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With 22 plates and 17 text-figures

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ABSTRACT. The Santonian Chalk at One Tree Hill, Gingin, Western Australia yields an ostracod fauna of forty-nine species. Of these, thirty species and one subspecies are new, two were established by Chapman (1917), nine by Bate (1972), one by Neale (1974), and six are left under open nomenclature. The twenty species and varieties of Chapman's original work are reassessed and are considered to belong to seventeen species, one of which is left under open nomenclature and none of which can be assigned to European taxa.

The new families Collisarborisidae and Pennyellidae were confined to the South Africa–Australia–Western Pacific area during the Upper Cretaceous. After this the Collisarborisidae appear to have died out, but the Pennyellidae continued through the Tertiary to Recent times becoming cosmopolitan and deep water from the Oligocene onwards.

Six new genera—*Collisarboris*, *Cretaceratina*, *Ginginella*, *Hemingwayella*, *Rayneria*, and *Verseya*—are described, and the fauna shows a high degree of endemism. It is suggested that the combination of cosmopolitanism and endemism seen in the fauna is a reflection of the ocean currents prevailing at that time. Orthographic projection equatorial and polar maps showing tentative reconstructions of the land areas and oceanic circulation in Upper Cretaceous times are given.

All the indications point to the environment being a warm, euhaline, shallow sea at this time, the depth being of the order of 100 m and the minimum temperature about 10 °C.

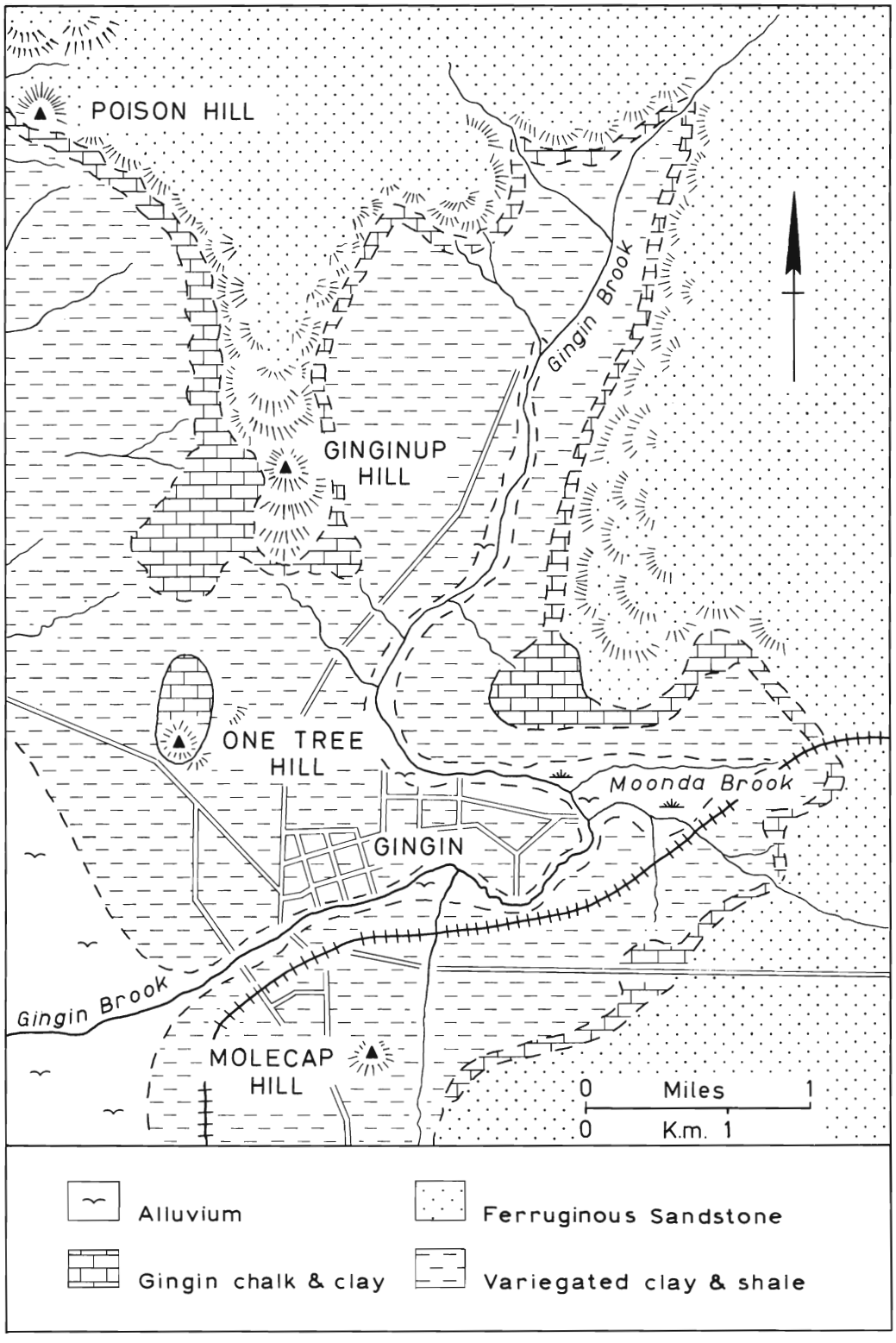
INTRODUCTION

GINGIN, Western Australia, lies in the northern part of the Perth Basin about 45 miles (73 km) north of Perth itself. Here up to 70 ft (21 m) of fine-grained white chalk crops out in a series of exposures at One Tree Hill, McIntyre's Gully, and elsewhere. The chalk overlies a glauconitic sandstone, the Molecap Greensand, with transitional boundary and in turn is overlain by the Poison Hill Greensand with sharp contact. These Cretaceous outcrops continue for some 75 miles (121 km) to the north, beyond which there is a gap of 160 miles (258 km) before Cretaceous rocks crop out again in the Carnarvon Basin. Southwards the rocks dip into the Perth Depression and are known at depth under that city.

Work on the macrofauna, especially on the crinoids by Withers (1924, 1926), suggested a Santonian age for the Gingin Chalk. David (1950) gave the age as Lower Santonian based on a variety of evidence and suggested that the Molecap Greensand might be Coniacian and the Poison Hill Greensand Upper Santonian. Teichert (1947) had suggested that the latter was Campanian and Belford (1959) thought that possibly most of it was of that age but that the higher beds could extend up into the Maastrichtian or beyond. The Poison Hill Greensand is unfossiliferous and of no importance in this work except inasmuch as it defines the top of the Gingin Chalk.

Feldtmann (1951) working on the pectens accepted a Santonian age for the Gingin Chalk. More recently Belford (1959, 1960) described the stratigraphy of Western Australia and the Foraminifera from the Toolonga calcilutite and Gingin Chalk regarding them as Santonian, a view also adopted by McWhae *et al.* (1958). Edgell (1962) working on *Globotruncana* elsewhere in Australia agreed that some of Belford's evidence favoured a Santonian age. Thus it is generally accepted that the Gingin Chalk, and in consequence the fauna described here, is of Santonian age. In 1917 Chapman, whose map of the area is given here (text-fig. 1), published his now classic account of the microfauna of the Gingin Chalk listing one hundred and thirty-four species and varieties of Foraminifera and twenty species and varieties of ostracods. Except for two new species and one new variety, the latter were all referred to well-known European forms. In 1965 the author was able to examine and photograph Chapman's types at the Bureau of Mineral Resources in Canberra where it was obvious that the species differed from the European ones to which Chapman had assigned them. Collecting from his type locality of One Tree Hill, Gingin, confirmed this and also showed that the fauna was far richer than hitherto suspected. The aim of the present work is to refigure and reassess Chapman's material in conjunction with a detailed study of the Gingin Chalk ostracod fauna.

Unfortunately the photography carried out in Canberra by the author was very unsatisfactory and the work had to be shelved. In 1969 a change in policy of the Canberra Bureau of Mineral Resources enabled Chapman's types to be sent to the British Museum (Natural History) in connection with an investigation of the sub-surface ostracods from the Carnarvon Basin then being carried out by Dr. R. H. Bate. Some of Chapman's species were found in that material which ranged from Coniacian to Campanian and included Santonian deposits. Dr. Bate kindly supplied scanning



TEXT-FIG. 1. Geological Map of the Gingin Area (Chapman 1917 redrawn).

electron microscope (S.E.M.) photographs of Chapman's types which form Plates 1 and 2 of the present work. Many of Bate's species from the Santonian of the Carnarvon Basin were found at Gingin confirming correlation of the Gingin Chalk with at least part of the Toolonga calcilutite of the area to the north. The Gingin fauna contains a number of new genera and more than double the previous number of known Australian Santonian ostracod species. The fauna is discussed after the systematic examination which follows directly.

Repositories. Chapman's types, prefixed by the letters CPC, are in the Collections of the Bureau of Mineral Resources, Canberra. Specimens prefixed by Io are in the Collections of the British Museum (Natural History). The remaining specimens, prefixed by HU, are in the Collections of the University of Hull.

SYSTEMATIC DESCRIPTIONS

Order PODOCOPIDA Müller, 1894
Suborder PLATYCOPINA Sars, 1866
Family CYTHERELLIDAE Sars, 1866

The Cytherellidae are very important elements in the Gingin Chalk fauna and usually make up between 30 and 40% of the specimens recovered. Of these, *Cytherella*, the commonest single genus at Gingin, accounts for more than two-thirds.

Genus CYTHERELLA Jones, 1849
Cytherella ludbrookae sp. nov.

Plate 1, figs. 1, 3; Plate 3, figs. 4–7

1917 *Cytherella muensteri*, Roemer sp.; Chapman, p. 57, pl. XIV, fig. 18.
1917 *Cytherella ovata*, Roemer sp.; Chapman, p. 57, pl. XIV, fig. 19.

Derivation of name. In honour of Dr. N. Ludbrook for her important contributions to Australian micropalaeontology.

Diagnosis. Right valve with posterior margin showing uneven curvature in side view, the gently convex postero-dorsal margin meeting the strongly convex postero-ventral margin in a rounded point at about mid-height. In the adult female the dorsal margin consists of gently convex antero-dorsal and postero-dorsal sections which meet in a rounded angle to form a 'peak' a little behind mid-height. In the left valve the postero-ventral margin shows the characteristic swing-away below mid-height.

Holotype. A female carapace, HU.65.C.30 from the Gingin Chalk.

Paratypes. Sixty valves and carapaces mounted as HU.65.C.4.1–60.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female carapace	HU.65.C.30	Pl. 3, fig. 6	0·987	0·603	0·428
Paratype, male right valve	HU.65.C.4.3	Pl. 3, fig. 4	0·870	0·519	0·195
Paratype, male left valve	HU.65.C.4.6	Pl. 3, fig. 7	0·896	0·480	0·169
Female right valve	Specimen lost	Pl. 3, fig. 5			
Female left valve	CPC 7148 (Chapman, pl. XIV, fig. 18)	Pl. 1, fig. 1	1·03	0·60	0·25
Juvenile right valve	CPC 7149 (Chapman, pl. XIV, fig. 19)	Pl. 1, fig. 3	0·93	0·60	0·24

Description. Right valve smooth, elongate-oval, tapering posteriorly, overlapping left valve with the greatest height a little behind the mid-length where the dorsal margin forms a 'peak' which is more pronounced in the female. Anterior margin evenly rounded, ventral margin very gently convex to almost straight. Posterior margin unevenly rounded, the very convex postero-ventral margin and much more gently convex postero-dorsal margin meeting in a rounded point at about mid-height where lies the greatest height. In dorsal view the valve reaches its greatest inflation posterior of the mid-length and curves in sharply posteriorly (Pl. 3, figs. 6*b*, 7*b*). Left valve follows the outline of the right valve rather closely except for the lesser height because of the marked dorsal overlap of the right valve. The peak is present although more subdued than in the right valve and the posterior infracurvature is less marked than in the right valve. The ventral margin is gently convex. The male left valve is lower with less prominent dorsal peak.

Remarks. Chapman's specimen referred to *C. muensteri* is a typical adult female left valve whilst the right valve which he assigned to *C. ovata* is an immature right valve of the present species. Roemer's *C. ovata*, the genotype of *Cytherella*, came from the Senonian Lower Kreidemergel near Lemförde, Germany, and unfortunately are no longer available for study. Jones (1849) gave good figures of material from the English Chalk which he considered to belong to *C. ovata* and this agrees well with subsequent interpretations by Bonnema (1940) on specimens from the Schreibkreide of north-east Holland and by Herrig (1966) from the Lower Maastrichtian Weissen Schreibkreide of Rügen. *C. ludbrookae* is easily differentiated in all cases by its distinctive, markedly assymetrical posterior outline in side view. Roemer's *C. münsteri* came from the Lutetian of the Paris Basin and the excellent figure by Keij (1957) of a specimen from the Ledian of Forest, Belgium, shows that there is no similarity between this species and *C. ludbrookae*. Resemblance to other recorded Cretaceous species is slight.

Cytherella jonesi sp. nov.

Plate 3, figs. 1–3

1972 *Cytherella* sp., Type B; Bate, p. 8, pl. 3, fig. 5.

Derivation of name. In honour of Mr. P. J. Jones who kindly arranged for me to examine Chapman's type material during a visit to Canberra in 1965.

Diagnosis. A species of *Cytherella* with two depressions posteriorly on the inside of female valves and with the larger right valve accommodating the left valve in a marginal groove, i.e. overlap relationship normal for the genus.

Holotype. A female carapace, HU.65.C.7.

