcana* (Lubimova & Guha) Siddiqui: 67; pl. 34, figs 3–5.

Quadracythere arcana cornigera subsp. nov.

Pl. 25, figs 4–8

NAME. 'Horned', with reference to the strong posterodorsal alae.

HOLOTYPE. A female carapace, OS 7844. Two specimens, OS 7845, 8258, are paratypes. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. 74 specimens, including juveniles, from samples FCRM 1575, 1578, 2033. See Remarks below for specimens from FCRM 1566 (Lower Miocene), e.g. OS 8257.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 7844	570	350	330
Paratype, male carapace OS 7845	620	355	350
Juvenile left valve (? this species) OS 8257	485	300	150

REMARKS. The new subspecies differs from *Q. arcana* s. str., from the Middle Eocene of Kutch, India, in having stronger posterodorsal alae, which give it a different shape in dorsal view. It also shows distinct sexual dimorphism, the presumed males being subrectangular compared with the more quadrate females. Only provisionally classified here are a large number of juvenile single valves from Lower Miocene samples (e.g. FCRM 1566; Pl. 25, fig. 8) which may not belong here, but this is the only species which they resemble in shape.

Quadracythere*? *acuta sp. nov. Pl. 24, figs 4–7

NAME. 'Pointed', with reference to the posterior extremity.

DIAGNOSIS. A species of *Quadracythere*(?) with coarsely reticulate ornament, the ridges being blade-like.

HOLOTYPE. A female carapace, OS 8245. A male carapace, OS 8247, is a paratype. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Two carapaces. Also occurs in FCRM 1578.

DESCRIPTION. Carapace medium-sized to large, with greatest height at anterior cardinal angle and greatest length in ventral half. Anterior margin rounded; posterior end acuminate in lateral view, making a pronounced posterior cardinal angle; both margins denticulate. Dorsal margin almost straight, ventral concave in the middle and convex on either side; posterodorsal margin concave. Sexes distinct, presumed males being shorter and more slender than females. Surface coarsely reticulate with sharp muri running predominantly longitudinally. Eye tubercle strongly developed. No internal details seen.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8245	810	500	390
Paratype, male carapace OS 8247	820	485	385

REMARKS. The produced and upturned posterior margin, sharp muri and shape intermediate between *Quadracythere* and *Agrenocythere* suggest that this species could be placed in either genus. However, *Agrenocythere* has no eye tubercle, so the species is tentatively assigned to *Quadracythere*.

Quadracythere distenta sp. nov.

Pl. 24, fig. 12; Pl. 25, figs 1–3

NAME. 'Swollen', with reference to the carapace.

DIAGNOSIS. A species of *Quadracythere* almost quadrate in lateral view, with length to height ratio of 3:2. Ridges on the surface slope longitudinally from the posterodorsal to the anteroventral region.

HOLOTYPE. A carapace, OS 8250. Another carapace, OS 8251, is a paratype. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. Four specimens from samples FCRM 1566 (e.g. OS 8252), 1989.

DESCRIPTION. Carapace tumid, subquadrate, with greatest height at anterior cardinal angle and greatest width about two-thirds of the length from the front. Anterior margin broadly rounded, posterior margin produced subventrally and obliquely truncated. Posterodorsal margin concave; dorsal and ventral margins modified in lateral view by marginal keels, dorsal margin being otherwise straight and ventral margin concave in the middle. Lateral surface reticulate, predominant lateral ridges sloping from posterodorsally to anteroventrally. Ridges are subparallel to margins along anterior and posterior ends. Duplicature moderately wide. Normal pores fairly numerous and widely scattered. Muscle scars could not

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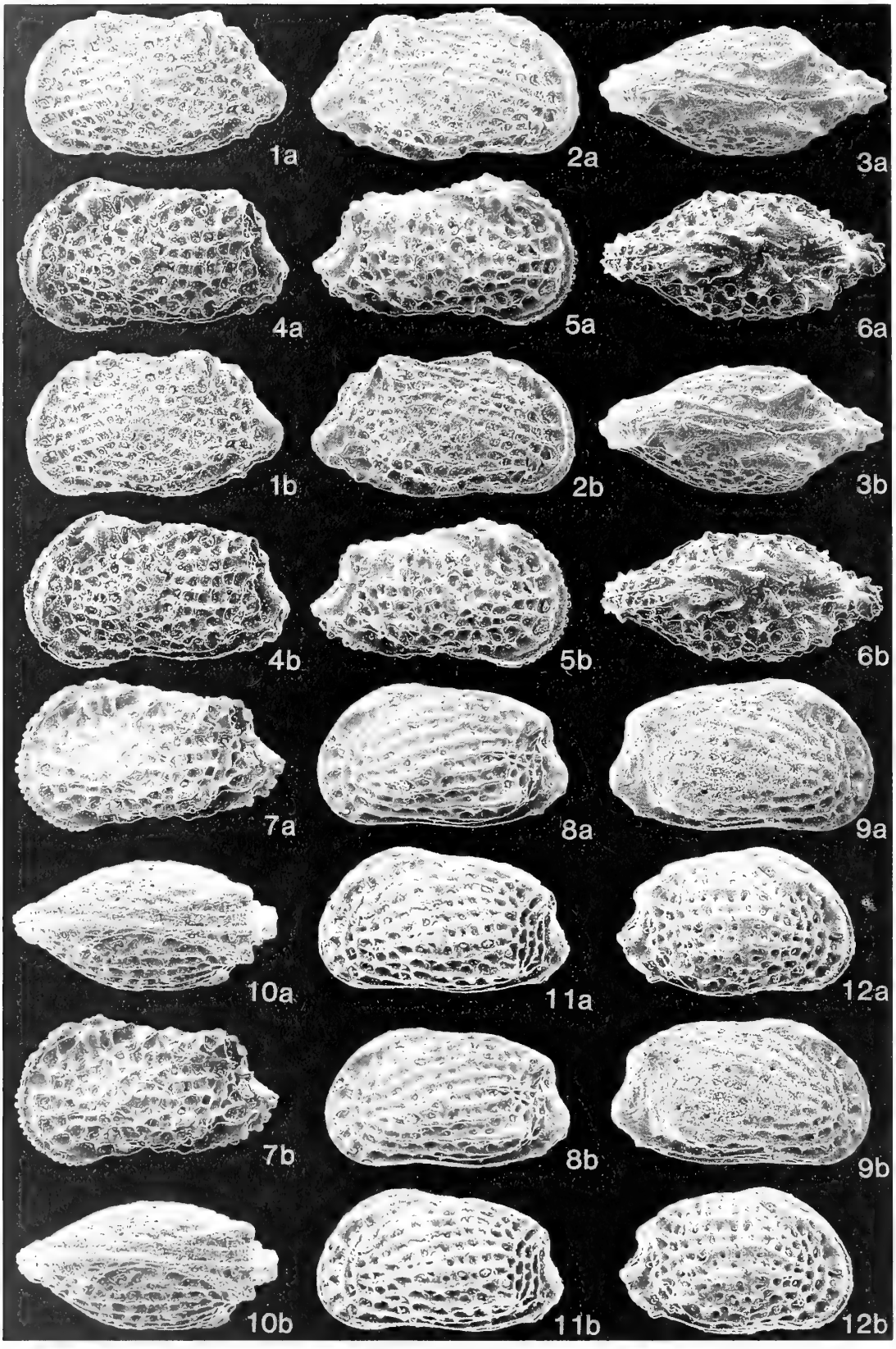
PLATE 23

Figs 1–3 *Bradleya*? sp. A. Right valve, OS 8187; 1, external lateral view, ×55; 2, internal lateral view, ×52; 3, 'ghost' reticulation on external lateral surface, ×123.

Figs 4, 5 *Bradleya*? sp. B. Carapace, OS 8328; 4, lateral view from right, ×76; 5, dorsal view, ×79.

Figs 6–12 *Quadracythere vanga* sp. nov. Figs 6, 9, paratype, female left valve, OS 8255; 6, internal lateral view, ×63; 9, external lateral view, ×63. Fig. 7, paratype, male carapace, OS 8254, lateral view from left, ×68. Fig. 8, **holotype**, male carapace, OS 8253, lateral view from right, ×68. Figs 10–12, paratype, female carapace, OS 8256; 10, lateral view from right, ×62; 11, dorsal view, ×70; 12, ventrolateral view from left, ×62.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be seen; hinge and other internal features typical of the genus.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8250	675	435	410
Left valve OS 8252	640	415	250

REMARKS. *Q. hornibrooki* Holden 1967 differs from *Q. distenta* in having the greatest height just behind the anterior margin. *Q. kenti* sp. nov. (below) is very similar to *Q. distenta*, but as they have slightly different patterns of ornamentation and *Q. distenta* is larger, the two are here considered to be distinct species.

Quadracythere kenti sp. nov. Pl. 24, figs 8–11

NAME. In honour of the late Sir Peter Kent, F.R.S., in recognition of his contribution to Tanzanian geology.

DIAGNOSIS. A subrectangular species of *Quadracythere* with reticulate surface, about ten ridges running from the posterior towards the anteroventral area. The three ventral ridges curve along, and run parallel to, the anterior and posterior margins.

HOLOTYPE. A male carapace, OS 8248. A female carapace, OS 8249, is a paratype. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. Two carapaces from the type locality and horizon.

DESCRIPTION. Carapace medium-sized, subrectangular in lateral view, with greatest height at anterior cardinal angle and greatest width at mid-length. Anterior margin asymmetrically rounded, posterior produced subventrally. Dorsal margin almost straight; ventral margin straight to slightly concave in the middle. Sexual dimorphism present, presumed females being subquadrate compared with males, which taper posteriorly. In dorsal view, carapace lens-shaped. Surface reticulate. About ten ridges run posterodorsally to anteroventrally. The three ventral ridges continue along, and run parallel to, the anterior and posterior margins. Ridges alate posterodorsally and posteroventrally.

DIMENSIONS (μm).	L	H	W
Holotype, male carapace OS 8248	640	380	330
Paratype, female carapace OS 8249	595	360	325

REMARKS. *Q.? sulcatopunctata* (Reuss) subsp. *mediterranea* Ruggieri, 1962 is the only species of *Quadracythere* with some resemblance to *Q. kenti*, but besides some other minor differences of ornamentation, Ruggieri's subspecies does not have ridges running parallel to the posterior margin. For comparison with *Q. distenta* see remarks under that species.

Quadracythere subquadra Siddiqui, 1971 Pl. 24, figs 1–3

1971 *Q.* (*Hornibrookella*) *subquadra* Siddiqui: 68; pl. 34 figs 6–11.

FIGURED SPECIMEN. A carapace, OS 8243. Sample FCRM 1575, shore south-west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. 29 specimens from samples FCRM 1574–8.

DIMENSIONS (μm).	L	H	W
Carapace OS 8243	670	380	320

REMARKS. Siddiqui (1971) described this species from the Upper Chocolate Clays (Upper Eocene) of the Zao River, Pakistan. The Tanzanian specimens differ slightly from these in being more produced posteriorly; they also lack the distinct subcentral tubercle which is characteristic of Pakistani ones.

Quadracythere trijugis Holden, 1976 Pl. 25, fig. 9

1976 *Quadracythere trijugis* Holden: 23, figs 14–15; pl. 5, fig. 24.

FIGURED SPECIMEN. A right valve, OS 7843. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. 11 specimens from samples FCRM 1575, 1578, 2010.

REMARKS. This species was originally described from the Upper Miocene of the Sand Island hole and the Lower Miocene of the Reef hole, Midway area, Hawaiian Islands. The Tanzanian specimens are identical with Holden's paratype USNM 184435 (1976: pl. 5, fig. 24) which has been described as 'young'. The internal details of the Tanzanian specimens suggest that these are juveniles as well.

DIMENSIONS (μm).	L	H	W
Right valve, juvenile? OS 7843	595	330	160

Quadracythere vanga sp. nov. Pl. 23, figs 6–12

NAME. 'A spade' (late Latin), with reference to the shape in lateral view.

DIAGNOSIS. A species of *Quadracythere* with a strongly protruding anterior cardinal angle, particularly in left valve.

HOLOTYPE. A male carapace, OS 8253. Three specimens, OS 8254–6, are paratypes. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Two specimens.

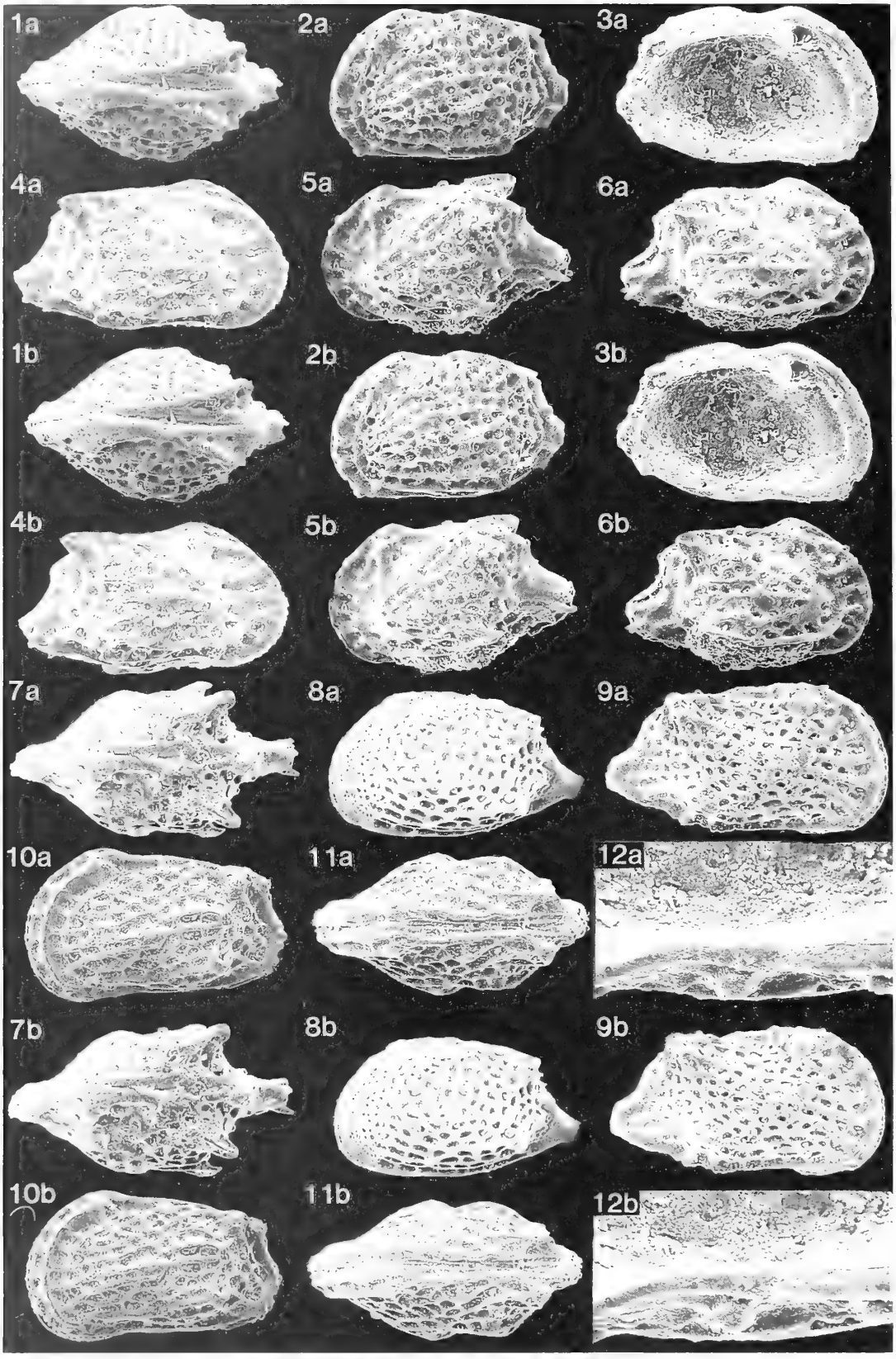
PLATE 24

Figs 1–3 *Quadracythere subquadra* Siddiqui, 1971. Carapace, OS 8243; 1, lateral view from left, ×64; 2, lateral view from right, ×64; 3, dorsal view, ×69.

Figs 4–7 *Quadracythere? acuta* sp. nov. Fig. 4, **holotype**, female carapace, OS 8245, lateral view from left, ×54. Figs 5–7, paratype, male carapace, OS 8247; 5, lateral view from right, ×51; 6, dorsal view, ×56; 7, lateral view from left, ×53.

Figs 8–11 *Quadracythere kenti* sp. nov. Figs 8–10, **holotype**, male carapace, OS 8248; 8, lateral view from left, ×63; 9, lateral view from right, ×67; 10, dorsal view, ×67. Fig. 11, paratype, female carapace, OS 8249, lateral view from left, ×69.

Fig. 12 *Quadracythere distenta* sp. nov. **Holotype**, carapace, OS 8250, lateral view from right, ×58. See also Pl. 25, fig. 1.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DESCRIPTION. Carapace medium-sized, with greatest height at anterior cardinal angle and greatest length subventral. Anterior margin broadly and obliquely rounded towards venter; posterior end with subventral caudal process. Anterior cardinal angle strongly protruding particularly in left valve; dorsal margin almost straight. Lateral surface reticulate. Carapace alate both dorsally and ventrally in the posterior half, ventral alae being sharper and more triangular than dorsal ones. Posterior margin has two or three marginal spines. Sexual dimorphism present, presumed males being narrower posteriorly than females. Duplicature moderately broad and very regular, selvage well developed mid-ventrally. Marginal pore canals obscure but seven or eight false ones visible. Muscle scars also obscure; only a V-shaped frontal scar and two adductor scars are visible. Hinge strongly holamphidont.

DIMENSIONS (μm).	L	H	W
Holotype, male carapace, OS 8253	585	370	320
Paratype, female left valve, OS 8255	630	405	220
Paratype, male carapace, OS 8254	540	345	285
Paratype, female carapace, OS 8256	610	410	350

REMARKS. *Q. vanga* is distinguished from the other Tanzanian species and from *Q. brachypygaia* van den Bold, 1965, from the Oligo-Miocene of Puerto Rico, by its strongly protruding anterior cardinal angle. In this respect it resembles *Q. orbignyana* (Bosquet) *emend.* Keij, 1957, but the latter has stronger reticulation.

Quadracythere sp. A

Pl. 25, figs 10–11

FIGURED SPECIMEN. A carapace, OS 8244. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene. The only specimen.

DESCRIPTION. Carapace subrectangular in lateral view, with greatest height at anterior cardinal angle and greatest width just behind mid-length. Anterior margin broadly rounded; posterodorsal margin concave, posteroventral bluntly produced. Dorsal margin almost straight, making a pronounced cardinal angle with posterior margin. Ventral margin straight to slightly concave in the middle. Lateral surface strongly reticulate, with foveolate muri and the ridges mostly longitudinal. Ocular ridge strongly developed, running parallel to anterior and ventrolateral margins. No internal details visible.

DIMENSIONS (μm).	L	H	W
Carapace OS 8244	780	490	415

REMARKS. *Quadracythere* (*Hornibrookella*) sp. A of Siddiqui, 1971, from the Middle–Upper Eocene Upper Chocolate Clays of the Zao River section, Sulaiman Range, Pakistan, is very similar to *Quadracythere* sp. A from Tanzania. But while the Tanzanian species is wider behind the middle, Siddiqui's species is wider in the anterior half. In addition, the fossae in the Tanzanian species are arranged longitudinally, while in the Pakistani species they are somewhat concentrically arranged around the subcentral tubercle.

Genus *CRENALEYA* nov.

NAME. From botanical Latin *crena*, a rounded projection; with reference to the round projecting snap-knob in the right valve of the type species.

DIAGNOSIS. Carapace elongate in side view, subrectangular, with dorsal and ventral margins straight and slightly converging posteriorly. Valves inflated ventrally, with greatest width about a third of the length from posterior end. Sexual dimorphism marked. Lateral surface reticulate, with deep fossae and crimped muri; eye tubercle present. Muscle scars not clearly visible in adults, but in less calcified juveniles the pattern consists of four adductor scars arranged in a row, with a V-shaped frontal scar. Hinge strongly holamphidont, closure further strengthened by a ventral snap-knob in right valve. There is no socket in left valve; instead the knob rests against the external surface of the mid-ventral margin.