Paratypes. Thirty valves and carapaces mounted as HU.65.C.3.1–30.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female carapace	HU.65.C.7	Pl. 3, fig. 2	0·824	0·506	0·351
Paratype, male right valve	HU.65.C.3.1	Pl. 3, fig. 1	0·863	0·480	0·159
Paratype, male left valve	HU.65.C.3.2	Pl. 3, fig. 3	0·847	0·470	0·195

Description. Female right valve oval in side view with evenly and symmetrically rounded anterior and posterior margins. Ventral margin almost straight, dorsal margin evenly convex with greatest height at about the mid-point. Greatest width about one-quarter the length from the posterior end. The male differs in having a markedly concave ventral margin in side view and in dorsal view the greatest width lies at about mid-length. Female left valves are evenly rounded anteriorly and posteriorly, but the dorsal margin shows a 'peak' at about two-thirds the length and the ventral margin is straight or slightly concave. The male is more elongate and has a slightly concave ventral margin and sub-parallel dorsal and ventral margins anteriorly. The female has two depressions disposed one above the other on the inside of the posterior part of the shell.

Remarks. The posterior depressions or brood chambers have no surface expression on the outside of the shell, but when the valves are filled with the white chalk matrix they are apparent from the outside as white patches. The brood chambers form the most distinctive feature of this species and it is only likely to be confused with Bate's *C. atypica* from the higher Campanian from which it is easily differentiated by the normal overlap relationships of the valves.

Genus CYTHERELLOIDEA Alexander, 1929

Cytherelloidea colemani sp. nov.

Plate 4, figs. 1–3

Derivation of name. In honour of Dr. P. J. Coleman of the University of Western Australia for his researches on fossil foraminifera and for his kindness and hospitality.

Diagnosis. A species of *Cytherelloidea* with prominent dorsal and ventral nodes posteriorly, a ventral rib which is gently concave upwards and declines in height anteriorly, and an antero-dorsal swelling.

Holotype. A left valve, HU.65.C.20 from the Gingin Chalk.

Paratypes. Four left valves (HU.65.C.12, HU.65.C.21.1–3), a right valve (HU.65.C.16), and three juvenile right valves (HU.65.C.11, HU.65.C.22.1–2).

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, left valve	HU.65.C.20	Pl. 4, fig. 1	0·617	0·351	0·133
Paratype, juvenile right valve	HU.65.C.11	Pl. 4, fig. 2	0·545	0·338	0·130
Paratype, right valve	HU.65.C.16	Pl. 4, fig. 3	0·623	0·377	0·172

Description. Right valve in side view rounded rectangular with gently convex dorsal margin and gently concave ventral margin. Evenly rounded anteriorly, asymmetrically rounded posteriorly with the postero-ventral margin falling away more rapidly than the postero-dorsal margin. Greatest length at about mid-height. A well-developed ridge with fossa inside follows the ventral, anterior, and dorsal margins. Posteriorly this is replaced by prominent postero-ventral and postero-dorsal nodes. The postero-ventral node leads anteriorly into the swollen ventral rib via a slight constriction or 'neck'. The ventral rib is gently concave upwards and decreases in height anteriorly. Dorsally a hollow separates it from an antero-dorsal swelling and the flatter surface

of the muscle-scar area. Posteriorly this hollow forms a col separating the postero-ventral node from the prominent postero-dorsal node. The latter has a rather flat, lozenge-shaped top, one corner of which passes into a short swollen rib which runs towards the muscle-scar area but stops before reaching it. Dorsal of this rib the valve surface falls towards the ill-defined swollen rib which runs postero-dorsally from the antero-dorsal swelling. The muscle scars lie in a gently depressed, flat-bottomed hollow and are well defined, forming an oval-shaped area with a dorsal scar and five pairs of scars below. In dorsal view the valve is almost parallel-sided in the posterior half where the greatest width occurs. Anteriorly it tapers but clearly shows the rib which runs postero-dorsally from the anterior swelling with the hollow on either side. Surface finely pitted. Ornamentation of the left valve is similar to that of the right. In juvenile forms (Pl. 4, fig. 2) the asymmetry of the posterior outline in lateral view is accentuated and the posterior nodes are less well developed and lie relatively far removed from the posterior margin.

Remarks. The basic pattern of ornamentation is reminiscent of the Tethyan *C. mandelstami* Neale (1966) from the Berriasian of the Crimea or *C. btaterensis* Bischoff (1964) from the Aptian–Albian of the Lebanon. Neither of these species develop the anterior swelling. However, the general pattern of land and sea during Cretaceous times (Neale 1973*b*) supposes an open seaway between these areas and Western Australia. This suggests that the swelling may be a later austral development from one of these groups. Some high Cretaceous American species also show similarities but lack the anterior swelling. *C. greenensis* Brown figured by Benson and Tatro (1964) from the Campanian Marlbrook Marl of Arkansas, differs in the finer, sharper, more slender ribs and in the upper rib continuing under the muscle pit. *C. inflata* Brown figured by Crane (1965) from the Maastrichtian Ripley Formation of Alabama shows a general similarity of ornamentation but the dorsal margin is rounded in side view lacking the rather square postero-dorsal corner of the present species, and the ventral and antero-dorsal ribs are continuous. In *C.? addisonensis* Hazel (1968) from the Danian Brightseat Formation of Maryland with its more slender ribbing, the posterior upper rib continues under the muscle-scar pit as in *C. greenensis*. Other species are not close.

Cytherelloidea lunata sp. nov.

Plate 4, figs. 4–6

Derivation of name. Lunatus, Latin—crescentic. A reference to the crescent-shaped marginal rib.

Diagnosis. A species of *Cytherelloidea* with a strong, inflated marginal rib which is absent in the median part of the dorsal margin and thus has a crescentic appearance. A well-developed median rib which is concave upwards is present.

Holotype. A left valve, HU.65.C.15 from the Gingin Chalk.

Paratypes. A right valve, HU.65.C.17 and thirteen valves, HU.65.C.18.1–13.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, left valve	HU.65.C.15	Pl. 4, fig. 5	0·668	0·351	0·188
Paratype, right valve	HU.65.C.18.6	Pl. 4, fig. 4	0·630	0·383	0·130
Paratype, right valve	HU.65.C.18.9	Pl. 4, fig. 6	0·598	0·377	0·143

Description. Valves robust. Left valve in side view rounded rectangular with parallel dorsal and ventral margins and symmetrically rounded extremities. A swollen rib follows the margins except in the middle half of the valve dorsally. The swollen mid-rib, which is gently concave upwards, occupies the middle of the valve and is separated from the marginal rib by a deep fossa. Dorsal of this mid-rib is a deep muscle-scar pit which helps to separate the two dorsal ends of the marginal rib.

In dorsal view the valve is widest posteriorly, where the posterior part of the marginal rib is prominent. Anteriorly, the marginal rib inside the flange is also prominent. The mid-dorsal gap forming a straight low section between the two ends of the marginal rib is striking and the convex mid-rib which reaches its greatest width in the posterior third of its length is well seen and forms the outline for some distance in the middle part of the valve.

The larger right valve has a marginal groove, well developed, except anteriorly, for the reception of the left valve. It has a similar pattern of rib ornamentation to the left valve but differs a little in shape. The dorsal and ventral margins taper slightly posteriorly and the ventral margin is gently concave. Like the left valve the anterior margin is symmetrically rounded but the posterior margin is asymmetrical and greatest length occurs above mid-height at about one-third the height from the dorsal margin. Dorsal view a mirror image of the left valve.

Remarks. C. lunata is unlikely to be confused with any other species. From the associated *C. westaustraliensis* Bate it is easily differentiated by its more rectangular shape and the crescentic marginal rib opening upwards, the analagous rib in Bate's species forming a spiral and being present above the muscle-scar pit.

Cytherelloidea westaustraliensis Bate, 1972

Plate 1, figs. 2, 4, 5; Plate 4, fig. 7

1917 *Cytherella williamsoniana* Jones; Chapman, p. 57, pl. XIV, fig. 20.
1917 *Cytherella williamsoniana* var. *stricta* Jones and Hinde; Chapman, p. 58, pl. XIV, fig. 21.
1917 *Cytherella chapmani* Jones and Hinde; Chapman, p. 58, pl. XIV, fig. 22.
1972 *Cytherelloidea westaustraliensis* Bate, p. 10, pl. 1, figs. 1–6; pl. 2, fig. 3; text-fig. 5A–E.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Female right valve	CPC 7150 (Chapman, pl. XIV, fig. 20)	Pl. 1, fig. 2	0·84	0·53	0·23
Juvenile right valve	CPC 7151 (Chapman, pl. XIV, fig. 21)	Pl. 1, fig. 4	0·75	0·50	0·20
Juvenile right valve	CPC 7152 (Chapman, pl. XIV, fig. 22)	Pl. 1, fig. 5	0·75	0·48	0·18
Male left valve	HU.65.C.31	Pl. 4, fig. 7	0·832	0·455	0·221

Remarks. C. westaustraliensis has been fully described and figured by Bate (1972) and there is nothing to add to his description. It is the commonest of the three species of *Cytherelloidea* at Gingin and all three specimens which Chapman assigned to different species belong here. The typical ornamentation suggests that it is related to the spirally ornamented *C. mairae* Ramsay (1968) from the late Cretaceous of Tanzania.

Suborder PODOCOPINA Sars, 1866
Superfamily BAIRDIACEA Sars, 1888

Bairdiacea form a small but important element in the Gingin Chalk fauna normally accounting for 3 to 4% of the specimens.

Family BAIRDIIDAE Sars, 1888
Genus BAIRDIA M'Coy, 1844
Bairdia cf. *B. austracretacea* Bate, 1972

Plate 5, fig. 4

cf. *Bairdia austracretacea* Bate, 1972, p. 16, pl. 4, figs. 1, 2, 5, 8, 11, 12; pl. 5, fig. 6; text-figs. 6, 7A–I, 8.

Material. A single right valve, HU.65.C.26.

Dimensions.

Length	Height	Width
mm	mm	mm
0·597	0·364	0·156

Description. Bairdioid in side view with slightly convex mid-section to the dorsal margin and gently concave antero-dorsal and postero-dorsal margins. The former meets the antero-ventral margin in a rounded point, the latter forms a blunt rounded termination with the posterior part of the ventral margin. The central part of the latter is slightly concave. In dorsal view the greatest width is a little in front of mid-length. Outline shows graceful curvature which becomes concave at the anterior and posterior extremities.

Remarks. This single right valve is the only specimen recovered from the Gingin Chalk which can be referred to *Bairdia*. The small size (1 = 0·597 mm) compared with normal adult *Bairdia* (usually 1 = 1 mm) suggests an immature form. It differs from *B. austracretacea*, which is only recorded from the Campanian, in the posterior termination which is less upturned than is usual in *Bairdia*, although to some extent this appearance may be due to the poor preservation of the postero-ventral margin. Otherwise it agrees well with Bate's Paratypes Io 4425 and 4426 in general shape. Since Bate's species shows considerable variability and there is otherwise generally good correspondence in outline it is compared with that species and adult forms may well confirm its identity. The general shape is also reminiscent of *Bairdia* sp. *C.*, van den Bold (1964) from the Turonian of Abu Rawash, Egypt. In view of the immaturity and limited material further detailed comparisons are of little value.

Genus BYTHOCYPRIS Brady, 1880
Bythocypris chapmani sp. nov.

Plate 1, fig. 10; Plate 5, figs. 3, 5, 6, 7

1917 *Bairdia arquata* Munster; Chapman, p. 52, pl. XIII, fig. 3.
1972 ?*Bythocypris* sp., Type A; Bate, p. 18, text-fig. 9.
non 1830 *Cythere arquata* Münster, p. 63.

Derivation of name. In honour of Dr. F. Chapman who described the first ostracods from the Gingin Chalk.

Diagnosis. Right valve in side view with gently convex median section and concave

antero-dorsal section of the dorsal margin. The concave ventral margin gives it a somewhat bairdioid appearance. Both valves end in a blunt point coinciding with the greatest length at about one-sixth the height above the ventral margin.

Holotype. A carapace (HU.65.C.14.3) from the Gingin Chalk.

Paratypes. Two valves (HU.65.C.14.1, 2) and twenty valves from the same locality (HU.65.C.19.1–20).

Other material. A carapace from the Gingin Chalk in the Bureau of Mineral Resources Collection, Canberra (CPC 7133) figured by Chapman as *Bairdia arquata.*

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, carapace	HU.65.C.14.3	Pl. 5, fig. 5	0·805	0·409	0·364
Paratype, right valve	HU.65.C.14.1	Pl. 5, fig. 6	0·792	0·415	0·169
Paratype, left valve	HU.65.C.14.2	Pl. 5, fig. 7	0·798	0·428	0·234
carapace	Specimen lost	Pl. 5, fig. 3			
carapace	CPC 7133 (Chapman, pl. XIII, fig. 3)	Pl. 1, fig. 10	0·83	0·44	0·38

Description. Smaller right valve in side view generally bairdioid in shape but lacking the upturned posterior portion and concave postero-dorsal margin of *Bairdia* and allied genera. The middle third of the dorsal margin slopes gently posteriorly and is slightly convex. The anterior part of the dorsal margin is slightly concave and falls steeply to a little below mid-height where it passes into the evenly rounded anterior margin. The posterior part of the dorsal margin is straight to gently convex and falls steeply to meet the ventral margin in a blunt point at about one-sixth the height of the valve. Ventral margin biconvex with a median concavity. Greatest length lies near the ventral margin at about one-sixth the height of the valve, greatest height at about one-third the length from the anterior end.

The larger left valve differs in side view in its more evenly rounded appearance. It lacks the concave antero-dorsal margin of the right valve, this margin being straight or gently convex, whilst the ventral margin is straight or almost straight with inconspicuous concavity. Carapace elliptical in dorsal view with the greatest width about the middle, the left valve overlapping the right at both ends. Hinge a crenulate ridge in the right valve which fits into a locellate groove in the left. The left valve overreaches the right valve conspicuously ventrally, but less so dorsally. Muscle-scar pattern a compact central group of adductors of which there appear to be four principal ones arranged roughly in the form of a cross (Pl. 5, fig. 6*b*). Some material suggests that two or three other scars may be associated with this central group and one specimen shows what appear to be two mandibular scars.

Remarks. The general characters of shape and muscle-scar pattern place this species in *Bythocypris* and it agrees well in general features with the genus as interpreted by Maddocks (1969). Chapman (1917) figured this species as *Bairdia arquata* Münster. Münster does not specify a type locality but as Chapman suggests, the name implies that the Castell' arquato section near Piacenza in northern Italy should be regarded as the type locality. Münster's original figure is small and not particularly informative but tapers much more strongly in side view than the present species. Keij (1957, pl. II, fig. 1) gives a good figure of Bosquet's specimen of Münster's species from the

Miocene of the Aquitaine Basin and this shows marked differences in shape, lacking the rather prominent cardinal angle of the present species and being more rounded posteriorly. Chapman's figure and the figure given here of Chapman's specimen (Pl. 1, fig. 10) are somewhat dorso-lateral, rather than true lateral views, but a wide range of other material available suggests that Bate's *Bythocypris*? sp. Type A from the Santonian Toolonga Calcilutite is indeed this species. Bate's Type B differs in the shorter and strongly convex dorsal margin as well as in its larger size. *B. chapmani* differs from *B. windhami* Butler and Jones (1957) from the Saratoga (L. Maastrichtian?) Chalk of Louisiana and from *B. windhami* Butler and Jones 1957? Gründel (1968) in its more pointed posterior end, the concave antero-dorsal margin, and the straighter dorsal mid-section of the outline.

Bythocypris howchiniana Chapman, 1917

Plate 1, fig. 12; Plate 5, fig. 2

1917 *Bythocypris howchiniana* sp. nov.; Chapman, p. 53, pl. XIII, fig. 2*a–c*.

Holotype. Chapman found only two specimens of this species at Gingin and his figured specimen CPC 7132 (here Pl. 1, fig. 12) must be regarded as the holotype.

Other material. Various valves and carapaces including ten mounted as HU.65.C.28.1–10 and eight as HU.65.C.5.20.1–8.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, carapace	CPC 7132 (Chapman, pl. XIII, fig. 2)	Pl. 1, fig. 12	0·69	0·36	0·33
Right valve	HU.65.C.27	Pl. 5, fig. 2	0·523	0·247	0·149

Description. A bythocyprid with marked overreach of the right valve by the left valve, especially ventrally, producing the characteristic difference in outline between the two valves as seen in lateral view. The larger left valve is elliptical with convex dorsal margin which is not quite a smooth curve, enabling a straighter middle portion to be distinguished from the antero-dorsal and postero-dorsal sections. In the right valve the convexity of the dorsal margin is not so marked but the straighter median portion is accentuated and the ventral margin is gently concave. The greatest height lies at approximately one-third the length from the anterior end, and this valve tapers much more quickly anteriorly than posteriorly where it is bluntly rounded, a feature which is more noticeable in juvenile specimens. In side view both ends show infracurvature, this being more marked posteriorly than anteriorly. The greatest length lies near the ventral margin. In the left valve the greatest height is almost at the mid-length. The muscle-scar pattern shows the characteristic clustering of four large principal scars which in the juveniles (Pl. 5, fig. 2) lie more posteriorly than in the adult.

Remarks. Chapman (1917) drew attention to the differences between this species and *B. brownei* Jones and Hinde (1890) in which the carapace has more evenly rounded ends. It is easily differentiated from *B. septentrionalis* Bonnema (1940) from the Schreibkreide and Mergel of Holland in dorsal view, the present species having the

greatest width at two-thirds the length and not being pointed posteriorly. Its wider, more rounded posterior part in dorsal view compared to the more tapering anterior part similarly differentiates it from the Maastrichtian *B. limburgensis* Veen (1934) and *B. veeni* Howe and Laurencich (1958). From the latter it also differs in the more marked ventral overreach of the right valve by the left valve. Other species of *Bythocypris* show little resemblance to *B. howchiniana*.

Family MACROCYPRIDIDAE Müller, 1912
Genus MACROCYPRIS Brady, 1867
Macrocypris australiana sp. nov.

Plate 1, fig. 11

1917 *Macrocypris simplex*, var. *africana* var. nov. Chapman, p. 53, pl. XIII, fig. 4.

Derivation of name. From its type occurrence in Australia.

Diagnosis. A species of *Macrocypris* reaching its greatest height at about the mid-point, with flexuous ventral margin and blunt posterior termination in lateral view.

Holotype. Chapman's specimen, a right valve from the Gingin Chalk in the Canberra Bureau of Mineral Resources Collection, no. CPC 7134.

Other material. A left valve in the Hull University Collection, HU.65.C.6.60.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Holotype, right valve	CPC 7134 (Chapman, pl. XIII, fig. 4)	Pl. 1, fig. 11	1·11	0·48	0·27

Discussion. This large species is easily distinguished on shape but on the material available it has not been possible to ascertain the internal characteristics which would place the generic assignment beyond doubt. Consequently a full description has not been attempted here and reference should be made to the figure.

Chapman (1917, p. 53) correctly observed that this species differed from *M. simplex*, which he had described from the Cambridge Greensand, in the more arched dorsal region and the flexuous ventral margin. He noted that it was found among the Pondoland Cretaceous ostracods where he described it as an aberrant form of *M. simplex* (Chapman 1904). Regarding the Pondoland and Australian specimens as identical he named them var. *africana* with obviously the former in mind. He did not designate a type although one must assume that it was the supposedly identical Gingin specimen and the slide of this in Canberra does indeed bear a red spot. Recently Dingle (1969*b*) has described Upper Senonian ostracods from Pondoland and states that his *Paracypris*? *umzambaensis* Dingle (1969*b*) is almost certainly that recorded by Chapman (1904) as *M. simplex*. *P.*? *umzambaensis* shows obvious differences in size (length 0·76–0·8 mm, cf. *M. australiana* left valve 1·065 mm) and a number of other details, notably the very acute posterior termination in lateral view. Dingle did not find anything resembling the Australian species in Pondoland, nor has it been recorded elsewhere in Africa. In spite of limited material it seems advisable to accord the distinctive Australian species specific rank and in so doing abandon Chapman's varietal name, thus avoiding a potential source of confusion.

Superfamily CYPRIDACEA Baird, 1845

Because of their fragile valves coupled with the lithology of the Gingin Chalk, Cypridacea are rare and fragmentary.

Genus PARACYPRIS Sars, 1866
Paracypris sp. nov.

Plate 1, fig. 9

1917 *Paracypris siliqua*, Jones and Hinde; Chapman, p. 52, pl. XIII, fig. 1.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Carapace	CPC 7131 (Chapman, pl. XIII, fig. 1)	Pl. 1, fig. 9	1·20	0·55	0·46

Discussion. As pointed out by Neale (1961), Chapman's species is not that of Jones and Hinde from which it differs in the much more tapering anterior part in lateral view and in the much steeper angle of the postero-dorsal margin. The figure given here (Pl. 1, fig. 9) repeats Chapman's view which is a little dorsal of the true lateral view and in consequence the overlap of the right valve by the left valve is accentuated. Only one valve of *Paracypris* was found in the present work (a left valve HU.65.C.6.59) and is thought to belong here. There is some resemblance to the *Paracypris* sp. figured by Bertels (1968, pl. 1, fig. 6) from the Huantrai-co Formation at the top of the Cretaceous in Argentina, but in true lateral view the ventral margin of the Chapman specimen is not noticeably concave and this, together with the narrower anterior part, effectively separates it from the South American species. *P.*? *umzambaensis* Dingle 1969*b* from the Upper Cretaceous (probably Upper Campanian/Lower Maastrichtian) of Pondoland appears closest to the present species but comparison of lateral views shows that the Australian form is higher in proportion to the length and has a more marked break of slope between the postero-dorsal and median section of the dorsal margin. Similarities to other species are not close and when more material is available the Australian form will need a name.

Genus PONTOCYPRELLA Ljubimova, 1955
Pontocyprella? sp.

Plate 5, fig. 1

A single right valve is here tentatively referred to *Pontocyprella*. In shape it agrees well with the usual interpretation of the genus especially anteriorly in lateral view and dorsally. The hinge is not the one typically recorded for the genus, consisting of a simple groove. Even so it is probable that the left valve is the larger and overlaps the right valve dorsally. Unfortunately no other valves were available for study and the figured specimen fragmented during removal from the S.E.M. stub for further examination.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Right valve	HU.65.C.29	Pl. 5, fig. 1	0·890	0·403	0·150

Superfamily CYTHERACEA Baird, 1850

Cytheracea form the majority of ostracods in the Gingin Chalk. At Gingin they make up between 56 and 67% of the fauna.

Family CYTHERIDAE Baird, 1850
Genus SAIDA Hornibrook, 1952
Saida rhomboidea sp. nov.

Plate 9, fig. 6; Plate 14, fig. 4

Derivation of name. A reference to its shape in lateral view.

Diagnosis. A species of *Saida* with rhomboidal lateral outline and alar expansions in which the margins of the alae lie approximately parallel to the ventral and postero-ventral margins.

Holotype. A right valve, HU.63.C.1.

Paratypes. A left valve, HU.63.C.3 and eight adult and two juvenile valves, HU.63.C.2.1–10.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, right valve	HU.63.C.1	Pl. 14, fig. 4	0·299	0·185	0·117
Paratype, left valve	HU.63.C.3	Pl. 9, fig. 6	0·312	0·185	0·107

Description. Typical *Saida*, the lateral outline showing parallel dorsal and ventral margins, parallel antero-dorsal and postero-ventral margins and symmetrical rounded postero-dorsal and antero-ventral margins. The alar expansions swing back more than in described species of the genus so that one margin is approximately parallel to the ventral margin and the other to the postero-ventral margin. The two margins of the ala meet at an angle of about 110°. Surface pitted, the density approximating to that seen in *S. exilis* Gründel 1968. The rounded fossae on the main body of the valve show the presence of sunken sieve plates and are much larger than the marginal fossae, except for the antero-ventral ones which show the development of second-order reticulation. Posteriorly, a little in front of the posterior margin and just below mid-height, is a cone-like tubercle which is a constant feature of adult specimens. Antero-ventrally four or five short ribs join the anterior marginal rib to the outer margin with a tendency to project and form small randzähnchen. The same occurs postero-ventrally. For further details of ornamentation see Plate 14, fig. 4.

Remarks. This small but distinctive genus was based on *S. truncula*, a Recent species from New Zealand where Hornibrook (1952) noted that the genus occurred as early as the Middle Eocene. It has been found rarely in the Cretaceous of western Europe where Herrig (1968) listed six species (four of them new) ranging from Albian to Danian. This author drew attention to the progressive changes in two lineages and suggested that the species of the genus may be valuable stratigraphically. The present species is unlikely to be confused with any of the described species, being differentiated by the 'set' of the alar expansion, the one margin of which lies parallel to the ventral margin of the valve. This first species to be described from the Australian Cretaceous occurs relatively rarely in the Gingin Chalk where it forms less than 1% of the fauna.

Family BYTHOCYTHERIDAE Sars, 1926
Genus CRETACERATINA gen. nov.

Type species. Cretaceratina trispinosa sp. nov.

Other species. Cytheropteron cuspidatum var. *tricuspidata* Jones and Hinde, 1890. Chalk, England. *Monoceratina bicuspidata* Grundel, 1964*b*. Middle–Upper Albian, Germany.

Derivation of name. Creta, Latin—chalk + *ceratina*.

Diagnosis. A genus of Bythocytheridae with spinose, elongate-rectangular valves with caudal process. Simple hinge of crenulate ridge with slight terminal expansions in the left valve and complementary structure in the right valve. Main spination consists of a well-developed postero-ventral spine, lesser-developed antero-ventral spine, and least-developed median ventral spine.

Discussion. This genus is allied to both *Monoceratina* Roth 1928 and *Bythoceratina* Hornibrook 1952. It differs from both in the marked development of an antero-ventral spine associated with a deep cavity on the inside of the shell, and in the hinge structure which lacks the terminal right valve teeth of *Bythoceratina*, and the posterior right valve ridge of *Monoceratina*.

The Lower Maastrichtian *Monoceratina*? *tricuspidata* (Jones & Hinde) of Herrig (1966, p. 916) certainly belongs here, as does the form assigned to this species by Keij (1957, pl. XIV, fig. 13) from the Lutetian of Belgium. The forms from the Lower Maastrichtian of Rügen described by Herrig (1967*a*) as *Monoceratina* (s. gen. n.? 1) are also closely related but develop small anterior and posterior teeth in the right valve.

Cretaceratina trispinosa gen. et sp. nov.

Plate 9, figs. 1, 2

Derivation of name. Trispinosa, Latin—three spines in reference to the principal spination of the valves.

Diagnosis. A species of *Cretaceratina* with very elongate valves which carry well-developed marginal spination anteriorly and postero-ventrally, a large, narrow postero-ventral spine, well-developed conical spine antero-ventrally with deep complementary cavity internally, and a medium spine between the latter two.

Holotype. A right valve, HU.63.C.4.

Paratypes. Nine specimens, HU.63.C.5.1–9.

Other material. Various valves of which three left valves are mounted as HU.65.C.5.25 and one right valve as HU.65.C.6.42.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Right valve	Specimen lost	Pl. 9, fig. 1	0·682	0·262	0·318
Left valve	Specimen lost	Pl. 9, fig. 2	0·627	0·264	0·228

Description. Lateral outline rounded oblong with dorsal, horizontally directed caudal process. Valves very long in proportion to their height. Surface of valves with three major spines, all laterally directed and lying in the ventral part of the valve.