TYPE SPECIES. *Crenaleya tuberis* sp. nov.

REMARKS. The new genus appears to be related to *Oertliella* Pokorný, 1964*a*, *Bradleya* Hornibrook, 1952, *Urocythereis* Ruggieri, 1950, *Agrenocythere* Benson, 1972, *Phalcocythere* Siddiqui, 1971, and some species of *Hermanites* Puri, 1955. It can be distinguished from *Oertliella* by the absence of a strong ventrolateral ridge, a dorsal ridge often reduced to spines, and a hemiholamphidont hinge, all of which are characteristic of *Oertliella*. *Crenaleya* differs from *Bradleya* in lacking dorsal and ventral ridges, which are found in that genus. In side view, *Crenaleya* resembles *Urocythereis*, but in dorsal view the latter is lens-shaped, while the former is trapezoid, being very wide posteriorly; also, *Urocythereis* has the frontal muscle scar divided. *Phalcocythere* has a ventral ridge, distinguishing it from the new genus. Some species of *Agrenocythere* (e.g. *A. pliocenica* (Segueza)) and *Hermanites* (e.g. *H. volans* Neale, 1975) resemble the new genus, but they all have dorsal and/or ventral ridges; *Agrenocythere* also lacks eye tubercles. The new genus is further distinguished by the ventral snap-knob in the right valve and by the posteroventral inflation.

It is not known whether *Bradleya? cornuelina* (Bosquet) *emend.* Keij, 1957, *B.? voraginosa* Siddiqui, 1971, *Oertliella* sp. A of Donze *et al.*, 1970, and Genus Indet. Sp. 1 of Dingle,

PLATE 25

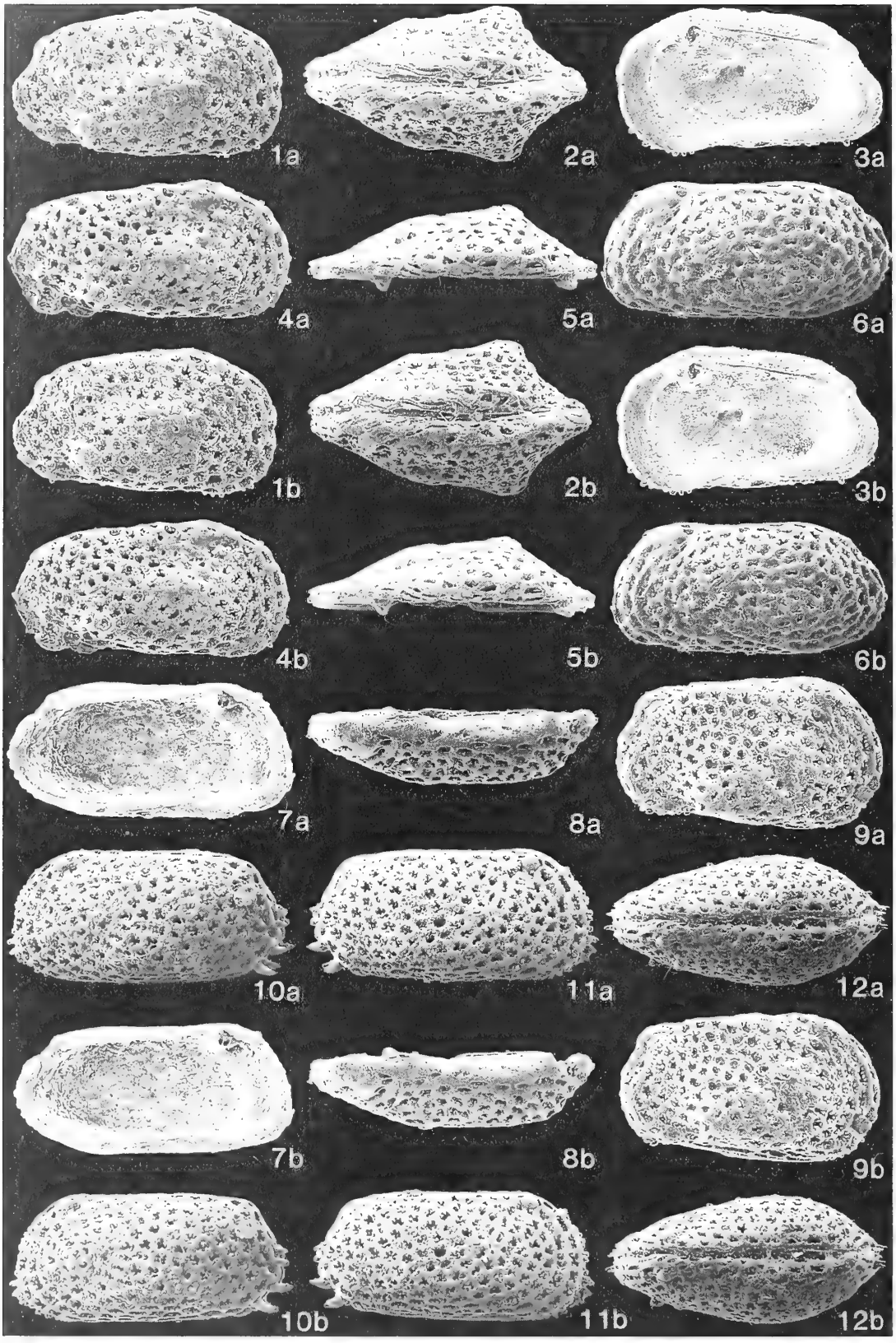
Figs 1–3 *Quadracythere distenta* sp. nov. Fig. 1, **holotype**, carapace, OS 8250, dorsal view, ×64; see also Pl. 24, fig. 12. Figs 2, 3, left valve, OS 8252; 2, external lateral view, ×61; 3, internal lateral view, ×66.

Figs 4–8 *Quadracythereis arcana* (Lubimova & Guha) *cornigera* subsp. nov. Fig. 4, paratype, male carapace, OS 7845, lateral view from right, ×72. Figs 5–7, subspecific **holotype**, female carapace, OS 7844; 5, lateral view from left, ×72; 6, lateral view from right, ×71; 7, dorsal view, ×82. Fig. 8, juvenile left valve, possibly not this species (see text, p. 231), OS 8257, external lateral view, ×85.

Fig. 9 *Quadracythere trijugis* Holden, 1976. Juvenile? right valve, OS 7843, external lateral view, ×76.

Figs 10, 11 *Quadracythere* sp. A. Carapace, OS 8244; 10, lateral view from left, ×53; 11, dorsal view, ×56.

Fig. 12 *Crenaleya tuberis* gen. et sp. nov. **Holotype**, female right valve, OS 8259, snap–knob as seen at mid–ventral margin, ×600. See also Pl. 26, figs 1, 3.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1976 have a snap-knob mechanism or not, but on the basis of shape and ornamentation these species belong to *Crenaleya*.

Crenaleya tuberis sp. nov. Pl. 25, fig. 12; Pl. 26, figs 1–5, 9

NAME. 'With a swelling', in reference to its ventrolateral swelling.

DIAGNOSIS. A *Crenaleya* with elongate, subrectangular carapace, gently tapering posteriorly in lateral view; ventrolateral swelling terminating in a tubercle in the posterior third. Sexual dimorphism pronounced. Surface reticulate, with trifoliate pits.

HOLOTYPE. A female left valve, OS 8259. Ten specimens, OS 8260–1, 8263–70, are paratypes. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. 18 specimens from the locality and horizon above. Also occurs in FCRM 1575 and 1576.

DESCRIPTION. Carapace medium-sized to large, subrectangular in side view; dorsal and ventral margins subparallel, tapering slightly posteriorly. Anterior margin symmetrically rounded, posterodorsal margin concave; gently convex posteroventral margin slightly produced. There are 14–17 anteroventral and 4–6 posterior marginal denticles. Sexual dimorphism marked; presumed females higher in proportion to their length and wider than males. Lateral surface reticulate. The muri have short spines projecting into the fossae, giving them a crimped and trifoliate shape. Subcentral tubercle present, less prominent than a wide tuberculate ventrolateral swelling at about a third the length from posterior end, where carapace attains greatest width. Eye tubercle prominent and glassy. Duplicature moderately wide; line of concrescence coincides with inner margin so there is no vestibule. Right valve has a midventral snap-knob which rests against the mid-ventral margin of left. Hinge strongly holamphidont; in the right valve the conical anterior tooth has a post-jacent socket joined to an elongate elevated tooth by a smooth groove.

DIMENSIONS (μm).	L	H	W
Holotype, female right valve OS 8259	700	410	220
Paratype, female carapace OS 8263	720	420	420
Paratype, male right valve OS 8260	810	425	255

REMARKS. *C. tuberis* resembles Gen. Indet. 3 sp. 1 of Dingle, 1971, but the latter has a distinct marginal rim which the new species lacks.

Crenaleya sp. A Pl. 26, figs 10–12

FIGURED SPECIMEN. A carapace, OS 8271. Sample FCRM 2014, stream south-west of Mtwero; Lower Miocene. The only specimen.

DESCRIPTION. A distinctive rectangular species of *Crenaleya* with two very strong horn-like spines at the posteroventral angle. Carapace large, elongate; rectangular in side view with greatest width in posterior half. Dorsal and ventral margins parallel; anterior symmetrically rounded with about 14 marginal denticles. Posterodorsal margin makes a prominent cardinal angle with dorsal, meeting posteroventral margin at an obtuse angle at a point slightly below mid-height. Posterior margin has two posterodorsal and two much larger horn-like posteroventral spines. Lateral surface reticulate; muri have short spines which project into the fossae, giving them an ornate three- to six-rayed appearance. Eye tubercle well developed and glassy. A right valve, from Mafia SP/40′, kept at the BP Research Centre, Sunbury-on-Thames, has a moderately wide duplicature with line of concrescence separated from inner margin by a vestibule; there is a ventral snap-knob. There are four adductor scars and a V-shaped frontal scar as in the less calcified juveniles of the type species; hinge holamphidont.

DIMENSIONS (μm).	L	H	W
Carapace OS 8271	1090	525	510

Crenaleya? sp. Pl. 26, figs 6–8

FIGURED SPECIMEN. A male left valve, OS 8262. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene. The only specimen.

DIMENSIONS (μm).	L	H	W
Male left valve OS 8262	1070	520	325

REMARKS. This specimen is placed in the genus *Crenaleya* with reservations because it differs markedly from the type species *C. tuberis* in lateral outline, particularly at the posterior margin. It is highest at the posterior third, in this differing from both *C. tuberis* and *C.* sp. A, which are highest at the anterior cardinal angle.

Genus ***UROCYTHEREIS*** Ruggieri, 1950

TYPE SPECIES. *Cytherina favosa* Roemer, 1838.

Urocythereis salebrosa sp. nov. Pl. 27, fig. 1

NAME. 'Rough, rugged', with reference to the surface ornamentation.

DIAGNOSIS. A species of *Urocythereis* with coarsely reticulate surface and fossae forming characteristic ventrolateral slits.

HOLOTYPE. A left valve, OS 7987. Two valves, OS 8272–3, are paratypes. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. Two single valves from the same locality and horizon.

DESCRIPTION. Carapace medium-sized, subrectangular in side view, with greatest height at anterior cardinal angle. Anterior

PLATE 26

Figs 1–5, 9 *Crenaleya tuberis* gen. et sp. nov. Figs 1, 3, **holotype**, female right valve, OS 8259; 1, external lateral view, ×61; 3, internal lateral view, ×63; see also Pl. 25, fig. 12. Figs 2, 9, paratype, female carapace, OS 8263; 2, dorsal view, ×62; 9, lateral view from right, ×66. Figs 4, 5, paratype, male right valve, OS 8260; 4, external lateral view, ×58; 5, dorsal view, ×58.

Figs 6–8 *Crenaleya*? sp. Male left valve, OS 8262; 6, external lateral view, ×43; 7, internal lateral view, ×43; 8, dorsal view, ×43.

Figs 10–12 *Crenaleya* sp. A. Carapace, OS 8271; 10, lateral view from left, ×41; 11, lateral view from right, ×41; 12, dorsal view, ×41

margin well rounded, somewhat oblique below; posterior bluntly produced, with straight to concave posterodorsal margin; marginal denticles very few or absent. Dorsal and ventral margins straight and subparallel. Surface coarsely reticulate with some fossae joining to form prominent slits, especially ventrolaterally. Eye tubercle very weakly developed. Duplicature narrow, hinge typical of genus. No other internal features were seen.

DIMENSIONS (μm)	L	H	W
Holotype, left valve OS 7987	760	410	270

REMARKS. The shape and pattern of *U. salebrosa* have some affinity with those of *U. sorocula* (Seguenza) of Uliczny, 1969, but in other details the two are dissimilar. The most apparent difference is that *U. sorocula* has an elongate groove more or less parallel to the anterior margin and the Tanzanian species has not.

Urocythereis? *apolegma* sp. nov. Pl. 27, figs 2–4

NAME. 'Hem of a robe' (Greek), with reference to the marginal rim.

DIAGNOSIS. A species with a well-developed marginal rim and a single row of deep subquadrate fossae along the anterior and posterior margins.

HOLOTYPE. A male carapace, OS 8276. Five specimens, OS 8275, 8277, 8279–81, are paratypes. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Two specimens from the same locality and horizon, and one (OS 8278) from FCRM 2010, Lower Miocene. Also occurs in FCRM 1576.

DESCRIPTION. Carapace medium-sized to large, subrectangular-elongate in side view, with greatest width in front of posterior margin. Anterior margin rounded, posterior subrounded to angulate in the middle; anterior and posteroventral margins denticulate. Dorsal margin straight; ventral margin gently concave. Species dimorphic; in dorsal view, presumed females more swollen than presumed males. Lateral surface reticulate; a strong marginal rim is present all round the carapace, with a row of deep fossae just within the anterior and posterior parts. Elsewhere fossae are elongate, with muri bearing short spines giving them a crimped appearance. Eye tubercle more or less distinct. Duplicature moderately wide along anterior and posterior margins and considerably wider along ventral margin; duplicature coincides with inner margin. Selvage runs near, and parallel to, outer margin; selvage groove well developed. Muscle scars not visible; hinge weakly holamphidont.

DIMENSIONS (μm).	L	H	W
Holotype, male carapace OS 8276	870	400	355

REMARKS. Gen. Indet. 3 sp. 1 of Dingle (1976: 52, fig. 9(4)) is extremely similar to *U.*? *apolegma*, but Dingle's species has less well developed anterior and dorsal marginal ridges. The uncertainty about the muscle scars and the general external habitus make it doubtful that this species belongs to *Urocythereis*; however, no closer assignment is possible at present.

Subfamily **ORIONININAE** Puri, 1974

Genus ***ANTEROCYTHERE*** McKenzie & Swain, 1967

TYPE SPECIES. *Anterocythere purii* McKenzie & Swain, 1967

Anterocythere sp. B of Swain & Gilby, 1974 Pl. 27, figs 11–12; Pl. 28, fig. 1

1974 *Anterocythere* sp. B Swain & Gilby: 316; pl. 7, fig. 2.

FIGURED SPECIMEN. An immature right valve, OS 7813. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

OTHER MATERIAL. Eight immature single valves, from FCRM 1566 (OS 7821), 1737, 1738, 1742, 1745, 1989, 2014, 2015.

DIMENSIONS (μm).	L	H	W
Right valve OS 7813	465	235	095

REMARKS. The genus *Anterocythere* seems to have been based on external ornamentation, which differs slightly from that of *Caudites* and *Orionina*, all three genera being identical internally. *Orionina* is well established and differs substantially from *Caudites*, being reticulate rather than smooth in the intercostal areas, but *Anterocythere* is neither well established nor much different from the other two. In fact an analogy may be drawn with some other genera which were erected a very long time ago on the basis of external ornament intermediate between that of two related genera, but which are still a source of considerable confusion. No adult specimens of *Anterocythere* were found in the Tanzanian sediments, hence Swain & Gilby's open nomenclature is retained; while the genus is retained here, grave doubt must attach to its value as a separate entity.

There is a striking resemblance between this taxon and *Caudites* cf. *rosaliensis* Swain, p. 240 (compare Pl. 28, fig. 1 with Pl. 27, fig. 7). However, in *Anterocythere* sp. B the principal posterior rib terminates in the middle of the posterior

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PLATE 27

Fig. 1 *Urocythereis salebrosa* sp. nov. **Holotype**, left valve, OS 7987, external lateral view, ×60.

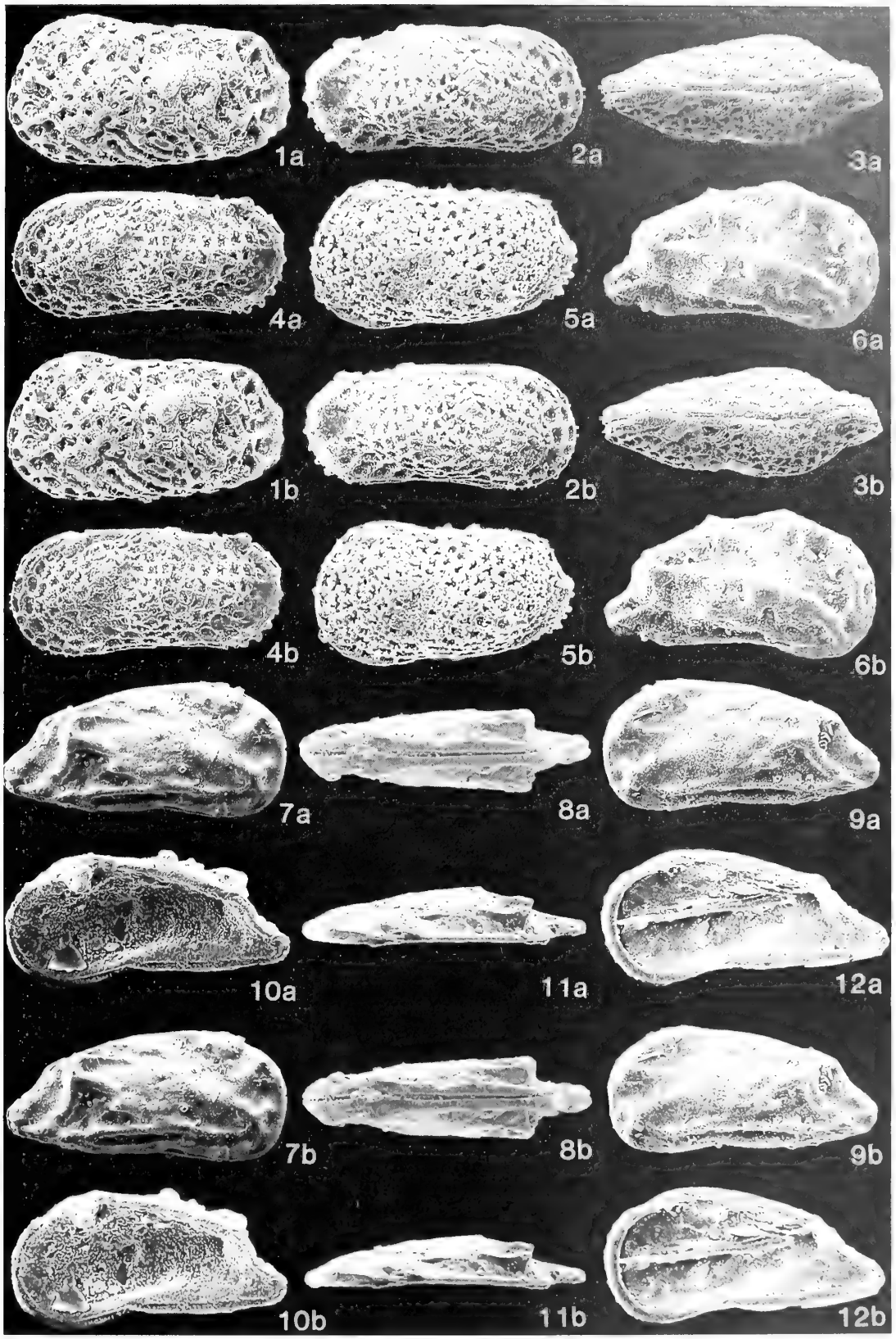
Figs 2–4 *Urocythereis*? *apolegma* sp. nov. **Holotype**, male carapace, OS 8276; 2, lateral view from right, ×53; 3, dorsal view, ×52; 4, lateral view from left, ×52.