The posterior one is long, narrow, and directed slightly posteriorly in dorsal view, the anterior one is stumpy and conical and directed slightly anteriorly, the median one is the smallest of the three and is at right angles to the plane of the valves. Marginal spines well-developed dorsally, anteriorly, and postero-ventrally. Well-developed antero-dorsal tubercle which is not connected with any complementary depression on the inside of the valve and appears to have no ocular function. Surface reticulate with the margins of the polygonal pits defined by lines of fine spines or pustules (Pl. 9, fig. 1*f*). No median sulcus apparent on the external surface. Ventral surface with four longitudinal ridges. Internal surface with deep depression corresponding to the antero-ventral spine, strong postjacent ridge, and excavate posterior area with depression above the postero-ventral spine. It has not been possible to investigate the latter fully because of the matrix. Muscle-scar pattern a row of five rounded scars on the ridge immediately posterior to the antero-ventral depression. Anterior scars not seen. Marginal areas relatively broad but nature of radial pore canals not ascertained. Hinge a crenulate ridge with slight terminal expansions in the left valve, and complementary groove in the right valve.

Remarks. The genus occurs in the Upper Cretaceous of Australia and in the Upper Cretaceous and Eocene of Europe and although not so far reported from intermediate areas, it clearly had a wide distribution in Tethyan seas. *C. trispinosa* is rare at Gingin accounting for less than 1% of the fauna.

Family PROGONOCYTHERIDAE Sylvester-Bradley, 1948
Subfamily PROGONOCYTHERINAE Sylvester-Bradley, 1948
Genus TICKALARACYTHERE Krömmelbein, 1975
Tickalaracythere annula (Bate, 1972)

Plate 8, fig. 8; text-fig. 2*a*

1972 *Majungaella annula* Bate, pp. 26–29, pl. 5, figs. 7–9; pl. 6, figs. 2–7; pl. 7, figs. 1–4; text-figs. 15B, 16A, B.
1975 *Tickalaracythere annula* (Bate); Krömmelbein, p. 464.

Bate (1972) has given a full description of this species and has drawn attention to the salient features which differentiate it from Chapman's figured *Majungaella*—notably the narrower posterior outline in side view and the ornamentation of weak concentric ridges combined with lack of strong reticulation. Recently, Krömmelbein (1975) has separated *Tickalaracythere* from *Majungaella*, primarily on the basis of the outline of the lateral view and in the number of radial pore canals anteriorly. There is overlap between these genera in the latter characteristic and the difference in shape seems a safer criterion. Both genera occur in Australia.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Carapace	Specimen lost	Pl. 8, fig. 8	0·741	0·511	—
Right valve	HU.64.C.24	Text-fig. 2*a*	0·715	0·471	0·292

Genus *Majungaella* Grekoff, 1963
Majungaella verseyi sp. nov.

Plate 2, fig. 4; Plate 8, fig. 5; Plate 14, fig. 3; text-fig. 2*b*

1917 *Cytheropteron concentricum*, Reuss sp.; Chapman, p. 56, pl. XIV, fig. 17.

Derivation of name. In honour of Professor H. C. Versey for his contributions to Mesozoic stratigraphy.

Diagnosis. A species of *Majungaella* with strong reticulate ornamentation, relatively broad posterior end in lateral view, gently convex dorsal margin, and fine marginal spination.

Holotype. A right valve, HU.66.C.11.

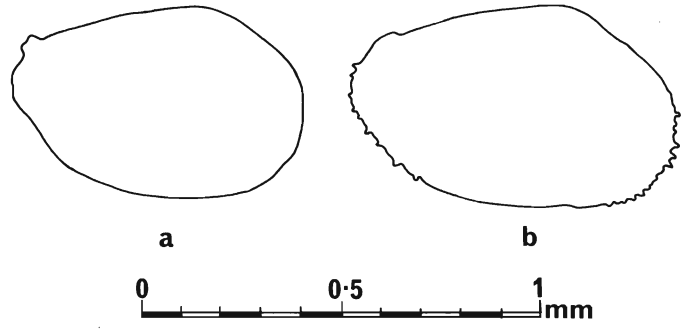
Paratypes. Two right valves, HU.66.C.10 and HU.64.C.1.41.

Other material. A carapace, CPC 7147 figured by Chapman, and a number of fragmentary specimens including HU.64.C.1.42 and HU.64.C.6.28.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, right valve	HU.66.C.11	Pl. 8, fig. 5; Pl. 14, fig. 3	0·741	0·484	0·299
Paratype, right valve	HU.66.C.10	Text-fig. 2*b*	0·818	0·487	0·267
Carapace	CPC 7147 (Chapman, pl. XIV, fig. 17)	Pl. 2, fig. 4	0·78	0·53	0·48

Description. Shape elongate-oval, tapering gently posteriorly in lateral view, with gently convex dorsal and ventral margins, asymmetrically rounded anterior margin with infracurvature, and almost symmetrically rounded posterior margin. Surface with first- and second-order reticulation, the ornamentation having a generally concentric appearance with costation accentuated on the ventral surface where three or four longitudinal ribs occur. Fine marginal spines are present anteriorly and posteriorly and in well-preserved specimens the muri show a similar tendency to develop fine spination. Hinge structure and internal features (Pl. 8, fig. 5) generally similar to other members of the genus. About twenty-four radial pore canals occur in the anterior half of the valve which supports Bate's contention (1972, p. 26) that



TEXT-FIG. 2. *a*, *Tickalaracythere annula* (Bate, 1972). Right valve, HU.64.C.24. Lateral outline, × 54. *b*, *Majungaella verseyi* sp. nov. Paratype, right valve, HU.66.C.10. Lateral outline, × 54.

the number of radial pore canals anteriorly in *Majungaella* increases in ascending the stratigraphical column.

Remarks. The differences from *Tickalaracythere annula* (Bate, 1972) have already been noted under that species. *M. verseyi* is more elongate and reticulate than the type species *M. perforata* Grekoff, 1963 from the late Jurassic of Madagascar and is more evenly curved ventrally than *M. nematis* Grekoff, 1963 from the Valanginian of the same area. *M. pyriformis* Bate, 1969 from the Albian of Tanzania also tapers much more conspicuously in side view than the present species, as does *M. uitenhagensis* (Dingle 1969*a*) from the Neocomian of South Africa. Comparison is less close with the other South African species *M. brentonensis* (Dingle 1972) and *M. reticulata* (Dingle 1972) from the Upper Jurassic, both of which are slimmer and more acuminate posteriorly in lateral view.

Among the species described by Krömmelbein (1975), *M. verseyi* is closest to *M. queenslandensis* from the Albian–Cenomanian of the Great Artesian Basin. The Gingin species differs in its straight dorsal margin and more pronounced posterior taper in lateral view.

The genus, so far recorded only from Africa and Australia, is relatively rare at Gingin where it accounts for less than 1% of the fauna recovered.

Family COLLISARBORISIDAE fam. nov.

Type genus. COLLISARBORIS gen. nov.

Diagnosis. Antimerodont genera of general neocytherid shape which show marked sexual dimorphism. Ornamentation, when present, consists mainly of concentric carinae in the distal parts of the valve, and not strong pitting. The family includes *Collisarboris* gen. nov. and *Paraphysocythere* Dingle (1969*b*).

Discussion. This family closely resembles progonocytherids such as *Neocythere* Mertens, 1956 and *Centrocythere* Mertens, 1956 but differs fundamentally in exhibiting sexual dimorphism which is related to the distribution and development of the soft parts within the shell of these extinct forms. It also differs in lacking the typical progonocytherid hinge. But for the fact that sexual dimorphism has never been reported in them, the genera *Physocythere* Kaye, 1963 and *Sphaeroleberis* Deroo, 1966 would fit well here. As known at present, the family is confined to the Cretaceous of South Africa, Australia, and the Pacific.

Genus COLLISARBORIS gen. nov.

Type species. Collisarboris cooki sp. nov.

Derivation of name. Collis, Latin; *Arbor*, Latin—'Hill of the Tree', a reference to One Tree Hill, Gingin, the type locality.

Diagnosis. Equidimensional carapace of neocytherid appearance with antimerodont hinge, accommodation groove in the left valve, very strong accommodation shelf in the right valve, and an eye tubercle.

Remarks. Collisarboris is unlikely to be confused with any other genus. It differs from its nearest relative *Paraphysocythere* Dingle, 1969*b* in its straight hinge, in the very strong accommodation shelf in the larger right valve, and in the eye spot.

Collisarboris cooki gen. et sp. nov.

Plate 8, fig. 6; Plate 18, figs. 3–5

Derivation of name. In honour of Mr. Tom Cook who kindly took me to the exposures on One Tree Hill.

Diagnosis. A species with the margin of the ala defined by a carina and with another short concentric carina on the lateral surface.

Holotype. A female left valve, HU.67.C.30.

Paratypes. Thirty-eight valves, HU.67.C.29, 31, 32, 33 and HU.67.C.34.1–34.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female left valve	HU.67.C.30	Pl. 8, fig. 6	0·455	0·286	0·188
Paratype, male left valve	HU.67.C.31	Pl. 18, fig. 3	0·454	0·286	0·156
Paratype, male left valve	HU.67.C.32	Pl. 18, fig. 4	0·389	0·247	0·143
Paratype, female right valve	HU.67.C.33	Pl. 18, fig. 5	0·395	0·263	0·143

Description. Valves oval, with straight hinge line; anterior margin with infracurvature. The small ala is bounded by a carina, above which is a short concentric rib on the lateral surface of the valve. Ventral surface with longitudinal ribbing. From the small eye spot a rib runs parallel to the anterior margin of the valve and ends at about mid-height (Pl. 8, fig. 6*a*; Pl. 18, fig. 4). Hinge antimerodont with accommodation groove in the left valve (Pl. 18, fig. 3) and strong accommodation shelf in the right valve (Pl. 18, fig. 5). Marginal areas simple with about eight, straight, radial pore canals anteriorly and five posteriorly. Muscle-scar pattern of a vertical row of four adductor scars set almost at mid-height. Frontal scar(s) not seen. Sexual dimorphism marked, the presumed males tapering more strongly posteriorly than the females.

Remarks. The most outstanding feature in this species is the strong accommodation shelf in the right valve (Pl. 18, fig. 5) which is seen in a variety of sizes of right valve up to the adult stage. A flat, approximately vertical area of the right valve towers above the left in consequence. Sexual dimorphism can be recognized in the penultimate instar where, as in the adult, the rarer males taper more pronouncedly posteriorly in side view. The only species with which comparison can be made is *Paraphysocythere riedeli* Swain, 1973 from the Maastrichtian of cores taken in the north-western Pacific Ocean at 32° 26·9′ N., 157° 42·7′ E. and 32° 24·5′ N., 158° 01·3′ E. Referred to Dingle's genus, Swain's species fits better in *Collisarboris* on the basis of its straight hinge line and the very marked accommodation shelf in the right valve (Swain 1973, pl. 1, fig. 7*b*). It differs from *C. cooki* in being higher in proportion to the length in side view, in having a vertical row of five or six pits in the median part of the valve, and in lacking an eye spot although two of Swain's figures suggest the incipient development of the latter.

C. cooki is fairly common at Gingin where it makes up about 1·5% of the fauna.

Family CYTHERURIDAE G. W. Müller, 1894
Subfamily CYTHERURINAE G. W. Müller, 1894
Genus EUCYTHERURA G. W. Müller, 1894
Subgenus EUCYTHERURA G. W. Müller, 1894
Eucytherura (*E.*) *antipodum* sp. nov.

Plate 9, figs. 5, 7; Plate 16, fig. 1

Derivation of name. *Anti*+*pous*, Greek—'opposite feet'. (Antipodean.)

Diagnosis. Shape rhomboidal with prominent antero-dorsal tubercle, reticulate surface, with more prominent costae delimiting the body of valve postero-dorsally and posteriorly, and antero-dorsally. Postero-ventral corner resembles an icositetrahedron, the edges of which are formed by the muri of the fossae.

Holotype. Adult left valve, HU.66.C.14.

Paratypes. Eleven valves, HU.66.C.15, 16, 18 and HU.66.C.17.1–8.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, left valve	HU.66.C.14	Pl. 9, fig. 7	0·364	0·208	0·130
Paratype, juvenile right valve	HU.66.C.15	Pl. 9, fig. 5	0·280	0·156	0·117
Paratype, juvenile right valve	HU.66.C.16	Pl. 16, fig. 1	0·263	0·149	0·107

Description. In lateral view rhombohedral with gently convex dorsal margin, asymmetrically curved anterior margin with infracurvature, gently convex ventral margin and short caudal process giving the greatest length at about two-thirds height. Surface coarsely reticulate, particularly in juveniles (Pl. 16, fig. 1), prominent antero-dorsal tubercle with deep circum-tubercular fossae and associated muri, a costa looping over the tubercle dorsally and running antero-ventrally to about mid-height. Postero-dorsally is a strong, gently curved costa which runs just below the dorsal margin, curving round to run ventrally to join the plexus of finer zigzag costae which delimit the body of the valve from the caudal process. Postero-ventrally is the angular, reticulate expansion noted in the diagnosis which is more prominent in the juveniles than the adults. Costae occur on the ventral surface. One runs from the lower anterior extremity of the postero-ventral expansion and rises anteriorly, being replaced *en echelon* below by others. Four marginal teeth occur antero-ventrally. In juvenile right valves there is a well-developed, arched, blister-like antero-ventral tubercle (Pl. 9, fig. 5*a*; Pl. 16, fig. 1). This is not very noticeable in the left valves and has not been observed in the adults. Internal features typical of the genus with eight or nine straight radial pore canals present anteriorly. No vestibules have been observed and the species in consequence is referred to *Eucytherura* s.s.

Remarks. Whilst adults (*c.* 0·351–0·364 mm) are rather rare, juveniles of the size range 0·260–0·275 mm are relatively common and highly characteristic. Details of ornamentation are best ascertained by reference to Plate 16, fig. 1. *E. antipodum* shows a number of features such as the rhombic shape, reticulation, marked postero-ventral expansion, and antero-ventral marginal teeth which are found in many

species of the genus throughout its range and comparison is often difficult because of the generally small size of the figures in the literature. The Hauterivian *E.* (*V.*) *multireticulata* Gründel, 1964*a* is the closest of the German Lower Cretaceous species and differs principally in being more elongate and, as far as can be ascertained from the figure, in the presence of two oblique ribs in the posterior part of the valve. Among the English species the closest similarity is with the Hauterivian and Lower Barremian *E. neocomiana* Kaye, 1964*a* and the Albian *E. rectangulata* Kaye, 1964*a*. The former differs from *E. antipodum* in possessing vestibules and being less rhombic in shape and the latter differs in the anterior costation. *E. tanzanensis* Bate, 1969 from the Aptian of Tanzania differs in being higher in proportion to the length and in the postero-ventral expansion lying more anteriorly.