Fig. 5 *Bythoceratina*? *asteria* sp. nov. **Holotype**, left valve, OS 8116, external lateral view, ×65.

Figs 6, 10 *Caudites* sp. Right valve, OS 7812; 6, external lateral view, ×92; 10, internal lateral view, ×94.

Figs 7–9 *Caudites* cf. *rosaliensis* Swain, 1967. Carapace, OS 7822; 7, lateral view from right, ×80; 8, dorsal view, ×82; 9, lateral view from left, ×79.

Figs 11, 12 *Anterocythere* sp. B of Swain & Gilby, 1974. Right valve, OS 7813; 11, dorsal view, ×99; 12, internal lateral view, ×101. See also Pl. 28, fig. 1.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margin of the caudal process, whereas in *C.* cf. *rosaliensis* it terminates in the ventral margin of the caudal process. We consider that the one cannot be regarded as a juvenile of the other. Nevertheless, the similarity sustains our doubts about the distinction of *Anterocythere* as a seperate genus from *Caudites*.

Genus ***CAUDITES*** Coryell & Fields, 1937

TYPE SPECIES. *C. medialis* Coryell & Fields, 1937.

Caudites sp. Pl. 27, figs 6, 10

FIGURED SPECIMEN. A right valve, OS 7812. Sample FCRM 1661, near top of old garnet mine, Lindi; Lower Miocene.

OTHER MATERIAL. Four specimens, including one broken valve from FCRM 1989, and two valves (e.g. OS 7815) from FCRM 1566.

DESCRIPTION. Valves robust, tapering posteriorly, with gently sloping dorsal, and strongly concave posterodorsal, margins. Greatest height at anterior cardinal angle, greatest length below mid-height. Anterior margin gently rounded towards venter; posterior end drawn out, giving valves a subtriangular shape. Ventral margin slightly concave. External ornament consists of a number of strongly developed ridges; one runs from eye tubercle towards anteroventral margin; another runs from anteroventral margin to mid-length, where it forms a subcentral tubercle, then turns down and runs for a short distance parallel to ventral margin. The ventral ridge, less well developed than the upper one, runs parallel to the latter and joins it below the subcentral tubercle. There is a typical *Caudites* U-shaped ridge in the posterior half. Intercostal reticulation absent. Internally, marginal pore canals numerous, short, straight, and parallel to each other. No inframarginal pillar structures or muscle scars visible; hinge holamphidont.

DIMENSIONS (μm).	L	H	W
Right valve OS 7812	490	275	120

REMARKS. The subcentral tubercle-like knot formed by the median ridge distinguishes the Tanzanian species from most others; the intermarginal pillar structures so characteristic of this genus were not seen in this species.

Caudites cf. ***rosaliensis*** Swain, 1967 Pl. 27, figs 7–9

cf. 1967 *Caudites rosaliensis* Swain: 80; pl. 5, figs 9–11, 13.
cf. 1967 *Caudites rosaliensis* Swain; McKenzie & Swain: 295; pl. 20, fig. 17a–c; text-fig. 20.
cf. 1969 *Caudites rosaliensis* Swain; Swain: 467; pl. 3, figs 4a–c, 7a–b; pl. 10, figs 10a–b.
cf. 1969 *Caudites* sp. C Swain: 467; pl. 3, figs 6a–b.
cf. 1974 *Caudites rosaliensis* Swain; Swain & Gilby: 311; pl. 4, figs 10–11, 13.

FIGURED SPECIMEN. A carapace, OS 7822; specimen lost. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

DIMENSIONS (μm).	L	H	W
Carapace OS 7822	570	255	170

REMARKS. The Tanzanian species is similar to Swain's in its outline and ornament. The only apparent difference between the two is that in the Tanzanian species the median ridge does not run from the posterior end towards the anteroventral margin; instead it is stepped, and joined to the ventral marginal ridge.

Family **LOXOCONCHIDAE** Sars, 1926
Subfamily **LOXOCONCHINAE** Sars, 1926

Genus ***LOXOCONCHA*** Sars, 1866

TYPE SPECIES. *Cythere rhomboidea* Fischer, 1855.

Subgenus ***LOXOCONCHA*** Sars, 1866

Loxoconcha (Loxoconcha) mbanjaensis sp. nov. Pl. 28, figs 11–12; Pl. 29, figs 1–5

NAME. After the Mbanja river, the type locality.

DIAGNOSIS. A subrhomboidal species of *Loxoconcha*, with the greatest height and width in the middle. Surface with concentrically arranged pits.

HOLOTYPE. A female carapace, OS 8096. A female left valve OS 8097, and a male carapace, OS 8099, are paratypes. Sample FCRM 1746, Mbanja River; Lower Miocene.

OTHER MATERIAL. Seven specimens from FCRM 1566 (OS 8101–2), 1661 (OS 8100), 1989 (OS 8103–4), and 2015 (8105–6). Also occurs in FCRM 1737, 1745, 2010 and 2016.

DESCRIPTION. Carapace subrhomboidal in lateral view, with greatest height and width almost in the middle. Anterior margin obliquely rounded; posterior end slightly produced subdorsally, with concave posterodorsal margin and convex posteroventral margin. Dorsal margin concave to very gently curved, ventral straight to concave in anterior half and convex in posterior half. Sexual dimorphism marked, carapaces of presumed males being narrower and more elongate. Left valve overlaps right; overlap not pronounced. Lateral surface pitted; pits elongate and arranged concentrically along valve

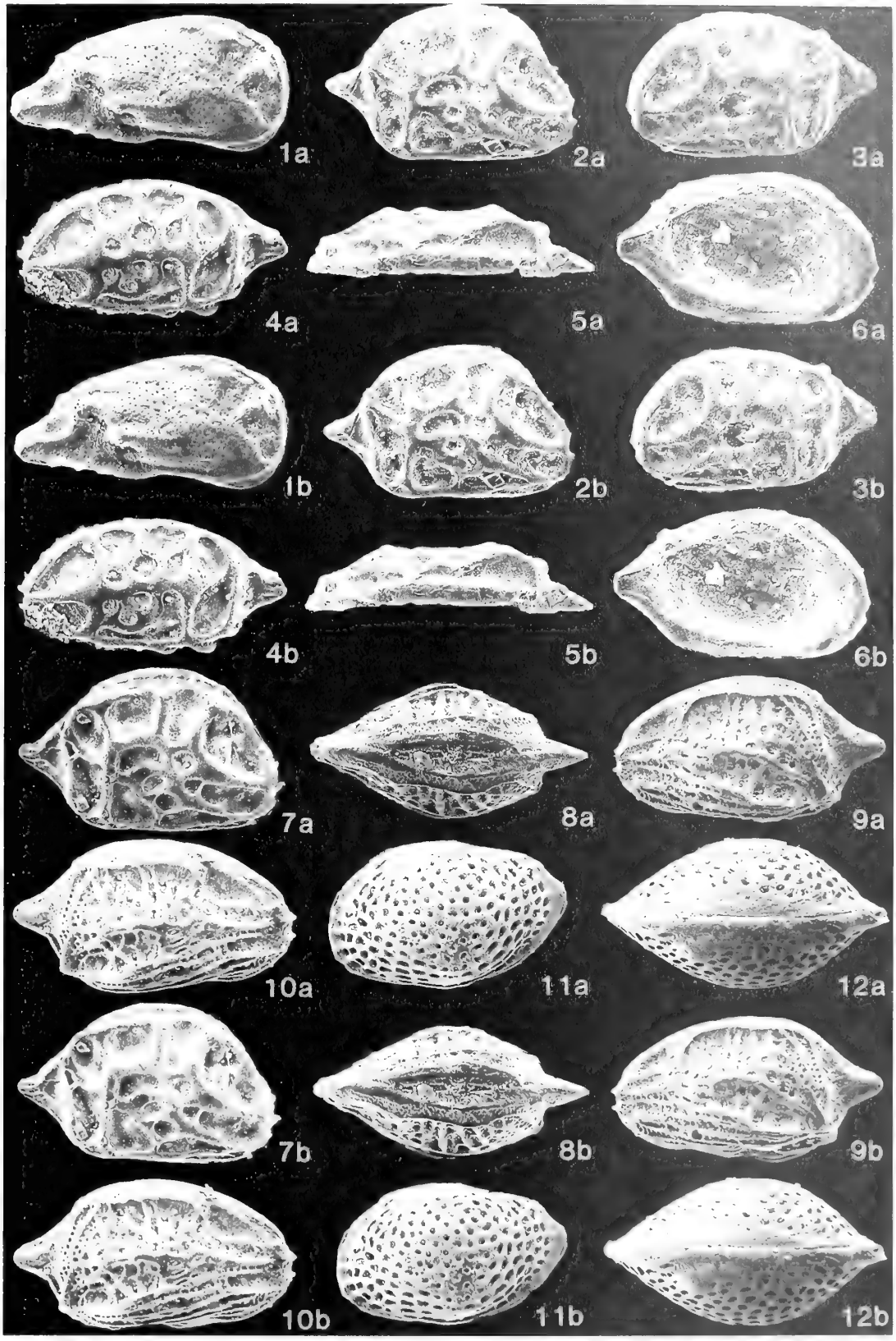
PLATE 28

Fig. 1 *Anterocythere* sp. B of Swain & Gilby, 1974. Right valve, OS 7813, external lateral view, ×97. See also Pl. 27, figs 11–12.

Figs 2–7 *Hemicytherura subulata* sp. nov. Fig. 2, **holotype**, male right valve, OS 8300, external lateral view, ×126. Figs 3, 6, paratype, female left valve, OS 8301; 3, external lateral view, ×132; 6, internal lateral view, ×135. Fig. 4, male left valve, OS 8305, external lateral view, ×133. Figs 5, 7, paratype, female right valve, OS 8304; 5, dorsal view, ×147; 7, external lateral view, ×134.

Figs 8–10 *Kangarina* sp. Carapace, OS 7983; 8, dorsal view, ×134; 9, lateral view from left, ×131; 10, lateral view from right, ×137.

Figs 11, 12 *Loxoconcha* (*Loxoconcha*) *mbanjaensis* sp. nov. Fig. 11, paratype, female left valve, OS 8097, external lateral view, ×78. Fig. 12, **holotype**, female carapace, OS 8096, dorsal view, ×99; see also Pl. 29, fig. 5.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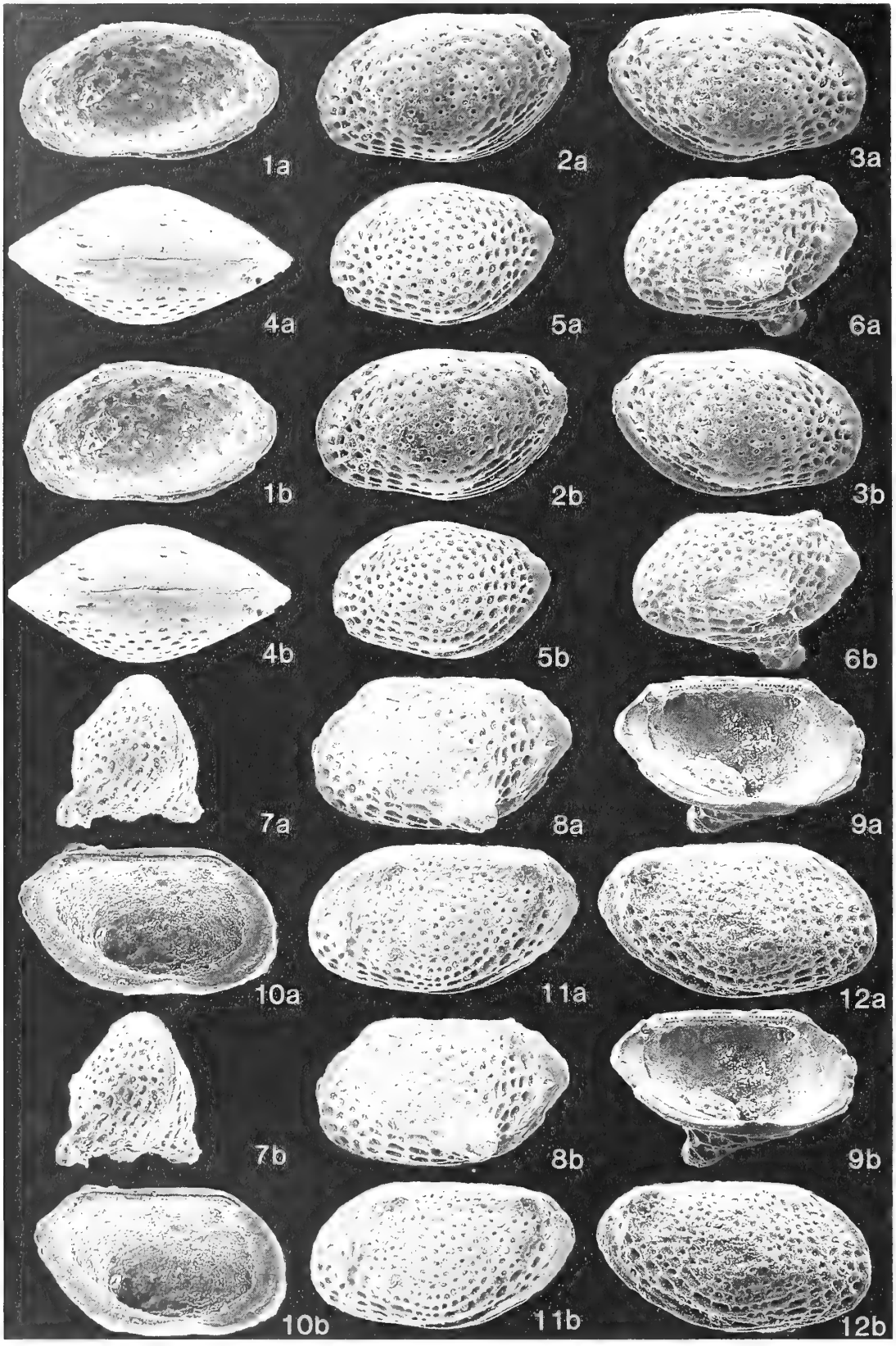
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margins, rounded on lateral surface. Eye spot very low, consisting of a large, opaque surface. Duplicature wide anteriorly and ventrally; inner margin and line of concrescence coincide except along anterior and posterodorsal margins where narrow vestibules are present. Selvage prominent. Marginal pore canals simple, straight and widely spaced. Normal pores moderately numerous, scattered and of various sizes. Hinge typically gongylodont, consisting of an anterior socket followed by a crenulate bar and an elongate posterior socket in the left valve.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8096	465	305	255
Paratype, female left valve OS 8097	485	305	150
Paratype, male carapace OS 8099	610	375	315
Female right valve OS 8100	460	275	140

REMARKS. The present species is closest to *L. yazooensis* Huff 1970, but the less concentric arrangement of pits and the smooth muri of the Tanzanian species easily distinguish them.

Subgenus ***LOXOCORNICULUM*** Benson & Coleman, 1963

TYPE SPECIES. *Cythere fischeri* Brady, 1869*a*.

Loxoconcha (*Loxocorniculum*) *postnodosa* sp. nov.

Pl. 29, figs 11–12; Pl. 30, figs 1–4

NAME. A reference to the posterodorsal node.

DIAGNOSIS. A species of *Loxoconcha* with pronounced sexual dimorphism. In lateral view, the valves are rhomboidal, with the dorsal and ventral margins almost parallel to each other.

HOLOTYPE. A male carapace, OS 8092. A female carapace, OS 8093, is a paratype; specimen lost. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

OTHER MATERIAL. Ten specimens from samples FCRM 1566 (e.g. OS 8091), 1575. Also occurs in FCRM 1574, 1576, 1578, 1628 and 1989.

DESCRIPTION. Carapace thickly calcified, rhomboidal, with greatest height and width in the middle. Anterior margin obliquely rounded towards the venter; posterior end upturned, forming a caudal process above mid-height. Dorsal margin straight and parallel to ventral, which is straight in the anterior half and curves upwards just behind mid-length. In dorsal view, carapace lens-shaped. Sexual dimorphism very pronounced, presumed males being more elongate than presumed females; females more tumid. Left valve larger than right; overlap not pronounced. Lateral surface coarsely pitted, pits being arranged almost parallel to outer margins. There is a prominent tubercle just below the posterior cardinal angle, also an eyespot. Internal features characteristic of genus.

DIMENSIONS (μm).	L	H	W
Holotype, male carapace OS 8092	540	305	250
Paratype, female carapace OS 8093	465	295	240

REMARKS. *Loxoconcha abrupta* Hornibrook 1952 is comparatively more ovate and has a stronger posterior tubercle; the posterior margin of *L. abrupta* is truncate in dorsal view whereas it is slightly produced in the new species. *L. pentockensis* Kingma 1948 is another species resembling *L. postnodosa* in some respects, but it differs in having a comparatively concave ventral margin and a more curved dorsal margin. *L. postdorsalata* Puri 1960 has a sinuous ventral margin with slight concavity anterior to the middle, whereas *L. postnodosa* has an almost straight ventral margin.

Two morphotypes are distinguished: see below.

Morphotype A

Pl. 30, fig. 5

FIGURED SPECIMEN. A male right valve, OS 8094. Sample FCRM 1575, shore south-west of Ras Tapuri; Middle Oligocene.

REMARKS. Morphotype A differs from typical *Loxoconcha* (*Loxocorniculum*) *postnodosa* in being more oblong, with a greater length/height ratio. The posteroventral curve is more gentle, and the posterodorsal tubercle is much reduced.

DIMENSIONS (μm).	L	H	W
Male right valve OS 8094	530	260	140

Morphotype B

Pl. 30, figs 6–7

FIGURED SPECIMEN. A male carapace, OS 8095. Sample FCRM 1575, shore south-west of Ras Tapuri; Middle Oligocene.

REMARKS. Morphotype B is like Morphotype A in most respects, but differs in having more and smaller pits, all of which are circular, and in the ventral margin being comparatively straight. In dorsal view it is more pencil-shaped than the lenticular *L. postnodosa*, s. str.

DIMENSIONS (μm).	L	H	W
Male carapace OS 8095	530	305	250

Loxoconcha (*Loxocorniculum*) *tricornis* sp. nov.

Pl. 30, figs 8–9

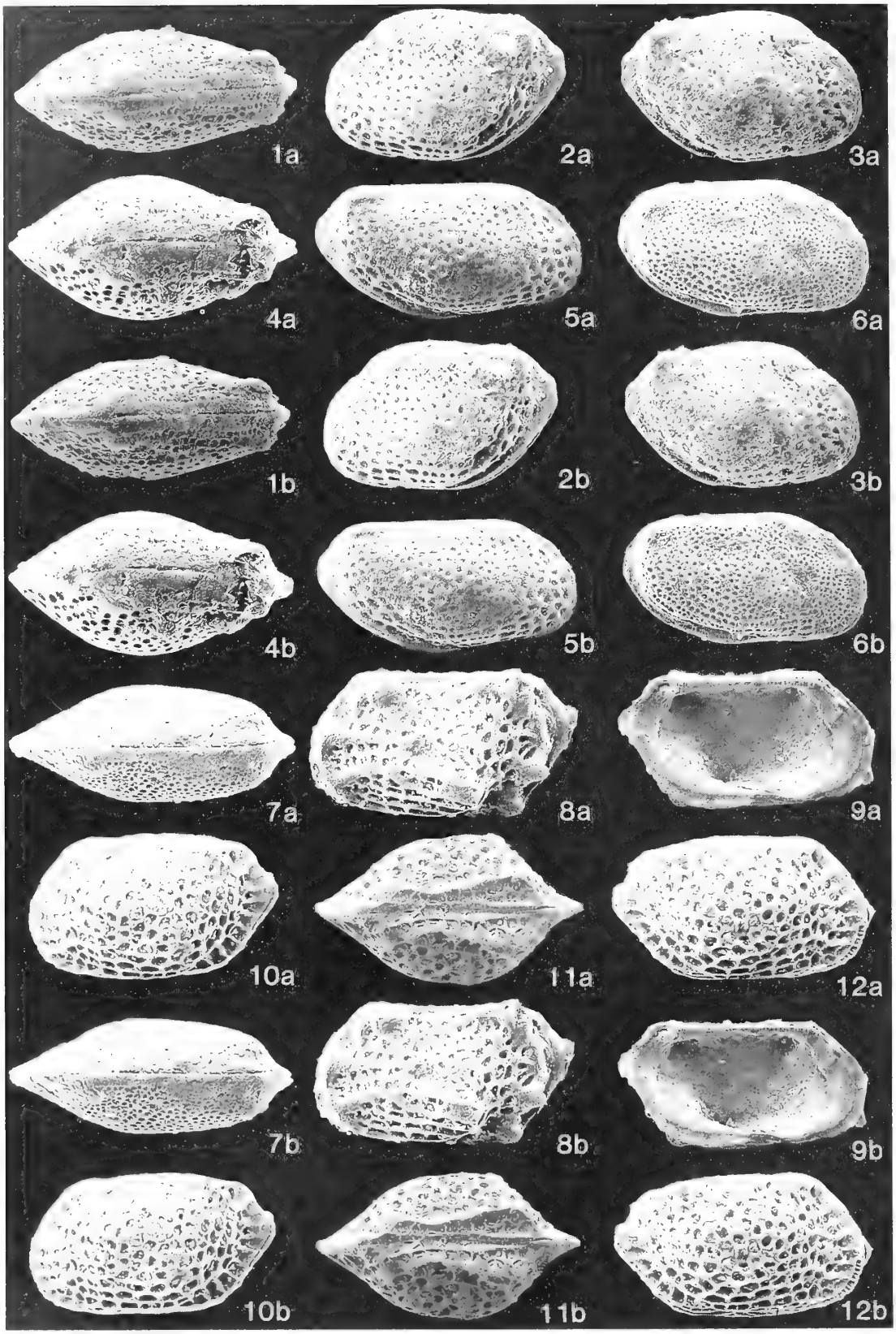
NAME. 'Three-horned', with reference to three tubercles in the posterior half of the valves.