Of the Dutch Upper Cretaceous species figured by Bonnema (1941) only *E. mulleri* Bonnema, 1941 as interpreted by Herrig (1966, pl. XXIX, figs. 6–9) is close and differs in tapering more abruptly posteriorly in side view and in the caudal termination being more dorsally directed. Holden (1964) gave excellent figures of some *Eucytherura* species from the Upper Campanian to Lower Maastrichtian of California, two of which resemble *E. antipodum* in ornamentation. *E. versabilis* Holden, 1964 is close but lacks the curved postero-dorsal costa, *E. planolata* Holden, 1964 is probably the closest comparable species of all and differs in the greater elongation in side view and the less dorsally directed caudal process with its straighter postero-ventral outline (cf. Pl. 9, fig. 7 with Holden, fig. 17*b*). *E. planolata* also has well-defined vestibules which have not been found in *E. antipodum*. Among the Polish species figured by Szczechura (1965) only the Palaeocene *E. tumida* Bonnema shows any close resemblance and this is effectively differentiated by the dorsal tuberculation. In her work on the Mönchneversdorf borehole of Germany, Moos (1973) figured eight Tertiary species of which *E. macropora* (Lienenklaus, 1894) from the Oligocene and *E. keijii* Pietrzeniuk, 1969 from the Lower Oligocene are generally similar to the present species. *E. macropora* is most easily differentiated by the absence of a curved postero-dorsal costa, whereas in the even more similar *E. keijii* a rounded tubercle is developed postero-dorsally.

Finally, *E. binocula* Allison and Holden, 1971 from the eastern tropical Pacific is easily differentiated by the development of tuberculation but the general resemblance is striking (cf. Pl. 9, fig. 5*a* with Allison and Holden, fig. 16*a*), and suggests that there is a strong genetic link between the two species even though they are separated in time by some eighty million years.

Eucytherura (*E.*) *fissipunctata* sp. nov.

Plate 9, fig. 3; Plate 16, figs. 2–4

Derivation of name. Findo—I split (supine—*fissum*)+*punctum*—a small hole, Latin—in reference to the slit-like pitting.

Diagnosis. A species with slit-like pits and postero-ventral alar spine.

Holotype. A left valve, HU.66.C.20.

Paratypes. Eleven valves, HU.66.C.21–23, HU.66.C.24, 1–5, HU.66.C.25–27.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, left valve	HU.66.C.20	Pl. 16, fig. 4	0·351	0·218	0·123
Paratype, right valve	HU.66.C.21	Pl. 9, fig. 3	0·390	0·221	0·169
Paratype, right valve	HU.66.C.22	Pl. 16, fig. 2	0·364	0·221	0·123
Paratype, right valve	HU.66.C.23	Pl. 16, fig. 3	0·395	0·224	0·133

Description. Valves alate, rhomboidal with dorsally directed caudal process in side view, greatest length lying at about one-third the height anteriorly and near the dorsal margin posteriorly. Antero-dorsal and postero-ventral margins rather straight, the latter with five marginal teeth and a second row of five teeth on the external surface a short distance inside the margin. Antero-dorsal and postero-dorsal tubercles prominent; lateral surface with characteristic slit-like fossae. Ventral and lateral surfaces separated by a rib which ends abruptly posteriorly. Three principal ribs on the ventral surface end posteriorly in spines of which the outer is the best developed (Pl. 16, fig. 2). Hinge in the right valve consists of a strong knob-like anterior tooth, a median locellate groove which expands at both ends, and a few small teeth posteriorly of which the oval terminal tooth is the largest. Dorsally there is an accommodation groove which is widest in the anterior half of the valve (Pl. 16, fig. 2). Marginal areas not clearly seen but sparse radial pore canals occur antero-ventrally and vestibules do not appear to be developed.

Remarks. Unlike the previous species only two species are comparable with *E. fissipunctata*. Although in developing only a strong anterior tooth *E. fissipunctata* agrees with *E. longicauda* from the Dutch Upper Cretaceous, to which it is similar in general aspect (especially Bonnema 1940, pl. V, fig. 97), there are several differences. In *E. longicauda* the ala curves up more posteriorly, the caudal process is sharper, and the antero-dorsal margin gently convex. In describing the ornamentation, Bonnema (p. 24) merely says that it has 'eine netzförmige Zeichnung', whereas slit-like ornamentation would doubtless have caused comment. The Australian Campanian form called ?*Paracytheridea* sp. by Bate (1972, pl. 18, fig. 7) is clearly closely related but has a more convex antero-dorsal margin and is not considered to be conspecific. *E. fissipunctata* is relatively rare at Gingin.

Genus SEMICYTHERURA Wagner, 1957

Semicytherura augusta sp. nov.

Plate 15, fig. 4

Derivation of name. Augustus, Latin—majestic.

Diagnosis. A species of *Semicytherura* with strong reticulation especially on the posterior half of the valve.

Holotype. A left valve, HU.66.C.8.

Paratype. A left valve, HU.66.C.9.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Holotype, left valve	HU.66.C.8	Pl. 15, fig. 4	0·328	0·162	0·091

Description. Typical *Semicytherura* shape with strong reticulation which is most marked on the posterior half of the valve. Dorsal margin curves round posteriorly to form a rim to the body of the valve, separating it from, and standing out above, the small caudal process. The posterior margin of the rim is straight and it runs postero-ventrally in a gentle concave curve. Dorsally there is a strong, arched, plate-like rib in the anterior half of the valve. One principal oblique rib runs from postero-ventrally to antero-dorsally, bifurcating at one-sixth the length from the anterior end; the dorsal branch runs to join the anterior end of the antero-dorsal rib, the ventral branch reaches the anterior margin at about mid-height. A second principal rib runs from the antero-dorsal rib about one-quarter of its length from the anterior end; it is concave upwards in the anterior half of its course where it approaches the first main rib, and is convex upwards in the posterior half of its course where it runs across the middle of the somewhat vaulted posterior half of the valve and forms part of the reticulation. A strong, gently convex upward rib in the antero-ventral part of the valve completes the principal ornamentation.

Remarks. Many species of this genus have been described ranging from Cretaceous to Recent but the number of closely comparable forms is limited. From the Campanian of the Carnarvon Basin, Western Australia, Bate (1972, pl. 18, fig. 6) figured as ?*Cytherura* sp., a carapace showing traces of reticulate ornamentation. Examination of the actual specimen shows that the rib pattern is somewhat similar but it is not possible to make out the critical details, and whilst undoubtedly closely related it is not possible to state that it is conspecific because of poor preservation. The Turonian *Cytherura luzangaziensis* (Bate, 1969) from Tanzania is also closely comparable in general ornamentation but the caudal process is strikingly different. The Lower Maastrichtian *C. pseudoexcavata* Herrig, 1964 differs in development of vertical ribbing in the median part, and although showing a somewhat similar pattern of ornamentation *C. clausi* Brady, 1880 from the early Miocene to Recent of New Zealand differs in details and in shape. Among more recent species, shape and ornamentation show some affinities with *S. ruggieri* (Pucci, 1955) as figured by Uffenorde (1972) and ornamentation alone with the *S.* cf. *S. rara* (Müller, 1894) of that author but the differences are obvious. *S. augusta* is very rare at Gingin and only two specimens of this very distinctive species have so far been found.

Semicytherura cretae sp. nov.

Plate 13, fig. 2; Plate 15, fig. 3

Derivation of name. Creta, Latin—chalk, in reference to its occurrence in the chalk of Gingin.

Diagnosis. A species with one main horizontal rib which occupies the median half of the valve and splits to form an elongate loop in the posterior third of the valve.

Holotype. A right valve, HU.66.C.5.

Paratypes. Five left valves, HU.65.C.23, HU.66.C.6, HU.66.C.7.1-2, HU.66.C.35.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, right valve	HU.66.C.5	Pl. 15, fig. 3	0·380	0·175	0·104
Paratype, left valve	HU.66.C.6	Pl. 13, fig. 2	0·377	0·182	0·091

Description. Shape typical of the genus with long, straight hinge line; sharply pointed caudal process giving the greatest length at a little above mid-height. In lateral view, postero-dorsal margin convex in the left valve, concave in the right valve. Ornamentation of one main longitudinal rib which starts at about one-quarter the length from the anterior end, runs at just above mid-height parallel to the dorsal margin until about two-thirds length where it splits into two to form an elongate loop which terminates at the commencement of the caudal process. A number of other costae occur anteriorly and longitudinal costae occur ventrally. The caudal process is finely reticulate and the valve surface is finely and densely pitted. Details of ornamentation are best seen in the stereoscopic figure (Pl. 15, fig. 3).

Remarks. The present species is unlikely to be confused with any other species and there is little that is comparable figured in the literature although *Semicytherura* n. sp. 2 Moos, 1971 from the Lower Oligocene of Latdorf may be distantly related. Some Recent forms such as *Semicytherura* sp. C. and *S.* cf. *quadratovolatilis* (Hartmann, 1953) of Uffenorde (1972) show aspects of ornamentation reminiscent of *S. cretae* but comparison is not close. *S. cretae* is rare at Gingin.

Genus VERSEYA gen. nov.

Type species. *Verseya pulchra* sp. nov.

Derivation of name. In honour of Emeritus Professor H. C. Versey of the University of Leeds for his researches into the Mesozoic rocks of Yorkshire.

Diagnosis. A small quadrate genus with dorsal and ventral ridges and prominent postero-dorsal projection pierced by coarse pores to form a 'pepperpot'. Hinge holomerodont.

Remarks. This unusual genus is unlikely to be confused with any other genus so far described. It is somewhat similar in general size and shape to species described as *Amphicytherura* but lacks the schizodont hinge and median rib of that genus and on these and other grounds cannot be assigned to the Schizocytheridae. Its small size and general shape is reminiscent of some of the Cytheruridae and it is placed in that family. It is closest, perhaps, to *Eucytherura* but shows obvious differences in hinge and type of ornamentation.

Verseya pulchra sp. nov.

Plate 15, fig. 2; Plate 17, figs. 1–5; text-fig. 3*a*, *b*

Derivation of name. Pulcher, Latin—beautiful.

Diagnosis. A species with bands of coarse pores in the posterior part of the valve lying ventrally of the dorsal ridge and dorsally of the ventral ridge. The dorsal ridge is inflated anteriorly and the ventral ridge shows inflation posteriorly.

Holotype. A left valve, HU.66.C.28.

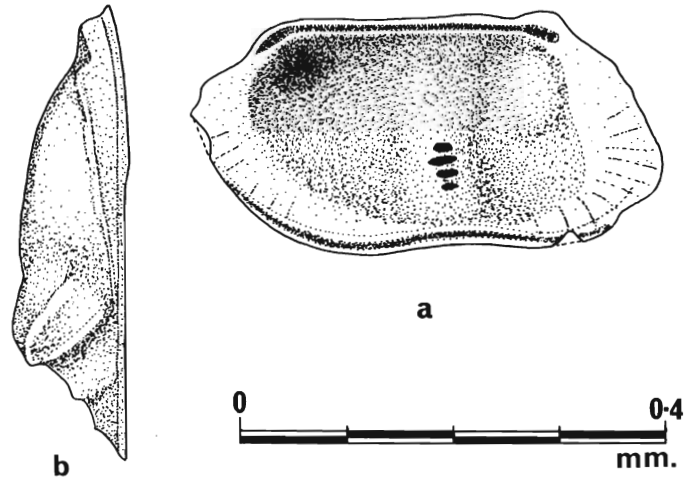
Paratypes. Nine valves, HU.66.C.29–33, HU.66.C.34.1–2, and HU.66.C.35.1–2.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, left valve	HU.66.C.28	Pl. 17, figs. 2–4	0·400	0·222	0·102
Paratype, right valve	HU.66.C.29	Pl. 15, fig. 2	0·402	0·198	0·136
Paratype, left valve	HU.66.C.30	Text-fig. 3*a*, *b*	0·442	0·228	0·108
Paratype, left valve	HU.66.C.31	Pl. 17, fig. 1	*c.* 0·384	0·220	0·102
Paratype, left valve	HU.66.C.32	Pl. 17, fig. 5	0·394	0·220	0·100

Description. Valves quadrate with the greatest length in the left valve at about two-thirds the height, the posterior part of the valve not having a very marked caudal process. Postero-dorsal margin concave becoming gently convex as it passes into the caudal termination and turns into the postero-ventral margin. A ridge is developed along the dorsal margin becoming strongly inflated anteriorly where it forms two convex upward arcs (of which the anterior one is the more inflated) and terminating anteriorly at about two-thirds the height. After a gap, the middle third of the anterior margin forms an inflated rib which joins the ventral ridge which delimits the small ala. This ventral ridge is concave upward and becomes increasingly inflated posteriorly where it forms two successive, sausage-shaped expansions complementary to the anterior ones of the dorsal ridge. The postero-dorsal tubercle is the most notable feature of the shell. This hollow structure is produced into a lenticular or 'ear-like' feature (Pl. 15, fig. 2; Pl. 17, figs. 2–4) which is pierced by coarse pits. Bands of coarse pitting occur posteriorly on the ventral side of the dorsal ridge and on the dorsal side of the ventral ridge. The rest of the valve surface is also pitted although not usually seen with the same clarity. Ventral surface costate. A sulcus occurs in the median part of the valve, and the larger left valve has an anterior cardinal 'ear'. The smaller right valve is similar except for the absence of the latter. In dorsal view hastate with the greatest width at about three-quarters length.