PLATE 29

Figs 1–5 *Loxoconcha* (*Loxoconcha*) *mbanjaensis* sp. nov. Fig. 1, female right valve, OS 8100, internal lateral view, ×92. Figs 2–4, paratype, male carapace, OS 8099; 2, lateral view from left, ×69; 3, lateral view from right, ×69; 4, dorsal view, ×77. Fig. 5, **holotype**, female carapace, OS 8096, lateral view from left, ×77; see also Pl. 28, fig. 12.

Figs 6–10 *Loxoconcha* (*Loxocorniculum*) cf. *longispina* Keij, 1953. Figs 6, 7, female carapace, OS 7958; 6, ventrolateral view from left, ×81; 7, anteroventral view, ×81. Figs 8, 9, female left valve, OS 7959; 8, external lateral view, ×88; 9, internal ventrolateral view, ×86. Fig. 10, female left valve, OS 7960, internal lateral view, ×88.

Figs 11, 12 *Loxoconcha* (*Loxocorniculum*) *postnodosa* sp. nov. **Holotype**, male carapace, OS 8092; 11, lateral view from left, ×80; 12, lateral view from right, ×82. See also Pl. 30, fig. 1.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DIAGNOSIS. Valves small and subrectangular. Surface with two prominent ridges in the anterior half and three tubercles in the posterior half.

HOLOTYPE. A female left valve, OS 8107. Three specimens, OS 8108–10, are paratypes. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

MATERIAL. Five specimens from FCRM 1566, 2014 (e.g. OS 8111–2). Also occurs in FCRM 2015 and 2016.

DESCRIPTION. Carapace subrectangular in side view, with obliquely rounded anterior margin; posterodorsal margin concave to straight; posteroventral margin convex to straight. Dorsal and ventral margins subparallel. Sexual dimorphism marked, higher forms being interpreted as females. External surface strongly reticulate, with two prominent longitudinal ridges in anterior half and three tubercles in posterior half of each valve. Eye tubercle strongly developed. Duplicature moderately wide. Selvage strongly developed, running near outer margin. Muscle scars, hinge and other internal details characteristic of genus.

DIMENSIONS (μm).	L	H	W
Holotype, female left valve OS 8107	470	265	150
Paratype, male left valve OS 8108	450	235	–

REMARKS. *L. antillea* var. *rugosa* van den Bold, 1946, is related to *Loxoconcha tricornis*, but differs in having a rather irregular posteroventral margin; the two anterior ridges seem to be shorter and more convergent than in the Tanzanian species.

Loxoconcha* (*Loxocorniculum*) cf. *longispina Keij, 1953

Pl. 29, figs 6–10

cf. 1953 *Loxoconcha alata* Brady var. *longispina* Keij: 160; pl. 1, figs 10a, b.
cf. 1967 *Loxoconcha longispina* Keij; Holden: 32–34, figs 23a–d.
cf. 1976 *Loxoconcha longispina* Keij; Holden: F32; pl. 4, fig. 14; pl. 5, figs 3–6; pl. 14, figs 12–15.

FIGURED SPECIMENS. A female carapace, OS 7958; two valves, OS 7959, 7960. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. Seven specimens, from the same sample. Also occurs in FCRM 1576, 2014 and 2016.

REMARKS. The Tanzanian specimens are very similar to Holden's from the Midway area, Hawaiian Islands, and may even be conspecific. Holden (1976) mentions that this species is very variable, the Pleistocene(?) specimens not being as strongly alate as his Miocene specimens. The Tanzanian specimens are strongly alate and come from the Mid-Oligocene. It seems therefore that the species originated as a strongly alate form on the western coast of the Indian Ocean.

DIMENSIONS (μm).	L	H	W
Female carapace OS 7958	470	290	350
Female left valve OS 7959	475	285	220
Female left valve OS 7960	480	290	200

Subgenus ***MYRENA*** Neale, 1967

TYPE SPECIES. *Loxoconcha meridionalis* Müller, 1908.

Loxoconcha* (*Myrena*) *loculus sp. nov. Pl. 30, figs 10–12

NAME. 'Box' or 'purse', with reference to its shape in side view.

DIAGNOSIS. A species of *Loxoconcha* with a dorsal marginal ridge and strongly reticulate surface.

HOLOTYPE. A carapace, OS 8282. Six specimens, OS 8283–8, are paratypes. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Three specimens from samples FCRM 2034 and 2046. Also occurs in FCRM 2045.

DESCRIPTION. Carapace small, subrectangular, with almost uniform height but varying width. Anterior margin broadly rounded towards venter; posterior produced subdorsally. Dorsal and ventral margins straight and subparallel; posterodorsal and posteroventral margins straight to slightly concave. External surface reticulate, with comparatively large rectangular fossae arranged parallel to margin. Dorsal margin strongly modified by a wavy rim. Left valve overlaps right slightly. Eye tubercle well developed. Internal details not visible because of small size and poor preservation.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8282	370	220	220

REMARKS. The ornament and shape are somewhat akin to those of *Kuiperiana nystiana* (Bosquet) Keij 1957, but the Tanzanian species is much smaller and has a more produced posterior margin.

PLATE 30

Figs 1–4 *Loxoconcha* (*Loxocorniculum*) *postnodosa* sp. nov. Fig. 1, **holotype**, male carapace, OS 8092, dorsal view, ×86; see also Pl. 29, figs 11–12. Figs 2–4, paratype, female carapace, OS 8093 (specimen lost); 2, lateral view from left, ×84; 3, lateral view from right, ×86; 4, dorsal view, ×101.

Fig. 5 *Loxoconcha* (*Loxocorniculum*) *postnodosa*, Morphotype A. Male right valve, OS 8094, external lateral view, ×81.

Figs 6, 7 *Loxoconcha* (*Loxocorniculum*) *postnodosa*, Morphotype B. Male carapace, OS 8095; 6, lateral view from right, ×77; 8, dorsal view, ×88.

Figs 8, 9 *Loxoconcha* (*Loxocorniculum*) *tricornis* sp. nov. Fig. 8, **holotype**, female left valve, OS 8107, external lateral view, ×93. Fig. 9, paratype, male left valve, OS 8108, internal lateral view, ×93.

Figs 10–12 *Loxoconcha* (*Myrena*) *loculus* sp. nov. **Holotype**, carapace, OS 8282; 10, lateral view from left, ×109; 11, dorsal view, ×115; 12, lateral view from right, ×118.

Subgenus ***PALMOCONCHA*** Swain & Gilby, 1974

TYPE SPECIES. *Palmoconcha laevimarginata* Swain & Gilby, 1974.

Loxoconcha (Palmoconcha) pinguis sp. nov.
Pl. 31, figs 1–3

NAME. 'Fat', with reference to the ventral swelling.

DIAGNOSIS. A species of *Loxoconcha* with pronounced ventrolateral swelling and distinct eye tubercle.

HOLOTYPE. A carapace, OS 8289. A carapace, OS 8290, is a paratype. Sample FCRM 1746, Mbanja River; Lower Miocene.

OTHER MATERIAL. Two carapaces from the same locality and horizon. Also occurs in FCRM 1628.

DESCRIPTION. Carapace small, subrectangular in side view. Anterior margin obliquely rounded towards venter; posterior margin curved towards dorsum. Dorsal margin straight, ventral margin with concavity about one-third length from front, slightly modified by the overhanging ventrolateral swelling. In dorsal view lens-shaped, much like any other species of *Loxoconcha* at this angle, in contrast to the striking difference in outline in lateral view. Left valve overlaps right. Surface reticulate; central fossae largest and arranged concentrically. Muri on ventrolateral swelling are stronger than elsewhere. Eye tubercle prominent.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8289	390	235	200

REMARKS. From their size, these specimens might appear to be juveniles, but the other *Loxoconcha* species with similar shapes are all rather small in size. *L. watervalleyensis* Krutak 1961 is 0·40 long and 0·24 mm high; *L. angustata* Brady 1869*b*: 48 is 0·46 mm long (1/55 inch).

Carbonnel (1986) describes a number of *Loxoconcha* species from the Tertiary of the Senegal–Guinea Bissau Basin. Of these, only his Neogene (Serravallian?/Tortonian?) *L. kafountinensis* resembles any of our species. This differs from *L. pinguis* in that the accentuated horizontal costae in the central part of the shell continue to the dorsal margin, whereas in our species they are absent in the upper half of the shell which is occupied by fine pitting.

Genus ***PHLYCTOCYTHERE*** Keij, 1958

TYPE SPECIES. *Phlyctocythere eocaenica* Keij 1958.

Phlyctocythere reniformis sp. nov. Pl. 31, figs 4–6

NAME. 'Kidney-shaped', with reference to its resemblance to a kidney.

DIAGNOSIS. A species of *Phlyctocythere* with a gently arched dorsal margin and compressed posteroventral margin.

HOLOTYPE. A carapace, OS 8292. Seven carapaces, OS 8291, 8293–8, are paratypes. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. Five carapaces from the same sample. Also occurs in FCRM 1745.

DESCRIPTION. Carapace small to medium-sized, kidney-shaped to subrhomboidal in lateral view, with greatest height in middle and greatest width at mid-length or slightly in front of it. Anterior margin rounded, dorsal margin arched; ventral margin almost straight, curved posteroventrally; posterior produced subdorsally. In dorsal view, carapace lens-shaped with slightly elongate posterior margin. Left valve overlaps right, overlap being clearly visible along anterior and ventral margins. Eye tubercle lacking; lateral surface smooth. No internal details visible, since there are no single valves.

DIMENSIONS (μm).	L	H	W
Holotype, carapace OS 8292	425	265	240

REMARKS. This species resembles *Hemicytherura*? *nealei* Swain 1976 in general shape, but is 1·5 times larger and has a compressed zone which is confined to the posteroventral margin, instead of extending to the anterior, posterior and posteroventral margins as is the case in *H.*? *nealei*.

Family **PARACYTHERIDEIDAE** Puri, 1957*c*

Genus ***PARACYTHERIDEA*** Müller, 1894

TYPE SPECIES. *Paracytheridea depressa* Müller, 1894.

Paracytheridea anapetes Ahmad, 1977*a*
Pl. 31, figs 10–12; Pl. 32, figs 1–6

1977*a* *Paracytheridea anapetes* Ahmad: 41–42.

FIGURED SPECIMENS. Holotype, female carapace, OS 7757. Paratypes, female left valve, OS 7758; male right valve, OS 7760. Sample FCRM 2034, Lindi Creek, east shore; Upper Eocene. Also male left valve, OS 7759 (not a paratype) from sample FCRM 2033.

OTHER MATERIAL. Ten specimens from FCRM 1574 (e.g. OS 7764), 1575 (e.g. OS 7795), 1578, 1627, 1628, 1981, 2014, 2033 (e.g. OS 7759). Also occurs in FCRM 1661, 1989 and 2010.

DESCRIPTION. Carapace medium-sized, subtriangular to sub-oval in shape, with greatest height and width in posterior half. Anterior margin rounded, posterior produced into a sub-

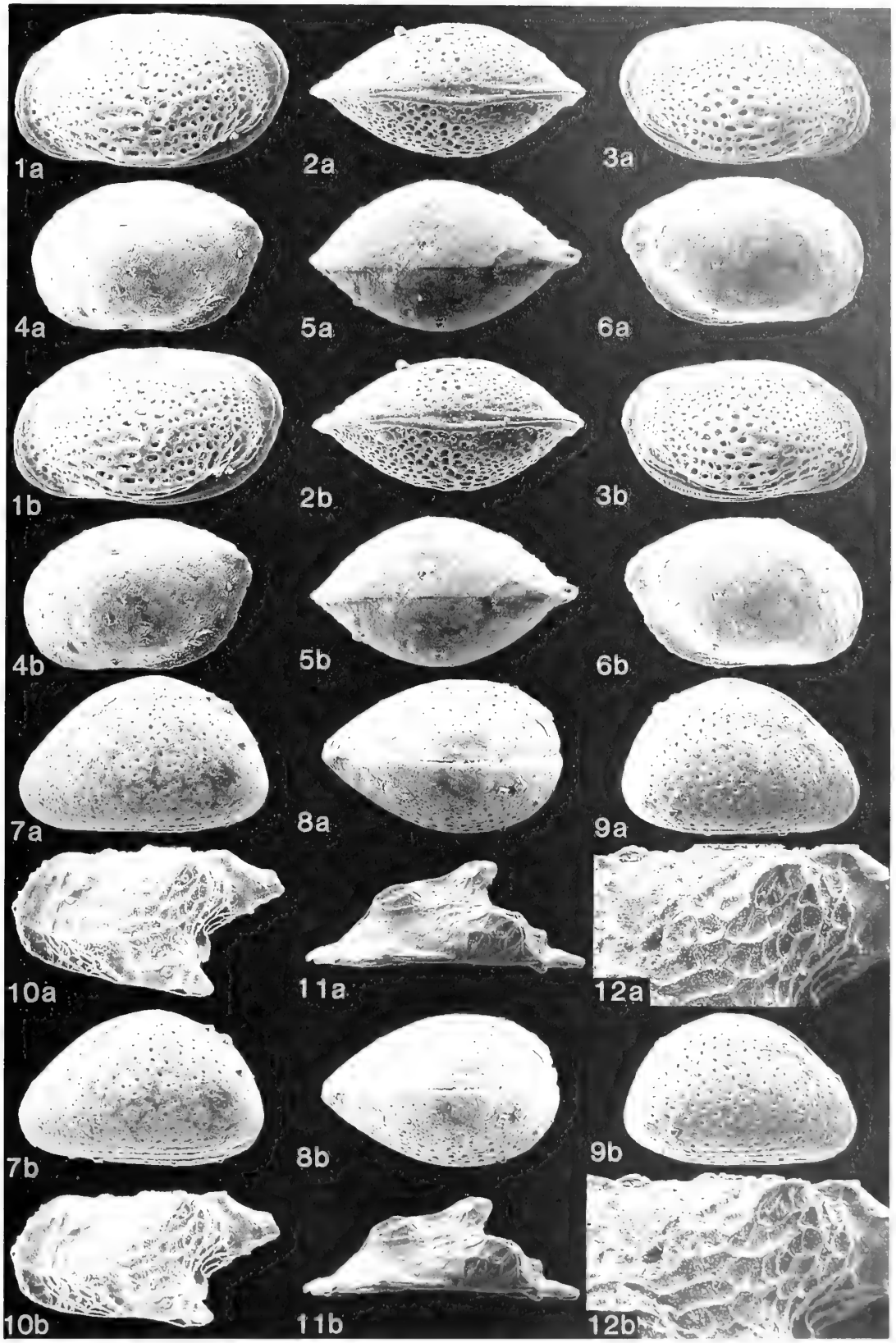
PLATE 31

Figs 1–3 *Loxoconcha* (*Palmoconcha*) *pinguis* sp. nov. **Holotype**, carapace, OS 8289; 1, lateral view from left, ×115; 2, dorsal view, ×115; 3, lateral view from right, ×105.

Figs 4–6 *Phlyctocythere reniformis* sp. nov. **Holotype**, carapace, OS 8292; 4, lateral view from left, ×89; 5, dorsal view, ×105; 6, lateral view from right, ×89.

Figs 7–9 *Uroleberis*? sp. Carapace, OS 8308; 7, lateral view from left, ×68; 8, dorsal view, ×66; 9, lateral view from right, ×65.

Figs 10–12 *Paracytheridea anapetes* Ahmad, 1977*a*. Fig. 10, 12, male left valve, OS 7759; 10, external lateral view, ×70; 12, details of ornament in the median area of the surface, ×300. Fig. 11, paratype, male right valve, OS 7760, dorsal view, ×86; see also Pl. 32, fig. 6.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dorsal caudal process. Dorsal margin strongly modified in lateral view by a bulbous posterodorsal swelling, appearing straight to concave anteriorly and strongly convex posteriorly. In dorsal view dorsal margin straight, carapace broadly arrow-shaped. Sexual dimorphism marked, presumed females having a bulbous swelling and small alar prolongations posterodorsally, while males have a reduced swelling but larger alar prolongations. Lateral surface almost smooth anterodorsally and posteriorly; other areas covered with a characteristic pattern of ridges. A strong ridge runs from mid-anterior margin towards posterodorsal area, where it branches to form several small ones. Ornament completed by other small ridges meeting these branches almost at right angles. Internally, duplicature wide; line of concrescence and inner margin coincide throughout. A very narrow vestibule may be present along anterodorsal margin; this was impossible to verify. Only three anterior and one posterior marginal pore canals visible. There are four adductor muscle scars and a U-shaped frontal scar. Hinge varies slightly from typical *Paracytheridea*; right valve hinge has 14–15 additional small denticles in front of anterior cusped dental area; left hinge has corresponding sockets.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 7757	595	325	305
Paratype, female left valve OS 7758	560	280	195
Male left valve OS 7759	630	330	290
Paratype, male right valve (juvenile) OS 7760	525	270	220

REMARK. This species was originally described (Ahmad 1977*a*) on the present material.

Paracytheridea culmen sp. nov. Pl. 32, figs 8–12

NAME. 'Ridge', with reference to the ventrolateral ridge.

DIAGNOSIS. A species of *Paracytheridea* with a ventral alar ridge, notched posteriorly. Surface strongly reticulate.

HOLOTYPE. A female left valve, OS 7790. Three specimens, OS 7839–41, are paratypes. Sample FCRM 2010, stream south-west of Mtwero.

OTHER MATERIAL. Ten specimens from samples FCRM 1566, 1575 (e.g. OS 7788), 1578 (e.g. OS 7789), 1648, 2010 (e.g. OS 7791–3), 2014 (e.g. OS 7786–7). Also occurs in FCRM 1989.

DESCRIPTION. Carapace small, subtriangular in lateral view, with greatest height at anterior cardinal angle and greatest width in midventral region. Anterior margin symmetrically rounded; posterior produced into a subventral caudal process. Dorsal and ventral margins almost straight, converging posteriorly. Sexual dimorphism occurs, presumed males being lower in proportion to their length. Surface strongly reticulate, with thin ridges, irregular swellings and a prominent ventrolateral alar ridge; latter notched just before posterior end and merging gradually with the valve anteriorly. Duplicature moderately wide, not well differentiated. Line of concrescence and inner margin coincide. About eight straight, simple, parallel marginal pore canals occur anteriorly and two posteriorly. Muscle scar pattern obscure; a frontal V-shaped scar and two adductor scars can be seen. Hinge very weakly developed.

DIMENSIONS (μm).	L	H	W
Holotype, female left valve OS 7790	500	250	190
Paratype, female right valve OS 7788	440	230	140
Paratype, male left valve OS 7787	450	210	150

REMARKS. Compared with *P. gradata* (Bosquet) *emend.* Keij, 1957, *P. fenestrata* (Bosquet) *emend.* Keij, 1957, and *P. belhavensis* Howe & Chambers, 1935, *P. culmen* is more triangular and has a slightly different pattern of ornamentation.

A morphotype is distinguished: see below.

Morphotype A Pl. 32, fig. 7

FIGURED SPECIMEN. A male left valve, OS 7838. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. One valve.

DESCRIPTION. Carapace elongate, subrectangular in side view, with greatest height at anterior cardinal angle and greatest length subventrally. Dorsal margin straight to slightly modified by posterodorsal swelling; ventral margin strongly modified externally by ventrolateral alar ridge, but straight when seen from inside. Anterior margin rounded, posterior margin truncate. Surface reticulate, with thin ridges, irregular swellings and a prominent anterolateral ridge which is divided in front of the posterior end. Smaller ridges arranged longitudinally below the ventrolateral alar ridge.

DIMENSIONS (μm).	L	H	W
Male left valve OS 7838	490	230	160

REMARK. Compared with typical *P. culmen*, Morphotype A is more elongate, less triangular and has a slightly different ornament.

Family **CYTHERURIDAE** Müller, 1894
Subfamily **CYTHERURINAE** Müller, 1894

Genus ***TANZANICYTHERE*** Ahmad, 1977*e*

TYPE SPECIES. *Cladarocythere pterota* Ahmad, 1977*b*.

Tanzanicythere pterota (Ahmad, 1977*b*) Pl. 33, figs 1, 2

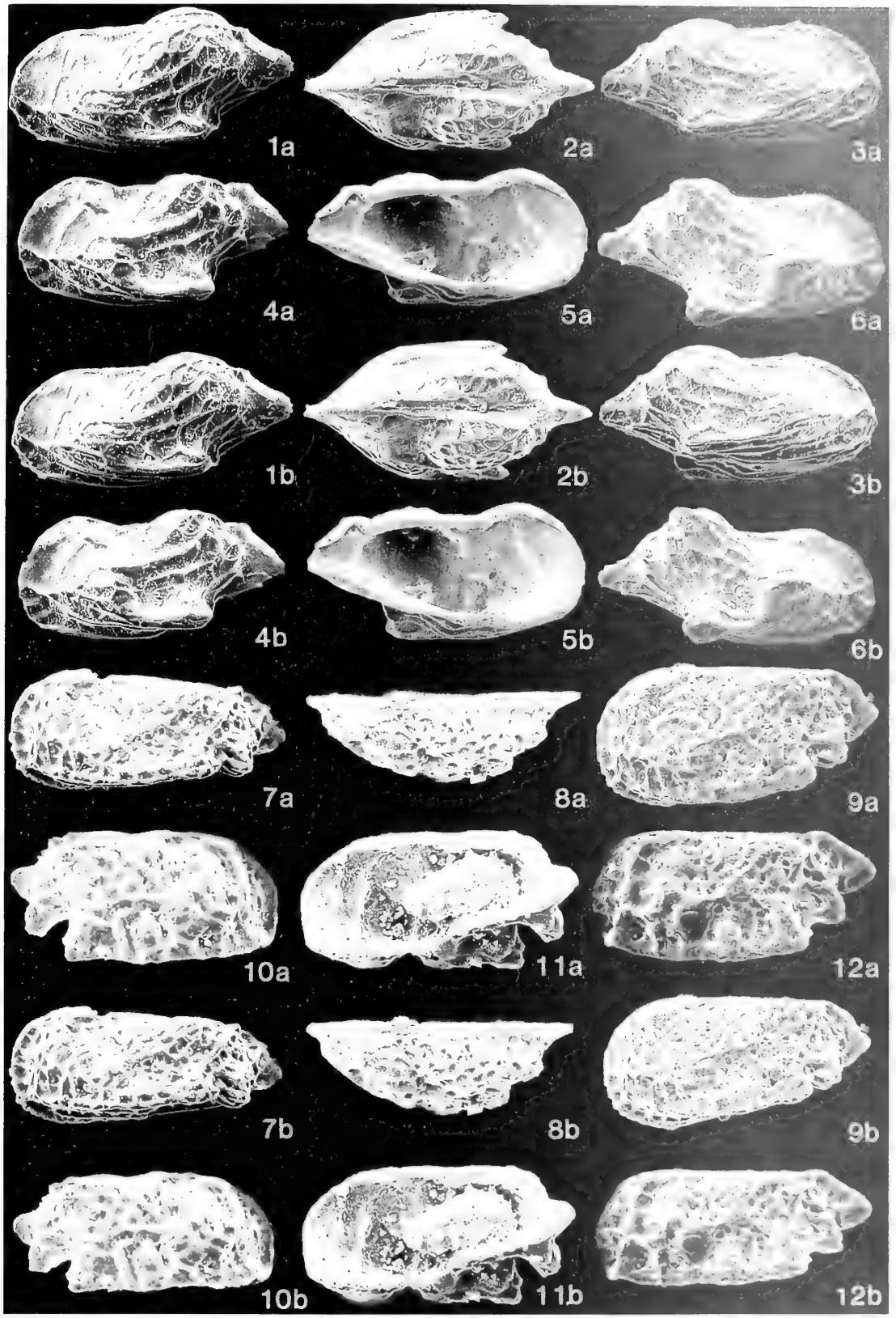
1977*b* *Cladarocythere pterota* Ahmad: 45–48.

PLATE 32

Figs 1–6 *Paracytheridea anapetes* Ahmad, 1977*a*. Figs 1–3, holotype, female carapace, OS 7757; 1, lateral view from left, ×79; 2, dorsal view, ×81; 3, lateral view from right, ×77. Figs 4, 5, paratype, female left valve, OS 7758; 4, external lateral view, ×80; 5, internal lateral view, ×82. Fig. 6, paratype, male right valve, OS 7760, external lateral view, ×91; see also Pl. 31, fig. 11.

Fig. 7 *Paracytheridea culmen* sp. nov., Morphotype A. Male left valve, OS 7838, external lateral view, ×93.

Figs 8–12 *Paracytheridea culmen* sp. nov. Figs 8, 9, **holotype**, female left valve, OS 7790; 8, dorsal view, ×90; 9, external lateral view, ×93. Figs 10, 11, paratype, female right valve, OS 7788; 10, external lateral view, ×101; 11, internal lateral view, ×101. Fig. 12, paratype, male left valve, OS 7787, external lateral view, ×102.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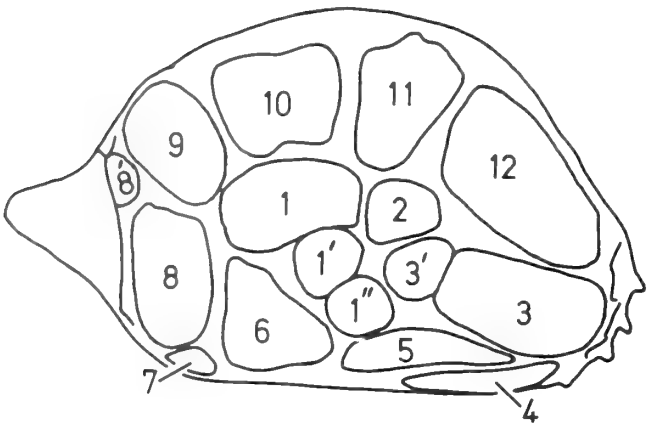


Fig. 9 *Hemicytherura subulata* sp. nov. Holotype OS 8300, ♀ right valve external lateral view, showing the arrangement of fossae. ×260.

FIGURED SPECIMENS. Holotype, right valve OS 7772. Paratypes (unfigured here, but see Ahmad 1977*b*), left valve OS 7774, right valve OS 7773. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. Sixteen single valves from samples FCRM 1738, 2010 (e.g. OS 7784–5 and paratypes OS 7775–6), 2015. Also occurs in FCRM 2014.

DESCRIPTION. Carapace small to medium-sized, with greatest height at anterior end and greatest width at middle; very fragile. Anterior margin modified externally by the ventrolateral frill but symmetrically rounded when seen from inside. Dorsal margin almost straight; posterior narrowly produced, giving a beaker-shaped appearance in internal view. Seen obliquely from inside, ventral margin almost straight, sub-parallel to dorsal margin, but in external view completely hidden by the overhanging lateral frill. Frill starts in ventral half of anterior margin, gradually increases in width and terminates abruptly anterior to caudal process. Lateral surface smooth except for frill. Three fine longitudinal ridges occur ventral to the frill. One runs just below top of the frill for its full length; the others are much shorter, and stronger in the posterior half than anteriorly. Internally, duplicature moderately wide; vestibule absent. Ten or eleven normal pore canals divide the frill into compartments; these canals are very much like marginal ones, and have been described by Maddocks (1966) as 'thick straight pore canals', while Hornibrook (1952) described those in *Manawa* as 'septa in the frill', and Ishizaki (1973) refers to them simply as 'marginal pore canals'. Three marginal pore canals visible. Four small adductor muscle scars in a vertical row, with three larger frontal scars placed dorsally, the lowest of which is V-shaped. Hinge very weak; crenulate anterior and posterior tooth plates in right valve, each with four or five teeth, connected by a crenulate bar. Left valve has complementary elements.

DIMENSIONS, including frill (μm).	L	H	W
Holotype, right valve OS 7772	490	270	235

REMARK. This species was originally described (Ahmad 1977*b*) on the present material.

Genus ***HEMICYTHERURA*** Elofson, 1941

TYPE SPECIES. *Cythere cellulosa* Norman, 1865.

Hemicytherura subulata sp. nov. Pl. 28, figs 2–7; Fig. 9

NAME. 'Awl-shaped, pointed', with reference to the shape and the pointed posterior end.

DIAGNOSIS. A small species of *Hemicytherura* with a marginal ridge running along the dorsal, anterior and ventral margins but slightly within the posterior margin. The fossae along the margins are large and of various shapes while those in the centre are small and round. The greatest height is at about mid-length.

HOLOTYPE. A female right valve, OS 8300. Four single valves, OS 8301–4, are paratypes. Sample FCRM 1566, Mongo Stream, Lindi; Lower Miocene.

OTHER MATERIAL. Two single valves from samples FCRM 1989 and 2015 (OS 8305).

DESCRIPTION. Anterior margin of carapace obliquely rounded towards the venter, with four or five denticles. Dorsal margin outline differs in the two valves, right being strongly arched, left with flatter curve. Ventral margin straight; posterior with caudal process just above mid-height. Sexual dimorphism marked, presumed females higher in proportion to length than males. Ornament typical of genus. For descriptive purposes the fossae have been numbered from 1 to 12, following Hoskin (1975). Fossa 1 is divided in some valves into 1, 1′, and 1″; 1 is rectangular, while 1′, 1″ and 2 are rounded. Fossa 3 is large, elongated, and broader anteriorly; fossa 3′ is narrowly separated from it and is semicircular to subtriangular. Fossae 4 and 5 are elongate and run along the ventral margin, separated from each other by a long murus. Fossa 6 is large, subtriangular, and separated from a small similar fossa 7. Fossa 8 is subrectangular and divided unequally into 8 and 8′. Fossa 9 is subrounded, 10 subquadrate, 11 narrow and subrectangular; these are large.

PLATE 33

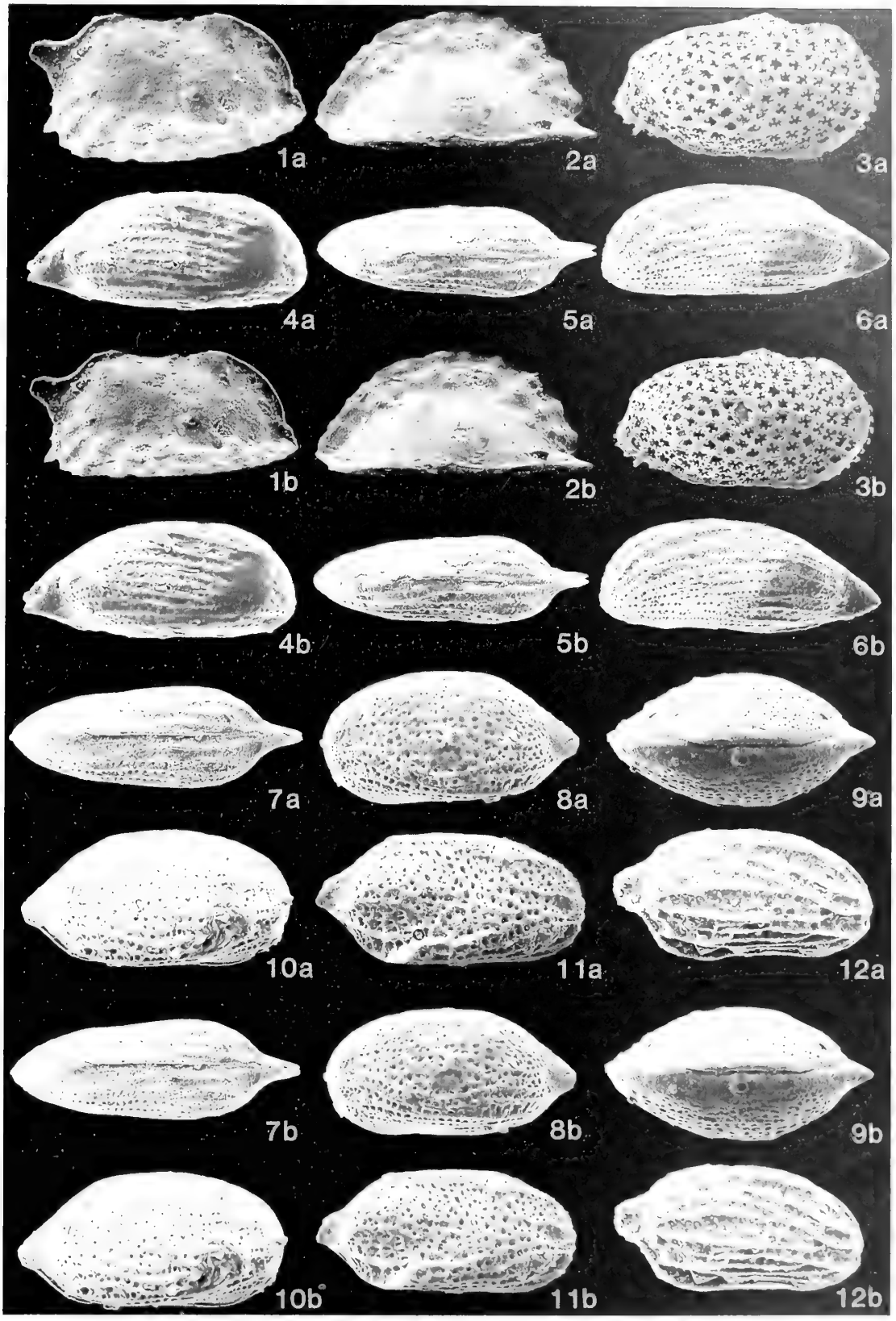
Figs 1, 2 *Tanzanicythere pterota* (Ahmad, 1977*b*). Holotype, right valve, OS 7772; 1, external lateral view, ×93; 2, dorsal view, ×95.

Fig. 3 Genus C sp. Right valve, OS 8320, external lateral view, ×78.

Figs 4–7 *Semicytherura opeata* sp. nov. Figs 4, 5, **holotype**, female carapace, OS 8313; 4, lateral view from right, ×94; 5, dorsal view, ×94. Figs 6, 7, paratype, male carapace, OS 8314; 6, lateral view from left, ×92; 7, dorsal view, ×93.

Figs 8–11 *Semicytherura emphysema* sp. nov. Figs 8–10, **holotype**, female carapace, OS 8309; 8, lateral view from left, ×116; 9, dorsal view, ×119; 10, lateral view from right, ×122. Fig. 11, paratype, male right valve, OS 8311, external lateral view, ×110.

Fig. 12 *Semicytherura* sp. A. Carapace, OS 8316, lateral view from right, ×110.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7a
8a
9a
10a
11a
12a
7b
8b
9b
10b
11b
12b

Fossa 12, the largest, is subrectangular. The arrangement of the fossae is shown in Fig. 9.

A left valve from sample FRCM 2015, interpreted as a male dimorph, shows a slightly different pattern, but the overall arrangement of fossae is compatible with that of the holotype. The 25–30 normal pore canals are widely scattered. Six or seven marginal pore canals are visible along the posterior margin, but it is difficult to discern any at the anterior end. Hinge artiperatodont, as described by Bate (1972: 45).

DIMENSIONS (μm).	L	H	W
Holotype, female right valve OS 8300	325	205	085
Paratype, female left valve OS 8301	310	195	095
Paratype, female right valve OS 8304	320	200	085
Male left valve OS 8305	330	170	075

REMARKS. *Hemicytherura* sp. of McKenzie, 1974, from the Jangukian (Mid? Oligocene) of south-east Australia, has a very similar shape; fossae 8–12 have almost identical outlines, but fossae 1 and 3′ are missing in the Australian species. The Tanzanian species has the same pattern of ornament as *H. videns videns* (Müller, 1894), but the slightly different fossae, especially 6 and 8 which are shorter and more triangular in *H. subulata*, easily distinguish them.

Genus ***SEMICYTHERURA*** Wagner, 1957

TYPE SPECIES. *Cythere nigrescens* Baird, 1838.

Semicytherura emphysema sp. nov. Pl. 33, figs 8–11

NAME. 'Something inflated' (Greek), with reference to its ventral inflation.

DIAGNOSIS. A species of *Semicytherura* with ventrally inflated valves; the muri of the fossae are more developed in the ventral half than in the dorsal.

HOLOTYPE. A female carapace, OS 8309. Three specimens, OS 8310–2, are paratypes. Sample FCRM 1989, Likonga bridge; Lower Miocene.

OTHER MATERIAL. One specimen from the same sample. Also occurs in FCRM 1737 and 2010.

DESCRIPTION. Carapace rectangular to subrounded in side view, with subparallel dorsal and ventral margins, and straight to concave posterodorsal margin. Anterior margin symmetrically rounded, posterior produced into a median caudal process. Valves inflated ventrally; carapace lenticular and slightly acuminate posteriorly in dorsal view. Sexual dimorphism present; presumed females much shorter and more tumid than presumed males. External surface pitted to reticulate; pits smaller and muri not as well developed in the dorsal half as in the ventral half of the valves. Internal features could not be seen clearly, except for the hinge, which is typical of the genus.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8309	390	190	190
Paratype, male carapace OS 8311	400	205	120

REMARKS. The difference in length between the presumed females and males suggests that the female carapace may represent the penultimate stage rather than the adult. The duplicature is not well developed in the single valves, which also suggests that the specimens may be juveniles. However, the sexual dimorphism can be clearly seen, and the size, though small, is within the limits of adults found in this genus. It was therefore thought better to name this species than to leave it under open nomenclature. *S. sella* (Sars, 1866) agrees in shape with the new species but differs from it in having coarser ridges and smaller pits.

Semicytherura opeata sp. nov. Pl. 33, figs 4–7

NAME. From Greek *opeas*, 'awl', with reference to the shape, especially in dorsal view.

DIAGNOSIS. A species of *Semicytherura* with 13 to 15 ridges, with lines of small rounded pits arranged longitudinally between them. The posterior is produced subventrally. Sexual dimorphism present.

HOLOTYPE. A female carapace, OS 8313. Two carapaces, OS 8314–5, are paratypes. Sample FCRM 1989, Likonga bridge; Lower Miocene. The only specimens.

DESCRIPTION. Carapace elongate-ovate in side view; dorsal margin strongly convex, almost continuous with the asymmetrically curved anterior margin and straight sloping posterodorsal margin. Ventral margin slightly concave in the middle and convex posteriorly; posterior produced into a ventral caudal process. Greatest height in the middle; greatest width just in front of posterior end. Sexual dimorphism present, presumed females being shorter and higher than males, and easily distinguished. In dorsal view, however, presumed males look more swollen than females. External surface ornamented with longitudinal ridges, about 13–15 in number when counted at mid-length; anteriorly and posteriorly the numbers decrease as adjacent ridges fuse. These ridges have lines of rounded pits arranged longitudinally between them. Lacking single valves, internal features were not seen.