Hinge holomerodont, in the left valve consisting of a straight locellate groove which curves terminally to form two curved loculate sockets which accommodate the



TEXT-FIG. 3. *Verseya pulchra* gen. et sp. nov. Paratype, left valve, HU.66.C.30. *a*, inside lateral view. *b*, dorsal view, × 140.

four or five teeth on the terminal toothplates of the right valve (Pl. 17, figs. 1, 5). Neither the toothplates nor the teeth are particularly well differentiated. A well-developed flange groove occurs ventrally to accommodate the ventral edge of the smaller right valve. The external sulcus is reflected by a ridge on the inside of the valve which carries the row of four adductor scars which lie low down in the valve, the second being more elongated than the others. There is some indication that minor scars occur between the four principal ones (Pl. 17, fig. 1). Two dorsal scars appear to occur higher up on the internal ridge and there is possibly a further scar more anteriorly. The frontal scar has not been seen. Anterior marginal area fairly wide (Pl. 17, fig. 5), inner margin and line of concrescence coinciding. Radial pore canals straight and simple, approximately twelve anteriorly, not seen clearly posteriorly. The postero-dorsal tubercle is clearly hollow inside (Pl. 17, fig. 5).

Affinities and differences. This species is so distinctive that there is little with which it can be compared. *Eucytherura oculata* Weingeist (1949) from the Palaeocene of the United States Gulf Coast obviously differs in the presence of a marked eye tubercle but certain features of the ornamentation are reminiscent of *V. pulchra* and re-examination of its postero-dorsal tubercle using modern techniques would be of interest, as also in the case of *E. tricornis* Weingeist. Again differing in the presence of an eye tubercle, re-examination of *E. chapmani* Kaye (1964*b*) from the Bargate Beds of Surrey might prove similarly rewarding. Interest in *Verseya* must centre on the hollow postero-dorsal tubercle with its pepperpot of pits. This forms the widest part of the shell dorsally and most probably had a sensory function. The only other closely comparable analogue appears to be the Pleistocene and ?Recent loxoconchid *Roundstonia* (Neale, 1973*c*) which also carries coarsely pitted tubercles for which a sensory function has been suggested. *Verseya* is relatively rare at Gingin where on average it forms 0·3% of the fauna.

Subfamily CYTHEROPTERINAE Hanai, 1957
Genus CYTHEROPTERON Sars, 1866
Cytheropteron collisarboris sp. nov.

Plate 8, figs. 7, 9

Derivation of name. Collis, Latin; *Arbor*, Latin—'Hill of the Tree', a reference to One Tree Hill, Gingin, the type locality.

Diagnosis. A large, fragile species of *Cytheropteron* with marginal antero-ventral spination in the right valve, but smooth antero-ventrally in the left valve. Well-developed alar rim with flat, costate venter.

Holotype. A right valve, HU.67.C.26.

Paratypes. Ten valves, mostly fragmentary, HU.65.C.34, 35, HU.67.C.27, HU.67.C.28.1–7.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, right valve	HU.67.C.26	Pl. 8, fig. 7	0·937	—	—
Paratype, right valve	HU.67.C.27	Pl. 8, fig. 9	0·819	0·423	—

Description. Valves large, dorsal and ventral outline subparallel in lateral view, anterior margin with infracurvature. Drawn out posteriorly into a caudal process with greatest length at about mid-height. Alae drawn out into a marginal rim (Pl. 8, fig. 9*a*, *b*) penetrated by translucent pore canals. Ventral surface flat, ornamented with five or six longitudinal costae. Antero-ventral margin in the right valve with three marginal spines, in the left valve smooth. Surface of valves generally smooth with small, white, scattered normal pore canals. In dorsal view asymmetrically rounded with the greatest width just behind mid-length and compressed anteriorly and posteriorly. Hinge typical of the genus. The terminal toothplates in the right valve are elegantly arched in dorsal view, carry five or six teeth anteriorly and posteriorly (Pl. 8, fig. 7*a*, *b*), and have a straight finely locellate groove between. Left valve hinge complementary. Muscle-scar pattern a vertical row of four adductors with a rounded frontal scar anteriorly at about the same height as the top adductor. Marginal pore canals straight and simple, about six above the most dorsal of the marginal spines anteriorly, and about fourteen antero-ventrally. Not observed clearly posteriorly. A vestibule is present antero-ventrally. Normal pore canals small and scattered.

Affinities and differences. C. collisarboris is closest to *C. carinoalatum* Bate (1972) from the Campanian but is easily differentiated by the antero-ventral spination of the right valve. It also differs in being slimmer in lateral view and asymmetrically, not evenly, rounded in dorsal view and in the lateral surfaces being smooth. There is nothing else in the literature that is closely comparable.

The great fragility of this species means that it is easily smashed and consequently it is rare at Gingin accounting at most for 0·6% of the fauna in any one sample. Over all its incidence is about 0·2%.

Subgenus AVERSOVALVA Hornibrook, 1952

Based on the Recent New Zealand species *Cytheropteron* (*Aversovalva*) *aureum*, *Aversovalva* was established by Hornibrook (1952) for species of *Cytheropteron* in which the relative sizes of the valves were reversed, the left valve being the larger. The species of *Cytheropteron* below belong in this subgenus.

Cytheropteron (*Aversovalva*) *mccomborum* sp. nov.

Plate 18, fig. 2; text-fig. 4*a*, *b*

Derivation of name. In honour of Dr. and Mrs. A. McComb for their kindness and hospitality during my stay in Perth.

Diagnosis. A species with strong ala which is terminally trispinate; the valve with dorsal and ventral marginal rims.

Holotype. A broken left valve, HU.62.C.6.

Paratypes. Three valves, HU.62.C.7-9.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, left valve	HU.62.C.6	Pl. 18, fig. 2	*c.* 0·312	0·214	0·169
Paratype, left valve	HU.62.C.7	Text-fig. 4*a*, *b*	0·351	0·253	0·136

Description. Valves of *Cytheropteron* shape, greatest length at about mid-height, drawn out posteriorly into a caudal process which has a straight or convex postero-dorsal margin. Valve with marginal rims dorsally and ventrally. Surface generally pitted, the pits being much coarser on the alae. Ala prominent and ending in three short spines. Hinge in left valve a locellate bar with terminal loculate sockets, and a dorsal accommodation groove/shelf for the right valve. About six straight, simple radial pore canals anteriorly and four posteriorly.

Affinities and differences. C. mccomborum is only likely to be confused with *C. harrisi* Skinner, 1956 from the Arkadelphia Marl and uppermost Saratoga Chalk of the Arkansas area, which was later recorded by Butler and Jones (1957) from the Saratoga Chalk of Louisiana. One must have reservations about Butler and Jones's determinations since their specimens appear to lack the typical terminal alar spination, and the same is true of the lowest record by Benson and Tatro (1964) from the Marlbrook Marl of Arkansas. Nevertheless, Crane's (1965) work suggests that the species does indeed occur in both the Campanian and Maastrichtian of the United States. The present species differs in its less-arched dorsal margin, the less-acuminate posterior part, and the somewhat more swept-back ala. The apparent similarity lies largely in the spination at the outer extremities of the alae. Skinner's figure is not particularly informative, but Crane (1965) figures this species from the Saratoga Chalk of Arkansas. Her specimen is broken but the difference between the 'set' of the ala and its spination compared with *C. mccomborum* is immediately obvious, even though the exact interpretation of *C. harrisi* must remain unsatisfactory until the type material is refigured to modern standards. Herrig (1966, p. 883, pl. XXXI, fig. 4) figured a similar *Cytheropteron* from the Lower Maastrichtian of Rügen as *C. harrisi.* As far as it is possible to tell, the same differences apply between his specimens and *C. mccomborum* as noted above.

This beautiful but fragile species is very rare at Gingin.

Cytheropteron (*Aversovalva*) cf. *C. mccomborum*

Text-fig. 4*e*, *f*

Two specimens occur which are similar to *C. mccomborum* but only develop one spine at the alar termination. As the figured specimen is larger than the holotype of *C. mccomborum* it is unlikely that these are immature forms as was at one time thought to be the case. Since material is insufficient to justify their formal separation as a distinct species they are here merely compared with the last species.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Left valve	HU.62.C.10	Text-fig. 4*e*, *f*	0·328	0·198	0·130

Cytheropteron (*Aversovalva*) *westaustraliense* sp. nov.

Plate 13, figs. 5–7; text-fig. 4*c*, *d*, *g*, *h*

Derivation of name. From its occurrence in Western Australia.

Diagnosis. A species with a coarsely pitted, short, triangular ala which has a strong

rim and a deep dorsal depression; the dorsal margin in the left valve is strongly arched.

Holotype. A left valve, HU.62.C.13.

Paratypes. Twenty-six valves, HU.62.C.14–19, HU.62.C.20.1–20.

Dimensions of figured specimens.

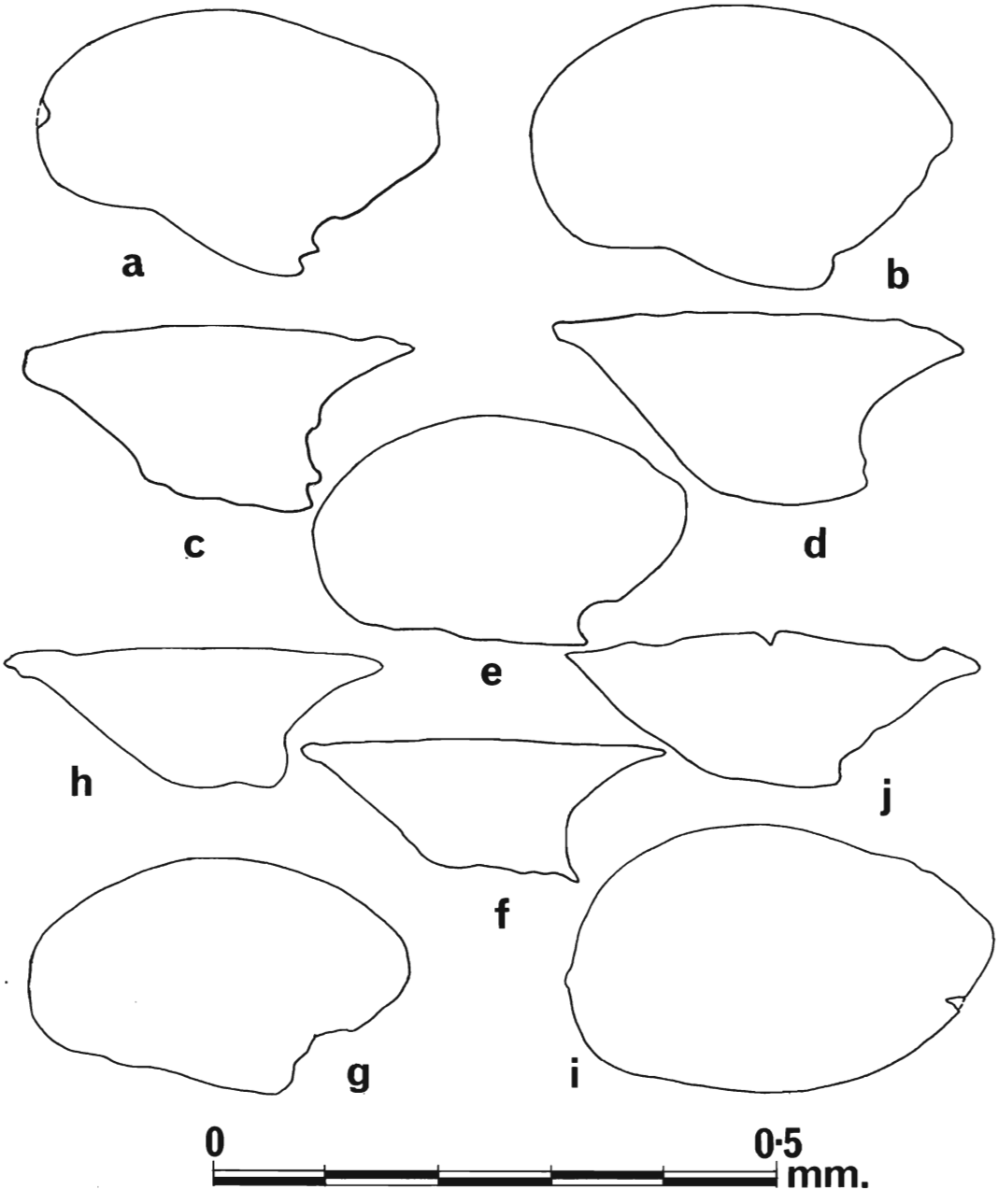
			Length mm	Height mm	Width mm
Holotype, left valve	HU.62.C.13	Pl. 13, fig. 7	0·338	0·240	0·117
Paratype, right valve	HU.62.C.14	Pl. 13, fig. 6	0·364	0·227	0·146
Paratype, left valve	HU.62.C.15	Pl. 13, fig. 5; text-fig. 4*g*, *h*	0·328	0·216	0·117
Paratype, left valve	HU.62.C.16	Text-fig. 4*c*, *d*	0·367	0·260	0·149

Description. Shape cytheropteronid, larger left valve with arched dorsal margin and dorsal marginal rim. Dorsal margin of right valve straight in side view. Stumpy triangular alae with depression on the dorsal surface and strong marginal rim, the posterior margin leaving the body of the valve almost at right angles. Dorsal alar surface ornamented with very coarse pits. Ventral surface costate. In dorsal view arrow-shaped with the greatest width at about two-thirds length. Hinge in left valve a locellate bar with terminal loculate sockets and a dorsal accommodation groove. About eight simple, straight radial pore canals occur anteriorly and about four posteriorly.