DIMENSIONS (μm).	L	H	W
Holotype, female carapace OS 8313	490	210	170
Paratype, male carapace OS 8314	520	215	190

REMARKS. Since no internal features were seen placement of this species in *Semicytherura* and not *Cytherura* is based only on comparison with species such as *Semicytherura sulcata* (Müller, 1894). This resembles the new species in shape and ornament, but in *S. opeata* the caudal process is ventral while in *S. sulcata* it is located subdorsally.

Semicytherura sp. A Pl. 33, fig. 12

FIGURED SPECIMEN. A carapace, OS 8316. Sample FCRM 1575; shore south-west of Ras Tapuri; Middle Oligocene.

OTHER MATERIAL. One specimen from the same sample.

DESCRIPTION. Carapace subrectangular in side view; dorsal margin gently convex, anterior margin rounded. Posterodorsal and posteroventral margins concave, with a subdorsal caudal process. Ventral margin concave in the middle and strongly convex posteriorly, with greatest height in posterior third. Sexual dimorphism present, the presumed female being shorter than the male. External surface ornamented with 8 or 9 longitudinal ridges but no pits. Internally, hinge typical for the genus; other features cannot be seen clearly.

DIMENSIONS (μm).	L	H	W
Carapace OS 8316	390	200	160

REMARKS. *S. sella* (Sars, 1866) and *Semicytherura* sp. A are very similar but can be distinguished by the patterns of the ridges. In *S. sella* the ridges in the dorsal half curve strongly towards the mid-anterior region, whereas in *Semicytherura* sp. A the curvature of these ridges is less abrupt. *S. sella* also has thin transverse ridges meeting the stronger longitudinal ones; these are absent in the Tanzanian species.

Subfamily **CYTHEROPTERINAE** Hanai, 1957*b*

Genus ***CYTHEROPTERON*** Sars, 1866

TYPE SPECIES. *Cythere latissima* Norman, 1865.

Cytheropteron epelyx sp. nov. Pl. 34, figs 1–3

NAME. 'Overshadowing' (Greek), with reference to the overhanging ventrolateral part of the carapace.

DIAGNOSIS. A species of *Cytheropteron* with overhanging ventrolateral margin and an acuminate posterior margin.

HOLOTYPE. A right valve, OS 7849. 36 single valves, OS 7850–85, are paratypes. Sample FCRM 1578, coastal cliff west of Ras Tapuri; Middle Eocene.

OTHER MATERIAL. 21 specimens from the same sample (e.g. OS 7756). Also occurs in FCRM 1574, 1575 and 1576.

DESCRIPTION. Carapace medium-sized, well calcified, with greatest height slightly in front of the middle. Anterior margin obliquely rounded towards the venter; posterior acuminate. Dorsal margin asymmetrically arched, divisible into strongly sloping anterior, gently sloping middle and steeply sloping to concave posterior portions. Ventral margin strongly modified, especially about one-third from posterior end, by the overhanging ventrolateral ala. Lateral surface reticulate but not uniformly so; surface almost smooth dorsally, becoming gradually more reticulate ventrally. There are four weak longitudinal ridges, without reticulation, on the ventral surface between the margin and the alae. Another weak ridge runs along the ventral swelling. Marginal pore canals very few and widely separated. Muscle scars not clearly seen but consist of four adductor scars with a V-shaped frontal scar open towards ventral margin. Hinge like that in the *C. latissimum* (Norman, 1865) group of species. Right valve hinge has five denticles on either end with a crenulate bar between; left valve has corresponding elements.

DIMENSIONS (μm).	L	H	W
Holotype, right valve OS 7849	550	325	220
Paratype, right valve OS 7850	590	340	220

REMARKS. *Cytheropteron subreticulatum* Bold, 1946, is closely related to *C. epelyx*, but has a more strongly curved dorsal margin and less distinct posterior point.

Cytheropteron cf. ***nipeensis*** Bold, 1946 Pl. 34, figs 6–9

cf. 1946 *Cytheropteron nipeensis* Bold: 113; pl. 16, fig. 1.

FIGURED SPECIMENS. Male carapace, OS 7961; female carapace, OS 7962 (lost). Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

OTHER MATERIAL. Eight specimens from the same sample (e.g. OS 7963).

DIMENSIONS (μm).	L	H	W
Female carapace OS 7962	385	205	150
Male carapace OS 7961	395	215	165

REMARKS. The Tanzanian species agrees with *C. nipeensis* Bold in outline; Bold's figure is not very informative, so it is not possible to say with certainty whether they are the same. Sexual dimorphism occurs in the Tanzanian species, the presumed males being longer and less high than the females; Bold does not mention dimorphism in *C. nipeensis*.

Cytheropteron sp. A Pl. 34, figs 4–5

FIGURED SPECIMEN. A carapace, OS 7846; the only well-preserved specimen. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

DESCRIPTION. Carapace strongly alate, highest in the middle. Anterior margin rounded towards venter, dorsal margin arched; posterior margin produced in a median caudal process. Ventral margin strongly modified by the ala in side view, but when seen obliquely from inside it is straight to slightly concave in anterior half and convex in posterior half. The strongly developed ventrolateral alae bifurcate at their posterior ends. Lateral surface smooth except for very fine hexagonal reticulations along the middle and four weak longitudinal ridges on ventral surface of ala. No internal details were seen.

DIMENSIONS (μm).	L	H	W
Carapace OS 7846	420	240	315

REMARKS. This species has a typical *Cytheropteron* shape but its bifurcated alae distinguish it from any other known species.

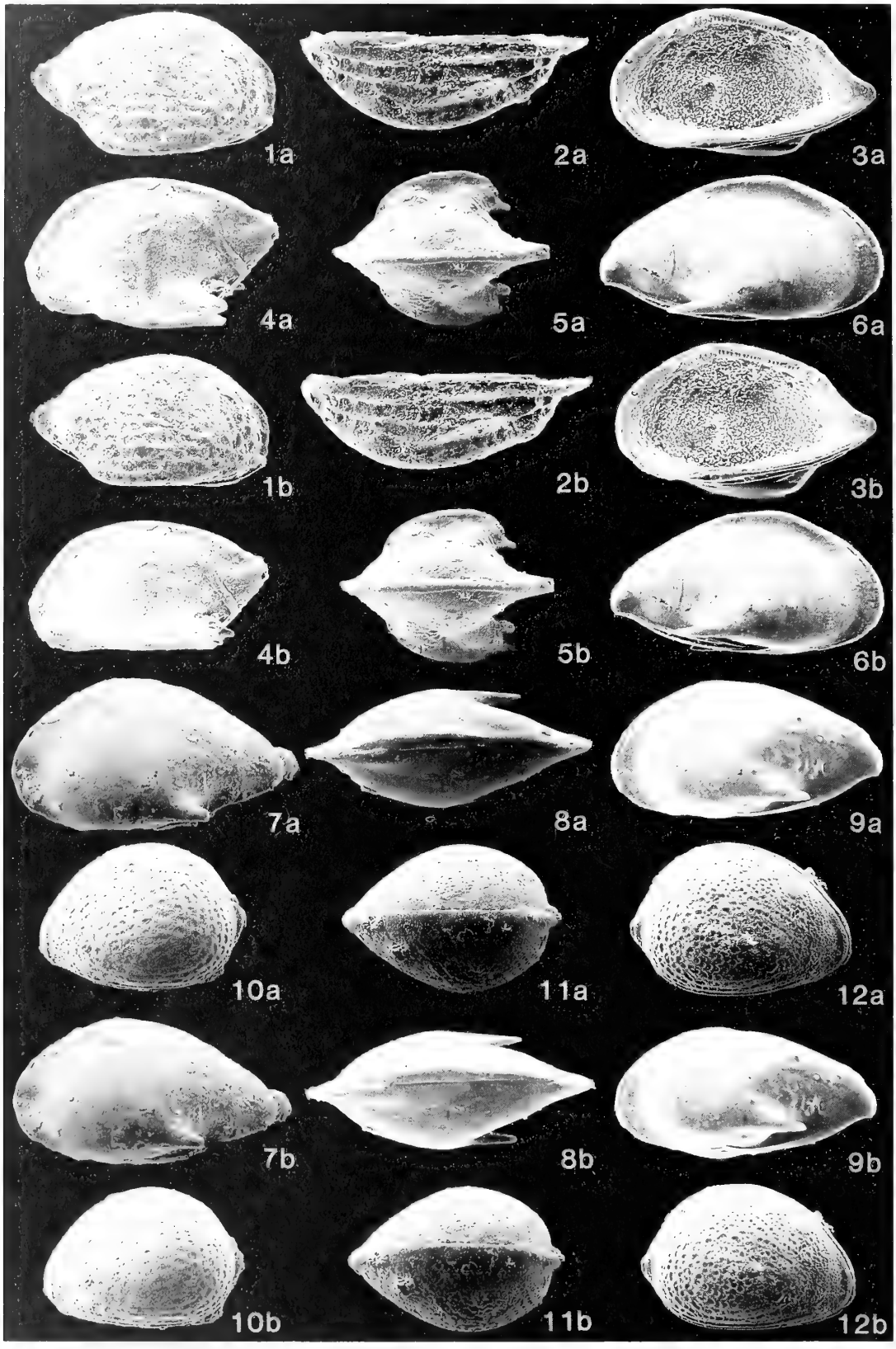
Genus ***KANGARINA*** Coryell & Fields, 1937

TYPE SPECIES. *K. quellita* Coryell & Fields, 1937.

Kangarina sp. Pl. 28, figs 8–10

FIGURED SPECIMEN. A carapace, OS 7983. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene. The only specimen.

DESCRIPTION. Carapace subtriangular in side view, with rounded anterior margin; posterior with a subcentral caudal process. Dorsal margin convex, posterodorsal concave, and ventral modified by the ventrolateral ridge. Ornament varies in different areas. Six ridges run back from the anterior end: two of them start above the middle and curve towards the dorsal margin; the other four start below the middle and tend to converge behind. Central dorsal area ornamented with transverse ridges; anterodorsal area reticulated with rounded fossae. The posteroventral and centroventral areas are reticulated with rounded fossae arranged longitudinally. No internal details visible.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Dimensions (μm).	L	H	W
Carapace OS 7983	335	175	165

Remarks. Although the Tanzanian specimen has a shape which is comparable with that of some Tertiary *Kangarina* species, the ornament is completely different.

Family **XESTOLEBERIDIDAE** Sars, 1928

Genus ***UROLEBERIS*** Triebel, 1958

Type species. *Eocytheropteron parnensis* Apostolescu, 1955.

Uroleberis kyma sp. nov. Pl. 34, figs 10–12; Pl. 35, figs 1–3

1988 *Uroleberis kymus* Ahmad, MS; Neale & Singh: 89; pl. 1, figs 9, 13 ('*kynus*' on p. 87).

Name. 'Swollen' (Greek), with reference to carapace.

Diagnosis. A dimorphic species of *Uroleberis* with strongly convex dorsal margin and almost straight ventral margin.

Holotype. A female carapace, OS 8189. Four specimens, OS 8188, 8190–3, are paratypes. Sample FCRM 2033, Lindi Creek, east shore; Upper Eocene.

Other material. Seven specimens from the same sample.

Description. Carapace ovate in female, ovate–elongate in male. Dorsal margin strongly convex, ventral margin almost straight. Anterior margin obliquely rounded below, posterior with laterally flattened caudal process slightly below mid-height. Left valve larger than right. Surface with concentrically arranged pits except along the ventral edge, where they are longitudinal. Eyesocket distinct from inside, with a reniform 'xestoleberis' spot behind it. Duplicature moderately wide; line of concrescence and inner margin separate throughout, forming an anterior vestibule. Marginal pore canals numerous, simple and straight, a few of them false. Four adductor muscle scars and a V-shaped frontal scar. Right valve hinge of crenulate terminal teeth, each with eight to ten denticles, connected by a narrow smooth groove. Left valve with corresponding terminal crenulate sockets connected by a narrow smooth ridge with a noticeable accommodation groove above.

Dimensions (μm).	L	H	W
Holotype, female carapace OS 8189	485	385	360
Paratype, female carapace OS 8188	470	360	335
Paratype, male right valve (specimen lost) OS 8192	450	285	260

Remarks. Sohn's genus and species indet. 4 from the Middle to Late Eocene of Pakistan (Sohn 1970: 68; pl. 4, figs 10–12) is most similar to *U. kyma*; however, the Tanzanian species has a less pitted surface and a straighter ventral margin. The present species is much smaller and has a better-developed caudal process than *Cythere ranikotiana* Latham, 1938, from Dandot, Pakistan. *Uroleberis armeniaca* Neale & Singh, 1985, is smaller and has a less arched dorsal margin than *Uroleberis kyma*.

***Uroleberis*?** sp. Pl. 31, figs 7–9

Figured specimen. A carapace, OS 8308. Sample FCRM 1989, Likonga bridge; Lower Miocene. The only specimen.

Description. Carapace rounded, subtriangular with greatest height two-fifths the length from posterior end. Greatest length below midline. Dorsal margin strongly arched, cardinal angles absent; ventral margin almost straight. Anterior and posterior margins both curve strongly towards the venter. Left valve overlaps right. Surface punctate centrally, becoming smooth peripherally; there are longitudinal ridges along the ventral margin.

Dimensions (μm).	L	H	W
Carapace OS 8308	600	415	390

Remarks. The present specimen shows some resemblance to *U. batei* Neale, 1975, but can easily be distinguished by its larger size and pitted surface.

Family **BYTHOCYTHERIDAE** Sars, 1866

Genus ***BYTHOCERATINA*** Hornibrook, 1952

Type species. *Bythoceratina mestayerae* Hornibrook, 1952.

Bythoceratina*? *asteria sp. nov. Pl. 27, fig. 5

Name. 'Spotted with stars' (Greek); with reference to its ornamentation.

Diagnosis. A species of *Bythoceratina*? with a very prominent eye-tubercle, and a ventrolateral swelling ending in a prominent sharp spine posteriorly.

Holotype. A left valve, OS 8116. Nine specimens, OS 8117–25, are paratypes. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene. No other material.

Description. Carapace quadrate in lateral view, tapering posteriorly, with the greatest height at the anterior cardinal angle. Anterior margin evenly rounded, posterior somewhat produced with straight posterodorsal margin. Dorsal and ventral margins almost straight. Marginal spines present at anterior and posterior margins, the posterior spines being

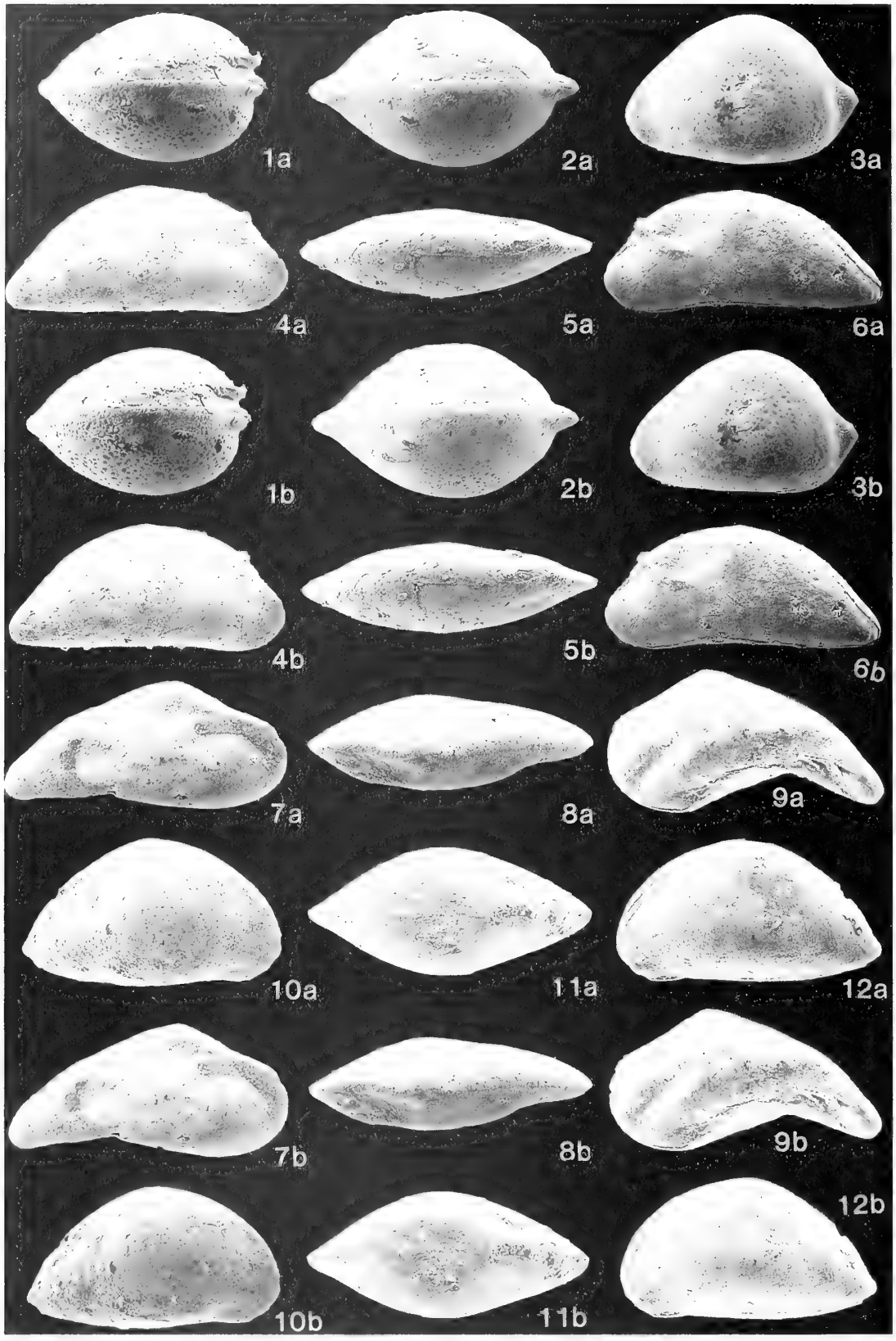
PLATE 34

Figs 1–3 *Cytheropteron epelyx* sp. nov. Figs 1, 2, **holotype**, right valve, OS 7849; 1, external lateral view, ×71; 2, ventral view, ×85. Fig. 3, paratype, right valve, OS 7850, internal oblique view, ×73.

Figs 4, 5 *Cytheropteron* sp. A. Carapace, OS 7846; 4, lateral view from left, ×96; 5, dorsal view, ×83.

Figs 6–9 *Cytheropteron* cf. *nipeensis* Bold, 1946. Figs 6–8, female carapace, OS 7962 (specimen lost); 6, lateral view from right, ×119; 7, lateral view from left, x119; 8, dorsal view, ×121. Fig. 9, male carapace, OS 7961, slightly ventrolateral view from left, ×111.

Figs 10–12 *Uroleberis kyma* sp. nov. Fig. 10, paratype, female carapace, OS 8188, lateral view from left, ×70; see also Pl. 35, fig. 1. Figs 11, 12, **holotype**, female carapace, OS 8189; 11, dorsal view, ×73; 12, lateral view from right, ×74.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strongly developed. A glassy round eye tubercle is present. External surface reticulate with trefoil-shaped ornamentation. Ventrolaterally each valve bears a hollow, sharp spine directed posteriorly. Median sulcus extremely shallow. Duplicature very narrow; radial pore canals very few and straight. Muscle scars not perfectly seen but probably the same as in *Bythoceratina*, consisting of five adductor scars arranged in a row. Right valve hinge consists of two elongate, crenulate terminal teeth with a crenulate median groove. Left valve has corresponding sockets and bar. The closure is additionally strengthened by a very weakly developed ventral snap-knob in the right valve and socket in the left valve.

DIMENSIONS (μm).	L	H	W
Holotype, left valve OS 8116	675	385	–

(Specimen cracked, too fragile to measure width.)

REMARKS. The distinct eye tubercle, snap-knob/socket mechanism, different hinge with crenulate terminal teeth, and slightly different shape distinguish this from other *Bythoceratina* species. However, the very narrow duplicature, suggesting that the specimens may be juveniles, and the imperfectly known muscle scars, do not justify the erection of a new genus. For the present this Tanzanian species is placed with doubt in *Bythoceratina*. *Leguminocythereis bisanensis* Okubo, 1975, agrees with this species in having similar spines directed posteriorly; internally, the marginal zone is equally narrow, and the terminal hinge elements are crenulate. However, the two can readily be distinguished. *Bythoceratina*? *asteria* is subrectangular in shape, has a well-developed eye tubercle, a shallow median sulcus and trefoil-shaped ornamentation, while *Leguminocythereis bisanensis* is more ovate, has an indistinct eye tubercle, no median sulcus, and rounded to subrectangular fossae.

Bythoceratina sp. A

Pl. 22, fig. 12

FIGURED SPECIMEN. A right valve, OS 8317. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

OTHER MATERIAL. Five single valves (none well preserved; all broken).

DESCRIPTION. Carapace oblong in lateral view with greatest height about one-quarter length from posterior end; greatest width in posterior half. Anterior margin narrowly rounded, posterior produced into a median caudal process. Dorsal and ventral margins run almost parallel for about one-third of the length and then diverge towards the posterior, the dorsal running almost straight and sloping upwards and the ventral strongly convex. Externally, the lateral surface has a shallow vertical sulcus at mid-length. The strong ventrolateral swelling terminates in a spine. Except for some sloping ridges on the swelling, the valve surface is smooth and punctate. Left valve hinge a crenulate median bar with weakly developed sockets at either end. Other internal features not clearly visible.

DIMENSIONS (μm).	L	H	W
Right valve OS 8317	575	345	280

REMARKS. All other species of *Bythoceratina* described so far have the caudal process in line with the hinge or just below it, but in *Bythoceratina* sp. A the caudal process is at mid-height. *Bythoceratina variabilis* Carbonnel 1969 is closely allied to *Bythoceratina* sp. A, but, besides the difference in the positions of the caudal processes, the two species have a different dorsal margin. The dorsal margin of Carbonnel's species is concave in the middle, whereas that of the Tanzanian species is concave in the anterior third.

Superfamily **CYPRIDACEA** Baird, 1846
Family **MACROCYPRIDIDAE** Müller, 1912

Genus ***MACROCYPRIS*** Brady, 1867

TYPE SPECIES. *Cythere minna* Baird, 1850.

Macrocypris? sp. A

Pl. 35, figs 10–12

FIGURED SPECIMEN. A carapace, OS 8306. Sample FCRM 1711, east flank of Kitulo Hill; Palaeocene. The only specimen.

DESCRIPTION. Carapace subtriangular in lateral view, with greatest height at about mid-length and valves tapering strongly posteriorly. Dorsal margin strongly curved in anterior half, sloping posteriorly; ventral margin almost straight. Anterior margin rounded, posterior acuminate. Right valve strongly overlaps left. No internal details visible.

DIMENSIONS (μm).	L	H	W
Carapace OS 8306	610	335	290

REMARKS. On the basis of shape this is not a typical *Macrocypris*, but no better assignment could be made in the circumstances so it is here doubtfully assigned to that genus. The only other described species which shows any resemblance to this specimen is the *Macrocypris*? sp. aff. *M.*? *dimorpha* Hazel & Holden, of Holden 1976; however the more acuminate posterior end of the Tanzanian specimen distinguishes it from Holden's species.

Macrocypris sp. B

Pl. 35, figs 4–6

FIGURED SPECIMEN. A carapace, OS 8307. Sample FCRM 1989, Likonga bridge; Lower Miocene. The only specimen.

DESCRIPTION. Carapace elongate, with dorsal margin arched; ventral margin slightly concave in the middle. Anterior end rounded, with some incurving below; posterior end narrowly

PLATE 35

Figs 1–3 *Uroleberis kyma* sp. nov. Fig. 1, paratype, female carapace, OS 8188, dorsal view, ×68; see also Pl. 34, fig. 10. Figs 2, 3, paratype, male carapace, OS 8192 (specimen lost); 2, dorsal view, ×98; 3, lateral view from left, ×84.

Figs 4–6 *Macrocypris* sp. B. Carapace, OS 8307; 4, lateral view from right, ×38; 5, dorsal view, ×40; 6, lateral view from left, ×38.

Figs 7–9 Genus A sp. Carapace, OS 7980; 7, lateral view from right, slightly oblique from dorsal, ×88; 8, dorsal view, ×90; 9, lateral view from left, slightly oblique from ventral, ×87.

Figs 10–12 *Macrocypris*? sp. A. Carapace, OS 8306; 10, lateral view from right, ×67; 11, dorsal view, ×75; 12, lateral view from left, ×67.

rounded. Left valve larger than right. No internal details visible.

Dimensions (μm).	L	H	W
Carapace OS 8307	1170	545	370

Remarks. *Macrocypris* sp. B strongly resembles *Macrocypris similis* Brady 1880, but the narrower anterior end and strongly concave ventral margin distinguish it from that species. This species differs from *M.*? sp. A in being more elongate and less triangular.

INCERTAE SEDIS

Genus A sp.

Pl. 35, figs 7–9

Figured specimen. A carapace, OS 7980. Sample FCRM 1989, Likonga bridge; Lower Miocene.

Other material. Five carapaces from the same locality and horizon.

Description. Anterior margin asymmetrically rounded, posterior end produced. Dorsal margin bent at mid-length, ventral margin concave. Right valve strongly overlaps left. No single valves found hence no internal details seen.

Dimensions (μm).	L	H	W
Carapace OS 7980	510	270	170

Remarks. Six specimens of this small new genus were found but naming it cannot be justified because of the absence of single valves. The specimens are unique in being very strongly bent at mid-length, behind which they narrow sharply. The smooth external surfaces and right-over-left overlap suggest that the genus is closely related to *Macrocypris*. *M. acuticaudata* Bate, *in* Bate & Bayliss 1969, from the Albian sediments of Kiwanga, Tanzania, is probably an ancestor of this Tertiary species.

Genus B sp.

Pl. 11, figs 4–6

Figured specimen. A left valve, OS 8113. Sample FCRM 2010, stream south-west of Mtwero; Lower Miocene.

Other material. Two specimens from the same locality and horizon. Also occurs in FCRM 2015.

Description. A species with concentrically arranged fossae; posteroventral complex consisting of three or four tubercles joined together. Anterior margin rounded, posterior subventrally produced, with a slightly concave posterodorsal margin; marginal spines present at both ends. Dorsal margin straight, ventral slightly concave; the two margins converge slightly behind. External surface reticulate with a few superimposed tubercles; eye tubercle present as an opaque spot. Muri thick and arranged concentrically, enclosing elongate fossae. Posteroventral complex conspicuously raised. Internally, duplicature fairly wide, with line of concrescence and inner margin slightly separated to give a narrow anterior vestibule. Selvage well developed at anterior and anteroventral margins. Marginal pore canals not visible; four adductor scars and a V-shaped frontal scar. Hinge holamphidont.

Dimensions (μm).	L	H	W
Left valve OS 8113	570	330	160

Remarks. While Genus B sp. is trachyleberine, it differs completely from *Trachyleberis* and cannot be placed in any of the other genera. It is here left under open nomenclature.

Genus C sp.

Pl. 33, fig. 3

Figured specimen. A right valve, OS 8320. Sample FCRM 1738, South Mtwero; Lower Miocene.

Other material. Two single valves from FCRM 1737 (OS 8319) and 1738.

Description. A species with reticulate surface, the muri being crimped. The right valve has a snap-knob which fits into the snap-socket of the left. Carapace subquadrate in lateral view, with greatest height near anterior cardinal angle. Anterior rounded, with marginal denticles; posterior margin truncated in upper half, rounded below and slightly produced. Dorsal and ventral margins straight and subparallel, slightly converging towards posterior end. Surface ornament consisting of a reticulate pattern of ridges, the muri being strongly crimped. Position of adductor muscle scars marked by an ovoid subcentral depression; eye tubercle elongate and not clearly developed. Three ridges are especially prominent; one, beginning near the posterior cardinal angle, runs forward parallel to the dorsal margin until it turns downwards about two-thirds of the way along and merges into other small ridges. The other two ridges are ventrolateral, the lower one running along the ventral margin and the upper one, about the same length and running parallel to it, ending in a small spine just in front of the posterior margin. Duplicature moderately wide. Line of concrescence and inner margin coincide throughout, so there is no vestibule. Selvage prominent along anterior and posterior margins, running at a little distance from outer margin. There is a unique snap-knob/socket mechanism; four small toothlike knobs in the right valve, behind the strong mid-ventral knob, correspond with sockets in the left. Marginal pore canals short, parallel and numerous, about 30 anteriorly and 8–9 posteriorly. Normal pore canals present all over the surface. Four adductor muscle scars, in a vertical row, with a fused V-shaped frontal scar which cannot be seen clearly. Hinge holamphidont; right valve has a smooth knob-like anterior tooth followed by a crenulate posterior tooth.

Dimensions (μm).	L	H	W
Right valve OS 8320	545	335	160

Remarks. Only one of the three specimens found is adult so the genus is left under open nomenclature. There is little in the literature with which this species can be compared. At the generic level, *Agulhasina* Dingle 1971 resembles it in outline and ornament, but has surface spines, no eye tubercle, and fewer marginal pore canals. *Australileberis* Dingle, 1976, agrees with this genus in some details but has different ornament. *Stigmatocythere* Siddiqui, 1971, has similar dorsal and ventral ridges and the hinge and marginal pore canals are similar also, but the frontal scar in *Stigmatocythere* is oval. The surface ornament is also different, the fossae in *Stigmatocythere* being subrectangular and shallow, while those of the new genus are trifoliate, crimped and deeper. The new genus differs from all the others in its snap-knob/socket mechanism. Palaeoecologically, Genus C has only been found in silty shaly clays, and is associated with deeper water genera such as *Krithe* and *Parakrithe*.

PALAEOECOLOGY

When the ecology at the species level is unknown, certain limitations are placed upon the interpretation of palaeocology. Based on the generally accepted habitat of certain genera, however, it has been possible to reach conclusions which are given below. We make the following assumptions.

(1) Certain genera with a strongly reticulate or ornamented lateral surface, strongly calcified carapace and well-developed eye tubercle inhabit shallow marine water. These genera are *Aurila*, *Quadracythere*, *Haughtonileberis*, *Leguminocythereis*, *Stigmatocythere*, *Cytheropteron* (thick shelled), *Callistocythere*, *Costa*, *Hermanites* and *Hemicytherura*.

(2) A second group of shallow-water marine genera is almost confined to tropical and subtropical waters, only living in or around reefs. This group includes *Triebelina*, *Paranesidea* and *Loxoconcha* (*Loxocorniculum*). The genera *Cytherelloidea*, *Uroleberis*, *Kangarina* and *Triebelina* may also be taken as indices for warm temperatures, above the 10°C isocryme according to Sohn (1964) for *Cytherelloidea*, and about 20°–25°C for all four genera according to McKenzie (1974).

(3) A third group of genera is often regarded as indicating moderately deep marine waters (>75 m). This includes *Krithe*, *Parakrithe*, *Paijenborchella* and *Henryhowella*.

Based on these assumptions, the following grouping of sample localities is suggested:

(1) Shallow water: FCRM 2010.
(2) Shallow water but indicating an approach to a reef environment: FCRM 1566, 1574, 1575, 1576, 1578, 1627, 1628, 1661, 1689, and 1692.
(3) Deep water: FCRM 1737, 1738; and less deep, FCRM 1742, 1745.
(4) Mixed fauna: FCRM 2033, 2034; these have a mixed fauna mostly indicating a shallow reef environment but with some deeper water incursions. For other samples nothing conclusive can be said except that they contain mostly shallow-water genera.

Ostracods are sensitive to many factors in the environment and consideration of various ecological parameters suggests that the Lindi fauna comes from waters with the following characteristics:

1. *Depth*: Apparently shallow water with some deep water incursion in Lower Miocene (FCRM 1737, 1738).
2. *Oxygen*: Generally well oxygenated. As the water was warm it would have held less oxygen, but no reducing environments are evident and none of the ostracods are pyritized. The ostracods are generally robust, indicating fairly high energy waters; this may also account for the lack of pyritization of the fauna.
3. *Salinity*: All the Lindi ostracod genera which are still living at the present time are now restricted to water with salinities in the range of 30 to 40%; Lindi ostracods probably lived in waters of this salinity range.
4. *Clarity*: Well-developed eye tubercles suggest that the waters were extremely clear. The deep-water genus *Krithe*, with its numerous species, is blind but its close relative *Ommatokrithe*, which occurs here, has eye tubercles and was separated from *Krithe* for that very reason.
5. *Temperature*: The size of these ostracods is generally small which suggests that waters were warm, temperatures at times reaching 20°–25°C.

An attempt was made to deduce the comparative rate of sedimentation on the basis of the ratio of single valves to carapaces. Pokorný (1964*b*) had observed that, in the case of *Karsteneis karsteni* (Reuss) and *Cythereis longaeva* Pokorný, the percentage of closed carapaces was higher in regions of rapid sedimentation. Oertli (1971), working on abundant ostracod material, concluded that in conditions of slow sedimentation the carapace opens because of bacterial decomposition of muscles and ligaments, but in rapid sedimentation conditions the dead ostracods quickly sink by their own weight far enough into the sediment for the valves not to be separated. Comparing the ostracods from the surface samples of Lindi with those from borehole samples of Lamu (Kenya), where the rate of sedimentation was almost the same (Kent, *in* Kent *et al.* 1971), the percentage of closed carapaces was found to be higher in the Lamu samples than in those from Lindi. It was also found that the ratio depended on the genera or species concerned. For example, in the Lindi area, species of *Costa*, *Paracytheridea* and *Tanzanicythere* were mostly found as single valves, but species of *Xestoleberis*, *Clithrocytheridea*?, *Phlyctocythere*, and *Incongruellina* were mostly present as entire carapaces, the two groups occurring together.

Based on the ten most productive samples from the three periods, we deduced that the maximum rate of sedimentation occurred during the Lower Miocene; the rate was slightly less for the Eocene. For the Oligocene, however, it was about half of the maximum deduced for the Lower Miocene. These results corroborate the comparative rates of sedimentation calculated by Kent *et al.* (1971: 89); a comparative chart is given in Fig. 6, p. 184. It is therefore concluded that during the Upper Eocene the water was mostly shallow with some deeper water incursions at times, and the rate of sedimentation was faster than in the overlying Oligocene. During the Oligocene there was a general regression, the water becoming shallower but with a greater development of reefs and much slower sedimentation. During the Lower Miocene a transgression occurred, the water being shallow near reefs but deeper in other places, and with a greater rate of sedimentation than previously. The greater diversity of the fauna in Lower Miocene times supports this speculation.

FAUNAL ASSEMBLAGES

During the Upper Eocene, *Paijenborchella*, *Hermanites*, *Uroleberis*, *Clithrocytheridea*?, *Quadracythere*, *Stigmatocythere*, *Triebelina*, *Paranesidea*, *Cytherella*, *Bairdia* and *Cytherelloidea* became well established. Some of the *Cytherelloidea* species are distinctive in having the selvage of the left valve grown out behind the anterior part of the hinge to form a tooth. Most of these genera continued to exist during the Oligocene, only *Cytherelloidea* and *Clithrocytheridea*? being absent in sediments younger than Eocene. *Paijenborchella* disappeared for a while, to reappear in the Lower Miocene. A number of new genera appeared during this time, including *Loxoconcha* (*Loxocorniculum*), *Leguminocythereis*, *Haughtonileberis*, *Crenaleya*, *Carinocythereis* and *Semicytherura*. *Paracytheridea* became rare.

It appears that *Aitkenicythere* Bate (1976), which existed in Tanzania during the Bajocian–Tithonian (Jurassic), may be a distant ancestor of *Haughtonileberis*, which appeared during the Campanian in South Africa and during the Oligocene at

Table 1 Range table of ostracod species. This table also includes data from the BP ostracod collection kept at Sunbury-on-Thames; see p. 264. • < 10 specimens. ● 11–20 specimens. ⬤ > 20 specimens.

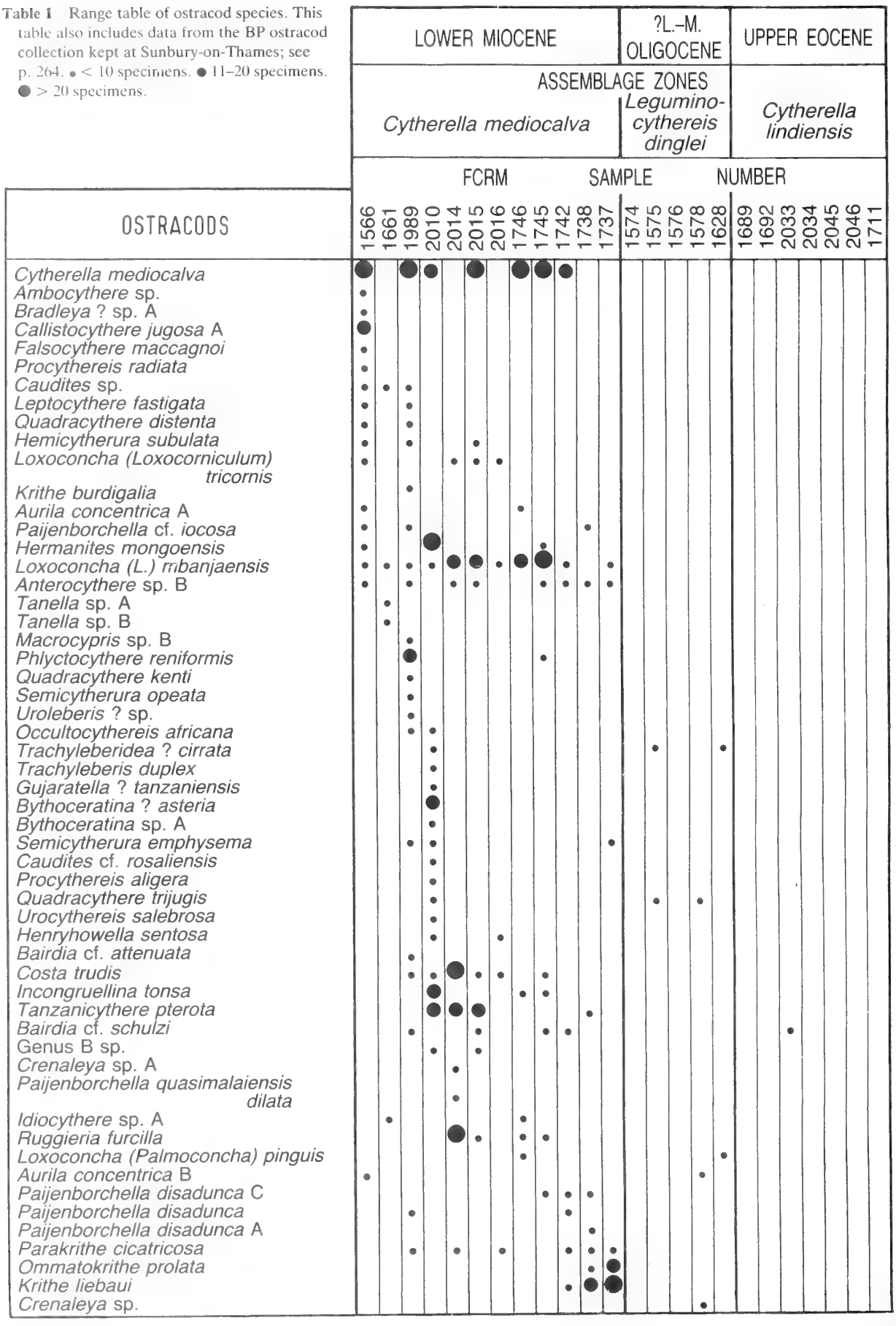
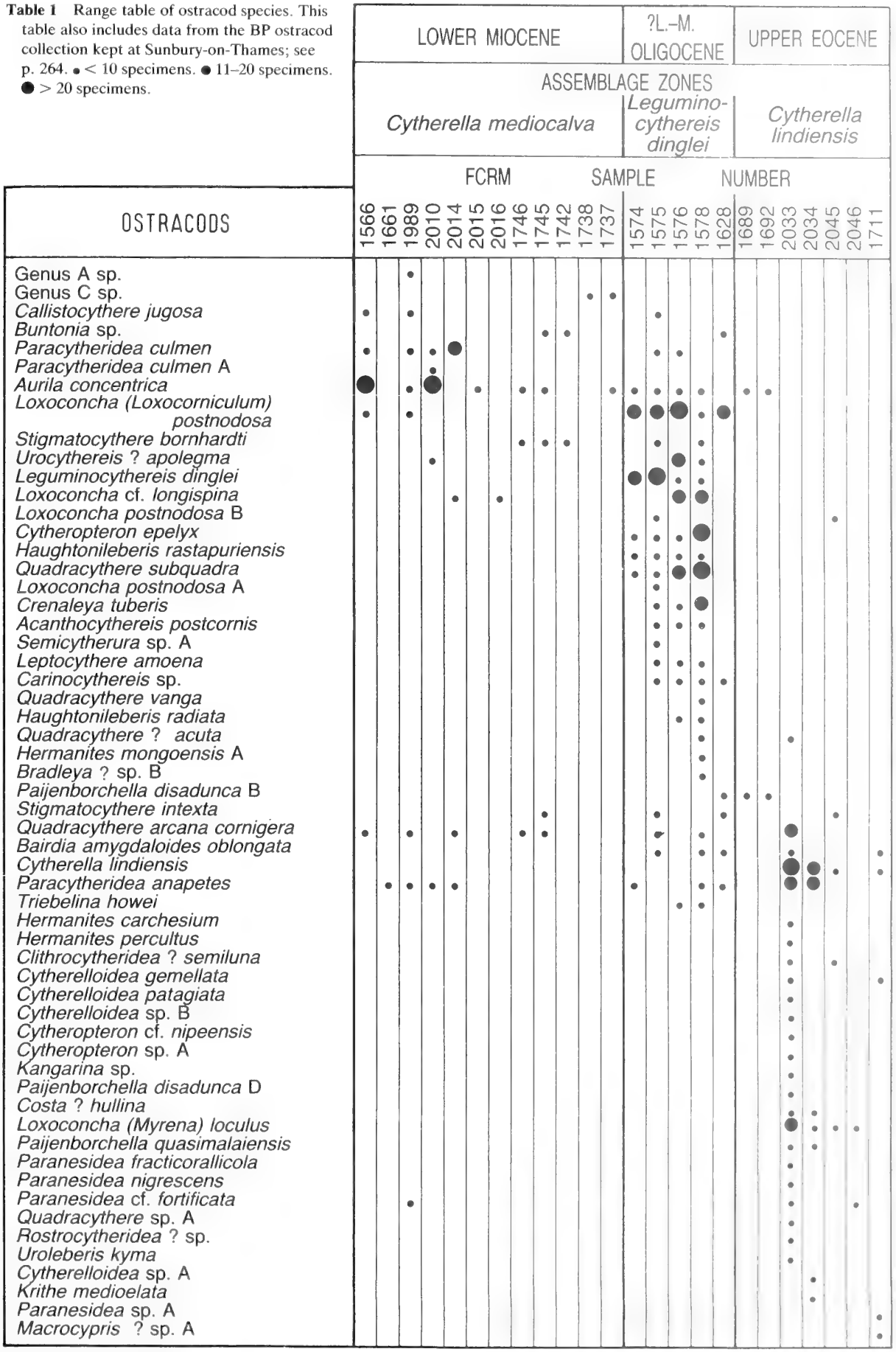