Affinities and differences. The small *Cytheropteron* species are notoriously difficult to deal with without good comparative material but in the present case the differences from other species are clear cut. Although differing in many other respects, particularly in its strong triangular, rather than gently curved, alae, the strong pitted rim to the latter in *C. westaustraliense* shows an interesting resemblance to that of the Upper Aptian *C.* (*Eocytheropteron*) *nova* Kaye, subsp. *reticulata* Kaye and Barker, 1965 from the Sutterby Marl of England. The Albian *C.* (*C.*) *milbournei* Kaye, 1965 differs in the more elongate triangular alae and in the more triangular arrow-shaped dorsal view.

By far the closest comparisons, however, are with two European Upper Cretaceous species. The French Lower Cenomanian *C. nanissimum* Damotte and Grosdidier, 1963 differs most noticeably in the straighter, less-humped, postero-dorsal margin; the lower margin of the ala in their species also swings up more towards the tip giving a more swept-back appearance. *Cytheropteron v-scriptum* Van Veen, 1936 from the Maastrichtian of Holland differs in the more swept-back alae in side view and in the rounding of the posterior margin of the alae in dorsal view. Van Veen's figures are very small, however, and the same species as figured by Herrig (1966) from the Lower Maastrichtian of Rügen is much closer to the present species. Again, in Herrig's figures the alae appear somewhat more swept back distally, rather longer than in *C. westaustraliense*, and the dorsal surface less coarsely pitted, although the appearance of the pitting may be deceptive. Whilst different the two species seem to be closely related.

Of Australian species, *C. westaustraliense* is only likely to be confused with *C. mccomborum* and then only in poorly preserved material in which the spination



TEXT-FIG. 4. *Cytheropteron* and *Oculocytheropteron*. Lateral and dorsal views, the latter drawn with the specimen resting on the ventral surface of the ala. All left valves × 159. *a*, *b*, *Cytheropteron* (*Aversovalva*) *mccomborum* sp. nov. HU.62.C.7. *c*, *d*, *Cytheropteron* (*Aversovalva*) *westaustraliense* sp. nov. HU.62.C.16. *e*, *f*, *Cytheropteron* (*Aversovalva*) cf. *C. mccomborum*, HU.62.C.10. *g*, *h*, *Cytheropteron* (*Aversovalva*) *westaustraliense* sp. nov. HU.62.C.15. *i*, *j*, *Oculocytheropteron praenuntatum* Bate 1972, HU.64.C.26.6.

has been worn away in the latter and in specimens of the former where the dorsal margin in the left valve is less arched than usual (Pl. 13, fig. 5). Usually the matter is easily resolved by examination of the dorsal margin in lateral view as shown in text-fig. 4.

C. westaustraliense is relatively common at Gingin where it may form up to 2% of the ostracod fauna.

Genus OCULOCYTHEROPTERON Bate, 1972

Oculocytheropteron praenuntatum Bate, 1972

Plate 18, fig. 1; text-fig. 4*i*, *j*

1972 *Oculocytheropteron praenuntatum* Bate, pp. 50–51, pl. 16, figs. 1–12; pl. 19, figs. 2, 3; text-fig. 28A–C.

The description of this species was based on Santonian and Campanian material from the Carnarvon Basin to the north. The figured specimen from Gingin shows the characteristic eye tubercle, concave antero-dorsal slope of the right valve, and ornamentation of the species. At Gingin it is rare, its incidence being about 0·3% in the ostracod fauna. Twelve specimens are deposited as HU.64.C.26.1–12.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Right valve	HU.67.C.25	Pl. 18, fig. 1	0·389	0·247	0·135
Left valve	HU.64.C.26.6	Text-fig. 4*i*, *j*	0·384	0·260	0·133

PARACYTHERIDEA Subgroup Hanai, 1957
Genus HEMINGWAYELLA gen. nov.

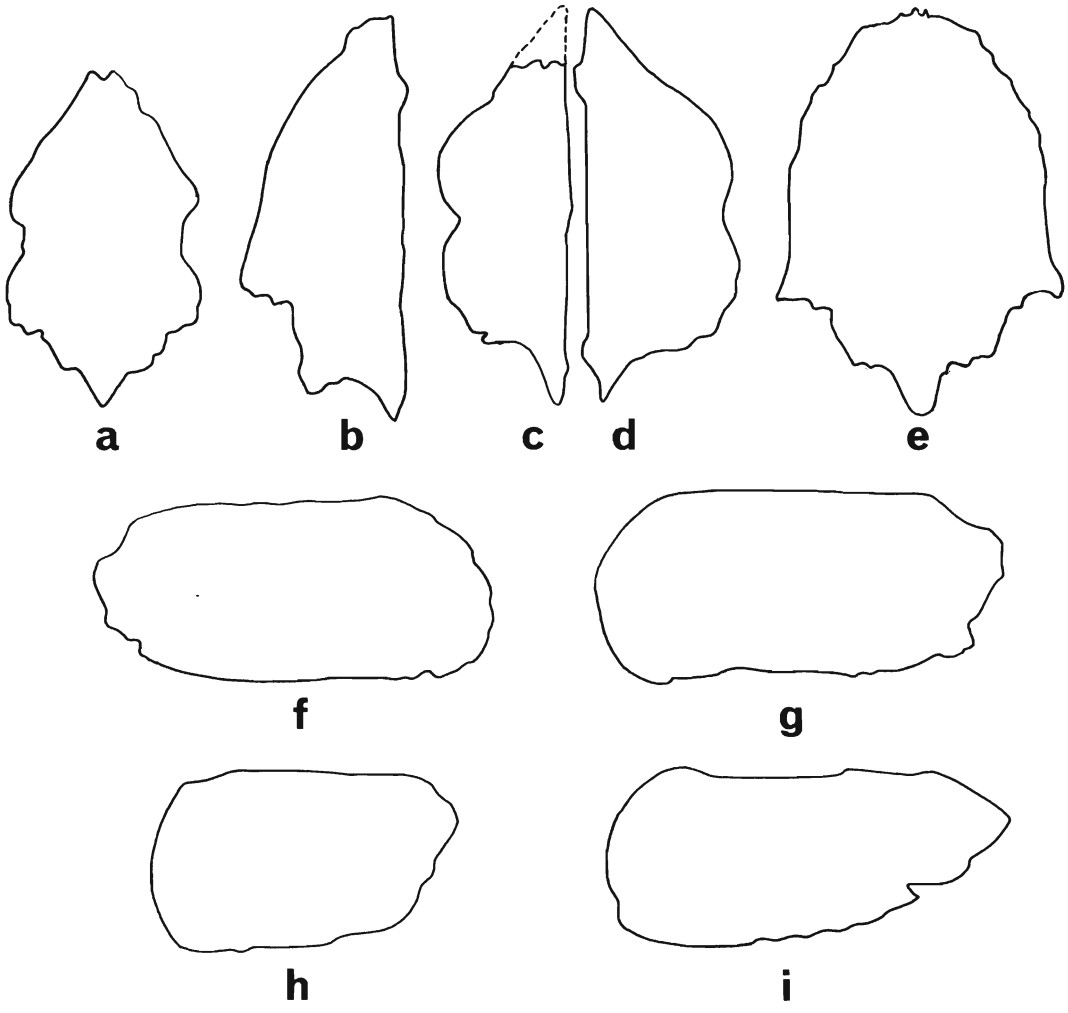
Type species. Hemingwayella ornata sp. nov.

Derivation of name. In honour of Professor J. E. Hemingway of the University of Newcastle upon Tyne for his researches into the Mesozoic rocks of Yorkshire.

Diagnosis. A small, elongate genus with parallel dorsal and ventral margins, antimerodont hinge, prominent eye tubercle, median sulcus, and ventral inflation with prominent antero-ventral tubercle.

Discussion. This distinctive genus clearly belongs in Hanai's (1957*b*) *Paracytheridea* subgroup of his Cytheropterinae. The closest resemblances are with *Eucytherura*, *Paracytheridea*, and *Paracytheropteron*. From *Eucytherura* Müller, 1894 (Cretaceous–Recent) it differs in its greater elongation, being oblong rather than sub-rhombic, and lacking a dorsally directed caudal process. From *Paracytheridea* Müller, 1894 (Upper Cretaceous–Recent) it differs in its stronger hinge, absence of a well-developed caudal process, and in the presence of a median sulcus which is well seen in dorsal view. In many ways it is closest to *Paracytheropteron* Ruggieri, 1952 (Miocene–Recent) based on *Cytheropteron calcaratum* Seguenza, 1880 from the Pleistocene of Italy.

Hemingwayella differs most noticeably from the latter in the development of the median sulcus and large antero-ventral tubercle which is best seen in dorsal view. The eye tubercle also appears better developed than in *Paracytheropteron* and the



TEXT-FIG. 5. Comparison of *Hemingwayella ornata* with the type species of *Eucytherura*, *Paracytheridea*, and *Paracytheropteron* in dorsal and lateral outline. *a*, *h*, *Eucytherura complexa* (Brady, 1867), ×127. *b*, *g*, *Paracytheropteron calcarata* (Seguenza, 1880), ×115. *c*, *d*, *f*, *Hemingwayella ornata* gen. et sp. nov. *c*, paratype, left valve, HU.62.C.2. *d*, *f*, holotype, right valve, HU.62.C.1, ×150. *e*, *i*, *Paracytheridea bovettensis* (Seguenza, 1880), ×108.

ornamentation is stronger and differently disposed, the costation being stronger and the reticulation smaller. Comparisons of the four genera are seen in text-fig. 5.

Hemingwayella ornata gen. et sp. nov.

Plate 13, figs. 8, 9; Plate 20, figs. 3–6; text-fig. 5*c*, *d*, *f*

Derivation of name. Ornatus, Latin—ornamented.

Diagnosis. A strongly ornamented species with highly developed antero-ventral tubercle.

Holotype. A right valve, HU.62.C.1.

Paratypes. Three valves, HU.62.C.2–4.

Other material. A number of other valves, mostly broken, were available for study.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, right valve	HU.62.C.1	Pl. 20, figs. 3, 5; text-fig. 5*d*, *f*	0·348	0·164	0·140
Paratype, left valve	HU.62.C.2	Pl. 13, fig. 9; Pl. 20, fig. 4; text-fig. 5*c*	0·320	0·148	0·116
Paratype, left valve	HU.62.C.3	Pl. 20, fig. 6	—	0·154	0·112
Paratype, right valve	HU.62.C.4	Pl. 13, fig. 8	*c.* 0·312	0·169	0·136

Description. In lateral view oblong with parallel dorsal and ventral margins, anterior margin with infracurvature, postero-dorsal margin concave with a negligible caudal process at mid-height. Greatest length a little below mid-height. Very inflated ventrally with a well-developed antero-ventral tubercle separated from the alate posterior part of the valve by a sulcus. Strongly ornamented with reticulate lateral surface and ventral surface with four longitudinal costae. A longitudinal rib occupies the middle of the posterior part of the valve, declining anteriorly and dying out at the median sulcus just before reaching the antero-ventral tubercle. Another longitudinal rib delimits the lateral and ventral surfaces. The antero-ventral tubercle has four strong short ribs in a vertical row one above the other. The muscle-scar pattern has not been seen but these ribs could bear some relationship to the adductor muscles. For further details of ornamentation see Plate 20. Hinge in right valve straight, consisting of a locellate groove and terminal tooth plates. The latter each carry about three teeth, the anterior one straight in dorsal view, the posterior one rounded to give a lobate appearance in dorsal aspect. Details of marginal areas not ascertainable.

Affinities and differences. The present species is so distinctive that there is little in the literature with which it may be compared. *Cytherura pseudoexcavata* Herrig, 1964 from the Maastrichtian of Rügen shows an approach in the type of ornamentation but any comparison is tenuous. *H. ornata* is rare at Gingin where it reaches a maximum of 0·66% of the ostracod fauna.

Genus HEMIPARACYTHERIDEA Herrig, 1963

Herrig (1963) established *Hemiparacytheridea* as a subgenus of *Paracytheridea* Müller, 1894 on the basis of the hinge structure of his type species *P.* (*H.*) *occulta* where the posterior hinge element is only weakly developed. In 1966 he gave excellent figures of the hinge in both subgenera. Gründel (1967), in an expanded diagnosis, drew attention to the convergence of the dorsal and ventral margins and the strongly developed sculpture. Herrig's subgenus differs in a number of other features from *Paracytheridea* s.s. Most obviously the caudal process is dorsally directed and the greatest length lies dorsally and not at, or about, the mid-line as in the type species of *Paracytheridea*. The second postero-ventral projection behind the main postero-ventral projection of the ala, which is such a feature of *P. bovettensis*, is absent in

Hemiparacytheridea occulta occulta (Herrig, 1963) and most species of *Hemiparacytheridea*, although vestiges are apparent in *H. occulta restricta* (Herrig, 1963). The eye tubercle is very strongly developed in Herrig's subgenus and ornamentation also shows differences in degree of development, tuberculation becoming a dominant feature, often coupled with some reticulation. Because of these differences, *Hemiparacytheridea* is here raised to full generic status. Gründel (1966) placed what he believed to be *Eucytherura longicauda* Bonnema, 1941 in *Hemiparacytheridea*. The present author agrees and would also transfer to this genus *P.* (*P.*) *longicauda* (Bonnema) as interpreted by Herrig (1966). Except for *P.* (*Paracytheropteron*) *fenestrata* (Bosquet) all the *Paracytheridea* species figured by Keij (1957) belong in *Paracytheridea* s.s. With the possible exception of *P. tuberosa* Lienenklaus, 1900 the same is true of all the Tertiary species figured by Moos (1971) and all the Tertiary species of Ishizaki (1966), Haskins (1970), and Blondeau (1972). The type species of *Paracytheridea* is *P. bovettensis* (Seguenza), beautifully figured from living Gulf of Naples material by Müller (1894) as *P. depressa*. A number of other Recent species exist, of which *P. tschoppi* Bold, 1946 from Clipperton Island in the eastern tropical Pacific has recently been discussed and well figured by Allison and Holden (1971).