Table 1 Range table of ostracod species. This table also includes data from the BP ostracod collection kept at Sunbury-on-Thames; see p. 264. • < 10 specimens. ● 11–20 specimens. ● > 20 specimens.



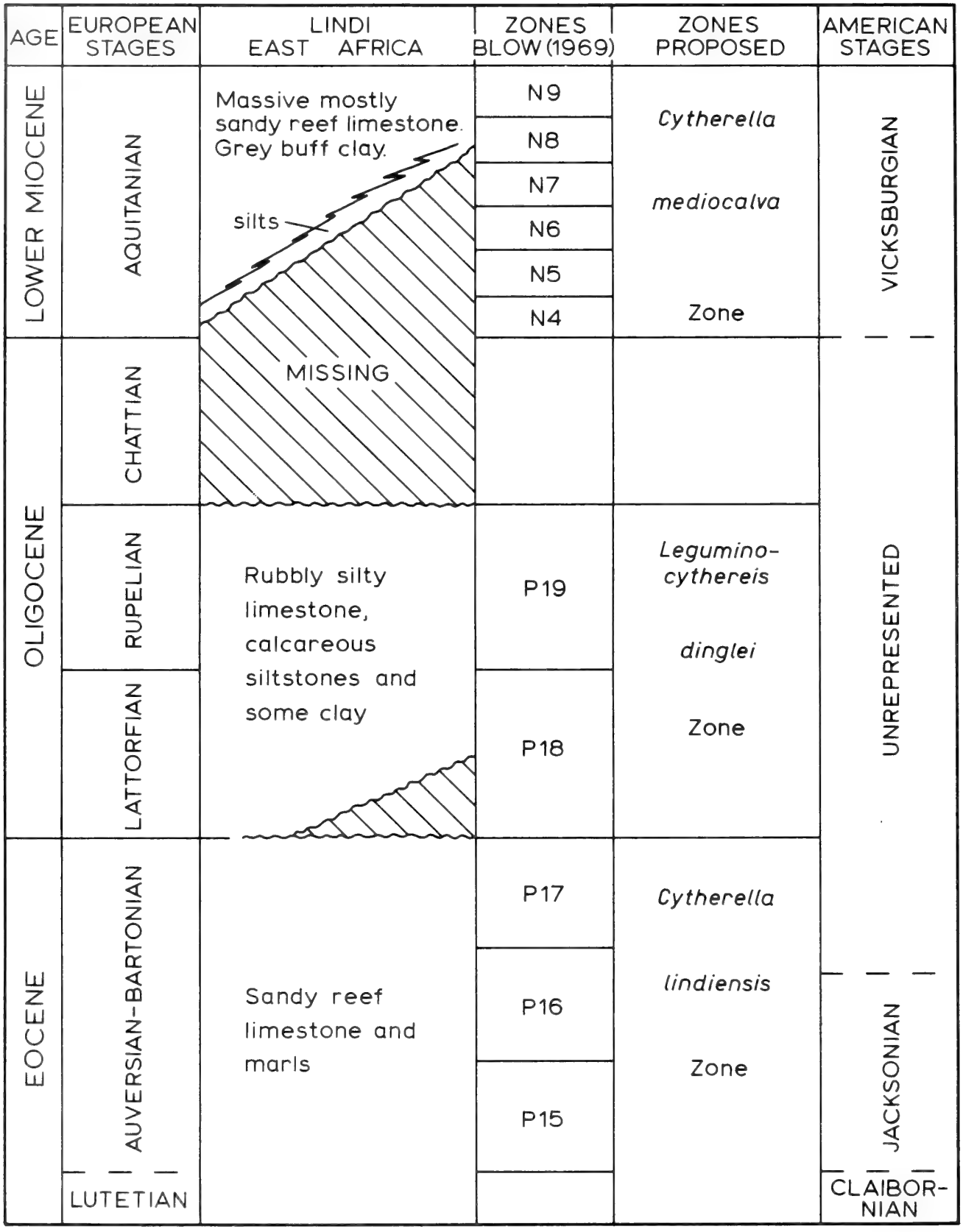


Fig. 10 Correlation of proposed ostracod biozones with those of Blow (1969).

Lindi; it is not known if it existed in Tanzania during the intervening time.

The Lower Miocene was a time of strong transgression, resulting in a very diverse fauna. New species appeared in the genera *Ommatokrithe*, *Bythoceratina*, *Ruggieria*, *Costa*, *Hemicytherura*, *Phlyctocythere*, *Tanzanicythere*, *Incongruellina* and *Xestoleberis*. Species of *Cytherella* and *Aurila* became abundant; *Paijenborchella* and *Krithe*, which first appeared in the Eocene and disappeared in the Oligocene, became re-established.

OSTRACOD BIOZONES

Planktonic foraminiferal biozones of the Lindi area and their relationships elsewhere in the world have been established by Eames *et al.* (1962) and Blow (1969). The ostracod zones suggested here are local Assemblage Zones; their correlation with Blow's Zones are shown in Fig. 10.

(1) *Cytherella lindiensis* Zone (= Upper Eocene). Corresponding roughly with Blow's Zones P15 to P17, this zone is defined by the abundance of *Cytherella lindiensis* sp. nov. and by the presence of the following species. (The species marked * are also known to occur elsewhere):

Cytherelloidea gamellata sp. nov.
Cytherelloidea patagiata sp. nov.
Clithrocytheridea? semiluna sp. nov.
Hermanites carchesium sp. nov.
Hermanites percultus sp. nov.
Krithe medioelata sp. nov.
Loxoconcha (*Myrena*) *loculus* sp. nov.
Paijenborchella (Eopaijenborchella) quasimalaiensis sp. nov.
Uroleberis kyma sp. nov.
* *Paracytheridea anapetes* Ahmad, 1977
* *Paranesidea* cf. *reticulopunctata* (Benson)
* *Stigmatocythere intexta* sp. nov.

The type locality for the *Cytherella lindiensis* Zone is the Lindi Creek, east shore, Tanzania, at FCRM 2033.

(2) *Leguminocythereis dinglei* Zone (= ?Lower to Middle Oligocene). This zone corresponds with Blow's Zones P18 and P19 and is characterized by the absolute range of the nominate taxon and by the presence of the following species:

Crenaleya tuberis gen. et sp. nov.
Cytheropteron epelyx sp. nov.
Haughtonileberis rastapuriensis sp. nov.
Hermanites mongoensis, Morphotype A
Leptocythere amoena sp. nov.
Quadracythere subquadra Siddiqui, 1971
Quadracythere vanga sp. nov.
* *Acanthocythereis postcornis* (Siddiqui, 1971)
* *Loxoconcha* (*Loxocorniculum*) cf. *longispina* Keij, 1953
* *Loxoconcha* (*Loxocorniculum*) *postnodosa* sp. nov.
* *Triebelina howei* (Stephenson)

There is an absence of such deeper-water genera as *Krithe* and *Ommatokrithe*.

The type locality for this zone is the shore south-west of Ras Tapuri, Tanzania, at FCRM 1576, which is also jointly the type locality for the *Globigerina oligocaenica* Zone of Blow & Banner (*in* Eames *et al.* 1962).

(3) *Cytherella mediocalva* Zone (= Lower Miocene). This zone corresponds roughly with Blow's Zones N4 to N9 and is defined by the presence of *Cytherella mediocalva* sp. nov., which is limited in range to this zone, and by the presence of the following species:

Bythoceratina? asteria sp. nov.
Tanzanicythere pterota (Ahmad, 1977)
Costa trudis Ahmad, 1977
Hemicytherura subulata sp. nov.
Hermanites mongoensis sp. nov.
Incongruellina tonsa sp. nov.
Krithe liebaui sp. nov.
Occultocythereis africana sp. nov.
Leptocythere fastigata sp. nov.
Loxoconcha (*Loxoconcha*) *mbanjaensis* sp. nov.
Loxoconcha (*Loxocorniculum*) *tricornis* sp. nov.
Ommatokrithe prolata Ahmad, 1977
Phlyctocythere reniformis sp. nov.
Paijenborchella (*Eopaijenborchella*) *disadunca* sp. nov.
Ruggieria (*Ruggieria*) *furcilla* sp. nov.
* *Aurila concentrica* sp. nov.
* *Callistocythere jugosa* sp. nov.
* *Paracytheridea culmen* sp. nov.

The type locality is the Mongo Stream, Lindi, at FCRM 1566.

CONCLUSIONS

The Tanzanian fauna forms part of the West Indian Ocean Ostracod Province. The fauna is linked to that of Pakistan by the presence of *Quadracythere subquadra*, *Q. arcana*, *Acanthocythereis postcornis*, and *Stigmatocythere bornhardti* (closely related to *S. obliqua* from Pakistan). Many more species common to the two regions may be found when the younger (Oligocene–Miocene) Pakistan fauna is fully documented. The Lindi fauna is related to the South African fauna by the presence of *Occultocythereis africana* (=Gen. Indet. 5, sp. 1 of Dingle, 1976), *Haughtonileberis radiata*, *H. rastapuriensis* (very similar to *H. fissilis*), and a number of other species. The Malagasy ostracod fauna is not well known, but the presence of the genus *Tanzanicythere*, so far found only in these two regions, suggests that they have close connections.

McKenzie's (1973: 479) suggestion that 'the Caribbean, Mediterranean, Indo–West Pacific and Australasian marine provinces are the spoor of Tethys' is supported by the Tanzanian ostracod fauna, which is linked to the Caribbean by the presence of *Triebelina howei* (Stephenson), and to Nicaragua by *Anterocythere* sp. B of Swain & Gilby. The presence of *Paijenborchella* (*Eopaijenborchella*) *quasimalaiensis* sp. nov. (closely related to *P. malaiensis* Kingma from Indonesia, and to *P. cymbula* Ruggieri from the Mediterranean), indicates a link, albeit rather tenuous, with all these areas. Similarly, the presence of *Quadracythere trijugis* Holden suggests a link with the Pacific. The biogeography of these species supports Keij's (1976) view that Tertiary to Recent tropical, shallow marine ostracods show a wide geographical distribution. No links, however, have been found with the West African, South American or Atlantic ostracod faunas. Palaeontologically, too, the relationships are closer with faunas of the southern hemisphere; for example for south-eastern Australia and New Zealand high temperatures

have been documented for the Upper Eocene and Oligo-Miocene (Gill 1968, Jenkins 1968 and McKenzie 1973). During this time the absence of any cold water taxa combined with the small size of ostracods, a factor normally attributed to tropical environments, suggests warm water temperatures for the Lindi area. If one accepts the suggestion by McKenzie (1973) that the presence of *Cytherelloidea* and *Uroleberis* indicates 20°–25° C, then the temperature during the Upper Eocene was at times as high as that. The strengthening of carapace closure by a snap-knob/socket mechanism in species such as *Bythoceratina? asteria*, *Trachyleberidea? cirrata*, *Crenaleya tuberis* and Genus C sp. suggests that the water may have been turbulent.

Another interesting feature of this fauna is the appearance of eye tubercles in genera which usually lack them, e.g. *Bythoceratina, Idiocythere* and *Ommatokrithe* (closely related to *Krithe*). This may indicate unusually clear water, which indeed occurs around tropical reefs.

Eames *et al.* (1962) mention the presence of laterally discontinuous reef-like conditions for only short periods during the Upper Eocene and Oligocene, and more widespread reef conditions during the Lower Miocene. The presence of *Triebelina*, *Paranesidea* and *Loxoconcha* (*Loxocorniculum*) is often associated with reef conditions. The presence of *Krithe* and *Parakrithe* is often associated with deep water; they occur in samples FCRM 1737 and 1738, but no other evidence of deep water sediments has yet been found.

As in some other areas changes in the ostracod distribution closely follow regional geological events. The Mid-Oligocene regression resulted in a great number of specimens and species, whilst the Lower Miocene transgression resulted in a very diverse fauna. This corroborates Kent's (1974) chronology of East African tectonic events (Fig. 5c, p. 183). Moreover, the rates of sedimentation calculated on valve/carapace ratios also show some agreement with Kent's (*in* Kent *et al.* 1971) estimates.

In summary, it is suggested that the Lindi Tertiary ostracod fauna may be regarded as indicative of a warm, clear-water deposit laid down in a shallow shelf area, whose depth may have been mostly less than 50 m but sometimes deepened to well over 75 m, and whose minimum temperature was not less than 10° C. During the Oligocene there was a general regression which was followed by a widespread Miocene transgression.

Three ostracod biozones corresponding roughly to well-established Planktonic Foraminifera zones occur (Fig. 10, p. 262).

FCRM SAMPLE DATA

The sample prefix FCRM refers to material collected by the BP-Shell geologist F.C.R. Martin in 1951–57 (Eames *et al.* 1962: 62); the locality and lithological information was given by him in a private report to BP-Shell in 1957. See Fig. 3, p. 181.

More than one-third of the samples were provided as washed residues; from some others only the ostracods which had been picked out and placed in the BP Research Centre, Sunbury-on-Thames, were available. Consequently most of the sample descriptions are based on the original accounts by Martin and other BP-Shell geologists. Wherever enough material was available, thin sections were made and studied and the descriptions amended where necessary.

Sample	Location	Lithology	Age
FCRM 1566	Mongo Stream, Lindi	Sandy detrital fossiliferous limestone	Lower Miocene
FCRM 1574	Shore south-west of Ras Tapuri, *c.* 6 km north of Lindi	Grey-buff silty sandstone	Mid-Oligocene
FCRM 1575	Shore south-west of Ras Tapuri, as above	Grey calcareous siltstone with quartz grains; some bivalve & echinoid remains; abundant orbitoids	Mid-Oligocene
FCRM 1576	Shore south-west of Ras Tapuri, about 18 m north of FCRM 1575	Buff-grey biomicrite with abundant orbitoids	Mid-Oligocene
FCRM 1578	Shore south-west of Ras Tapuri, as above	Hard sandy limestones and grey-buff silty sands	Mid-Oligocene
FCRM 1627	Kitunda Jetty road, near bottom of slope	Green-grey shaley clays	Mid-Oligocene
FCRM 1628	Kitunda Jetty road, *c.* 3 m above FCRM 1627	Shelly calcareous sand & orbitoidal clay with thin ribs of cemented orbitoidal rock	Mid-Oligocene
FCRM 1644 & 1645	North end of Kitunda slope, just above shore level	Grey-green clays with interbedded thin marly limestones	Upper Eocene
FCRM 1647 & 1648	Kitunda slope, from *c.* 3 m to *c.* 15 m above shore level	Grey-green silty clays with some thin-bedded marly foraminiferal limestones	Upper Eocene
FCRM 1661	Near top of old garnet mine, north Lindi	Dark grey-brown gypseous clays	Lower Miocene
FCRM 1689	Old quarry above road, east of Mchole salt works	Dark buff-grey silty clays	Upper Eocene
FCRM 1692	Old quarry below road, east of Mchole salt works	Dark grey-brown clays	Upper Eocene
FCRM 1711	Stream south-west of upper Wireless Station, Kitulo Hill	Massive rotten soft marly limestone; micrite	Palaeocene?

Sample	Location	Lithology	Age
FCRM 1737 & 1738	South Mtwero, in sisal waste gully	Bedded grey silty shaly clays with thin modular clay-stones	Lower Miocene
FCRM 1742	Mbanja River	Buff-grey silty foraminiferal clay	Lower Miocene
FCRM 1745 & 1746	Mbanja River, upstream of FCRM 1742	Fine-grained limestone	Lower Miocene
FCRM 1792	Beside Mingoya Road, about 1**g** miles from the Lindi bridge	Buff-grey, slightly gypsiferous clay	Upper Eocene
FCRM 1963	Lindi–Mingoyo road, south-west of Lindi (not covered by Fig. 3)	Soft buff-grey sands	?
FCRM 1964	Kitunda slopes	Dark grey, brown-stained shaly clay	Upper Eocene
FCRM 1981	Kikwetu factory refuse gully	Thin bedded micritic limestone with a little quartz	Lower Miocene
FCRM 1989	On west side of road bridge, 9° 49.4′S, 39° 43.8′E, south of Likonga estate	Foraminiferal lime-stone, about 95% carbonate material	Lower Miocene
FCRM 2010	Cliff on left bank of stream south-west of Mtwero Estate	Buff-grey highly fossiliferous carbon-ate muddy sands	Lower Miocene
FCRM 2014 –2016	Location given as 'various points up-stream of FCRM 2010'	Buff-grey silty nodular shaly clays	Lower Miocene
FCRM 2033	East shore of Lindi Creek	Brown silty clay with foraminifera and shell fragments	Upper Eocene
FCRM 2034	East shore of Lindi Creek, about 10 m south of FCRM 2033	Grey buff-stained clay	Upper Eocene
FCRM 2045 & 2046	Lindi–Mingoyo road, above 2**g** km south of Lindi	Fragmented buff-grey clay (reworked?)	Upper Eocene

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