Hemiparacytheridea hemingwayi sp. nov.

Plate 13, fig. 4; Plate 15, fig. 1

Derivation of name. In honour of Professor J. E. Hemingway for his contributions to Jurassic stratigraphy.

Diagnosis. A typical *Hemiparacytheridea* with prominent tubercles at the corners of the main body of the valve, and some reticulation including a rib which loops over the eye tubercle.

Holotype. A male right valve, HU.66.C.1.

Paratypes. Six valves mounted as HU.66.C.2, HU.66.C.3, 1–4, and HU.66.C.4.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, male right valve	HU.66.C.1	Pl. 15, fig. 1	0·286	0·143	0·110
Paratype, female right valve	HU.66.C.2	Pl. 13, fig. 4	0·286	0·169	0·130

Description. Shape typical of the genus with well-developed ala and dorsally directed caudal process. Principal ornamentation of tubercles with rounded eye tubercle, bun-shaped antero-ventral tubercle separated from the complex postero-ventral tubercle by a sulcus, and a pyramidal postero-dorsal tubercle. Ventral surface costate. Broad, pitted median sulcus, remainder of valve surface reticulate. One of the ribs loops over the eye tubercle from postero-dorsally to antero-ventrally and another runs dorso-ventrally across the eye tubercle in its posterior part almost at right angles to the former. Surface with a few simple, normal pore canals. For detailed ornamentation see the paired steroscopic photographs (Pl. 15, fig. 1).

Remarks. Closest comparison is with some of the Lower Maastrichtian species of which Herrig (1966) gives excellent figures. The present species is closest to *H. occulta* (Herrig) which is a dominantly tuberculate form, but is easily distinguished from both

Herrig's subspecies by its lack of a prominent ear at the anterior cardinal angle. *H. hemingwayi* differs from *H. longicauda* (Bonnema) in the much less prominent reticulation amongst other features. Comparisons with other species are not close. The genus is rare at Gingin.

Genus PEDICYTHERE Eagar, 1965
Pedicythere australis sp. nov.

Plate 13, fig. 1; Plate 14, figs. 1, 2; text-fig. 6*a–d*

Derivation of name. Australis, Latin—southern.

Diagnosis. A species showing dimorphism and prominent narrow ala which makes the valves wider than high. Dorsal view acutely triangular, alae merging gradually with the body of the valve anteriorly; posterior alar margins approximately perpendicular to the hinge line.

Holotype. A female left valve, HU.64.C.18.

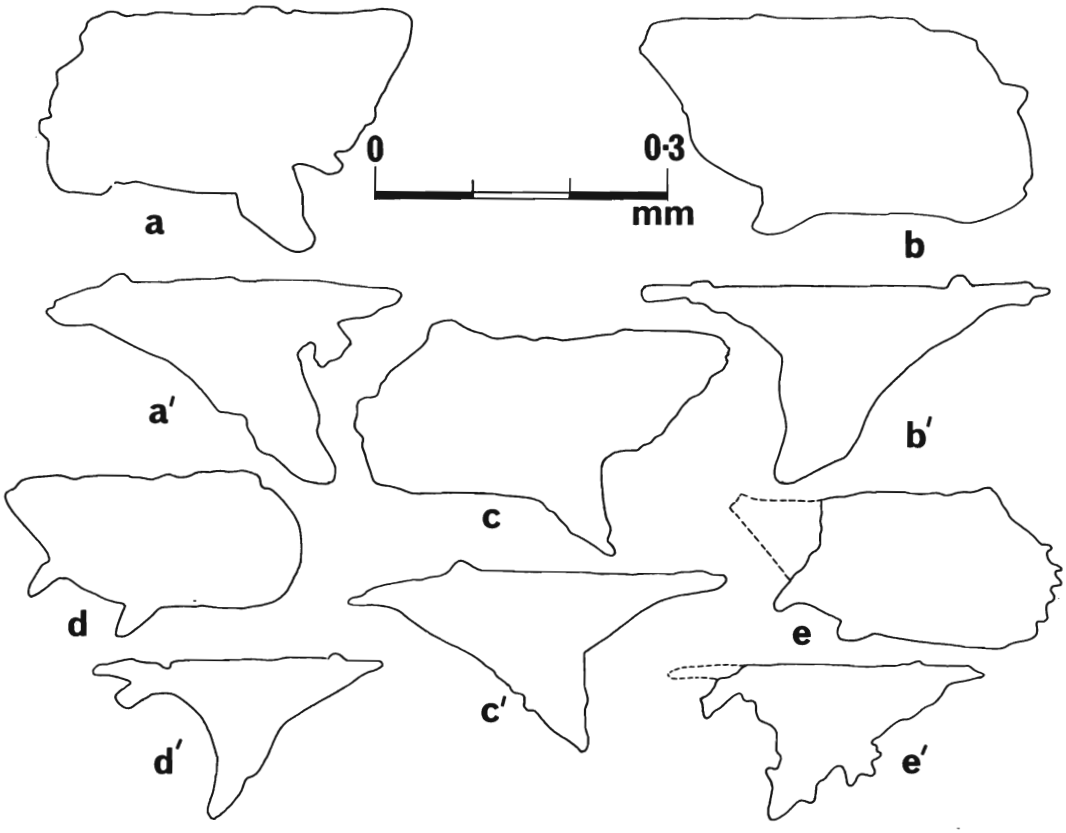
Paratypes. Seventeen specimens, HU.64.C.19, 21, 22, HU.64.C.20.1–12, HU.66.C.12, 13.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female left valve	HU.64.C.18	Text-fig. 6*a*	0·380	0·192	0·216
Paratype, female right valve	HU.64.C.19	Pl. 13, fig. 1; text-fig. 6*b*	0·40	0·200	0·204
Paratype, female right valve	HU.66.C.12	Pl. 14, fig. 1	0·368	0·182	0·234
Paratype, female left valve	HU.66.C.13	Pl. 14, fig. 2	0·390	0·208	0·247
Paratype, male left valve	HU.64.C.21	Text-fig. 6*c*	0·388	0·180	0·188
Paratype, juvenile right valve	HU.64.C.22	Text-fig. 6*d*	0·304	0·138	0·164

Description. Thin, smooth, fragile valves which are quadrate in side view with a dorsally directed, triangular caudal process. Anterior margin with about five small spines or marginal teeth which are best developed in juvenile forms. These are apparently easily eroded and the most dorsal one appears to be the most persistent, and is the one most commonly seen in adults (Pl. 13, fig. 1). Postero-ventral 'foot' prominent but fragile and often missing because of breakage. In both valves a thin, blade-like ridge stands up above the hinge line and forms the dorsal outline in lateral view. Alae narrow and very prominent so that the valves are wider than high. Dorsal view acutely triangular, the edge of the ala merging into the body of the valve anteriorly in a gentle concave curve. Posterior edge of the ala almost perpendicular to the hinge line, forming an obtuse angle with the body of the valve which is very narrow posteriorly.

Hinge in right valve with prominent round anterior tooth, round postjacent socket and finely crenulate groove in the median section, and posterior tooth. The latter is poorly seen in the Gingin material but appears to be small and elongate. An obscure indication of sub-division in the posterior tooth suggests that the hinge should perhaps be considered as hemiamphidont rather than holamphidont. In the left valve the poorly seen posterior socket appears to be open to the body of the valve ventrally. Duplicature fairly wide with inner margin and line of concrescence coincident. Five or six simple, almost straight, marginal pore canals anteriorly. Nature of



TEXT-FIG. 6. Lateral and dorsal views of *Pedicythere*, × 125. *a–d*, *Pedicythere australis* sp. nov. *a*, *a′*, holotype, female left valve, HU.64.C.18. *b*, *b′*, paratype, female right valve, HU.64.C.19. *c*, *c′*, paratype, male left valve, HU.64.C.21. *d*, *d′*, juvenile right valve, HU.64.C.22. *e*, *e′*, *Pedicythere* sp. juvenile right valve, HU.64.C.23.

posterior marginal areas difficult to ascertain, but apparently one fine radial pore canal bifurcates to form two openings in the tip of the caudal process, and two or three other canals occur ventrally of it. Muscle scars not seen.

This species is dimorphic, some 30% of adult specimens differing from the holotype in having valves which are lower in proportion to their length. Dimorphism has not hitherto been recorded in *Pedicythere*, probably because of the general rarity of specimens, and the lower valves are here interpreted as males. In dorsal view the latter have a more pointed ala than the female (text-fig. 6*a′*, *b′*, *c′*). Juveniles resemble the females in dorsal view (text-fig. 6*d′*); in side view the postero-ventral projection is proportionately better developed than the ala compared with the adult condition.

Remarks. P. australis is unlikely to be confused with other species. The genus is rarely encountered and Bate (1972) recorded it for the first time outside Europe when he found a single carapace, which he left under open nomenclature, in the Campanian Toolonga Calcilutite of Yanrey No. 1 core in the Carnarvon Basin. The alae were broken but there is some resemblance in side view to the forms here interpreted as

males, although the Campanian form has a very much slimmer caudal process. It is certainly a different species. *P. fluitans* (Bonnema) has been figured recently by Herrig (1966) from the Lower Maastrichtian Chalk of Rügen. It resembles the Australian species in many ways but is easily differentiated in dorsal aspect where the alae leave the body of the valve much more abruptly than in *P. australis*. In the latter the anterior margin of the ala merges gently into the anterior part of the valve, and the ala itself forms a 'hump' on the anterior side near its termination in dorsal view. Eagar's original species, *P. tessae* from the Eocene of the Reading district, differs in the thinner, more pointed ala and the larger pedal projection.

Pedicythere sp.

Text-fig. 6*e*

Included here is a single broken right valve which differs in a number of respects from *P. australis*. It is the only valve in which the width is not greater than the height. In addition a short, approximately vertical ridge runs from the anterior cardinal angle to the mid-height of the valve, a thin, frilled, more-or-less horizontal, plate occurs on the anterior part of the ala, the ala itself has a number of short spiny projections, and the spination along the anterior margin is well developed. This single specimen may be merely an aberrant variant of the previous species but at present it seems advisable to separate it under open nomenclature.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Juvenile right valve	HU.64.C.23	Text-fig. 6*e*	—	0·166	0·160

Subfamily EUCYTHERINAE Puri, 1954
Genus EOROTUNDRACYTHERE Bate, 1972
Eorotundracythere compta Bate, 1972

Plate 19, fig. 4

1972 *Eorotundracythere compta* Bate, pp. 42–44, pl. 12, figs. 3, 5, 6, 7; pl. 18, fig. 8; text-fig. 24A, B.

This characteristic and easily recognizable species is fairly common at Gingin where it reaches a maximum abundance of about 2% of the ostracod fauna. Twenty specimens have been mounted as HU.67.C.36.1–20.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Female left valve	HU.67.C.35	Pl. 19, fig. 4	0·389	0·266	0·130

Family XESTOLEBERIDIDAE Sars, 1928
Genus UROLEBERIS Triebel, 1958
Uroleberis batei sp. nov.

Plate 22, fig. 3; text-fig. 7*a–c*

Derivation of name. In honour of Dr. R. H. Bate of the British Museum of Natural History who kindly photographed Chapman's types for me and arranged the loan of various Carnarvon Basin specimens.

Diagnosis. A small, distinctive species with rounded triangular lateral outline and accommodation groove in the left valve.

Note on the genus. Uroleberis was based on *Eocytheropteron parnensis* Apostolescu, 1955 an Eocene species with an accommodation groove in the left valve and a caudal process. The present species agrees in possessing the former but differs in lacking a caudal process. Nevertheless, in lateral view the posterior part of the valve is more acuminate and not so vaulted as typical *Xestoleberis.* In this it agrees more with *Xestoleberis marssoni* Bonnema, 1941 and *X. supplanata* Van Veen, 1936. Deroo (1966) encountered these in his work on the Dutch Maastrichtian and referred them to *Uroleberis.* Following Deroo's interpretation of the genus, the Gingin species is also assigned to *Uroleberis.*

Holotype. A right valve, HU.62.C.21.

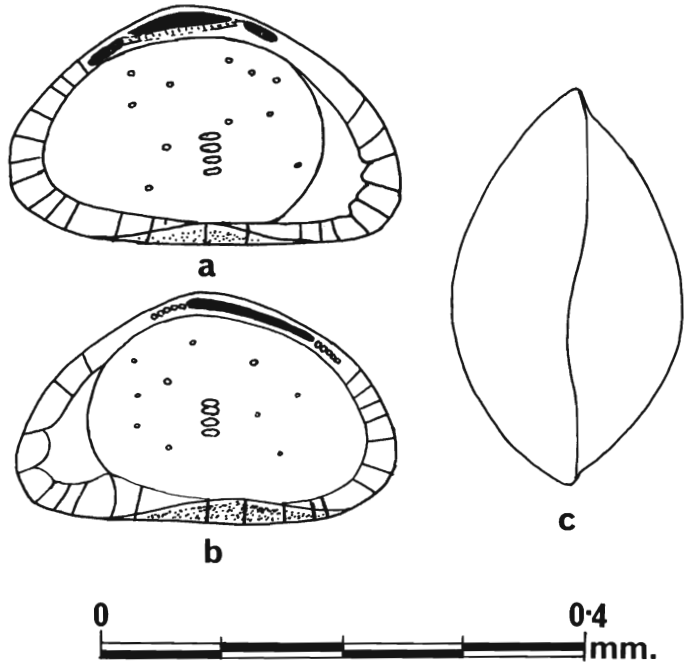
Paratypes. Ten valves and carapaces, HU.62.C.22-28, HU.62.C.29.1-3.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female right valve	HU.62.C.21	Pl. 22, fig. 3	0·325	0·208	0·117
Paratype, female left valve	HU.62.C.23	Text-fig. 7*a*	0·326	0·200	0·112
Paratype, female right valve	HU.62.C.24	Text-fig. 7*b*	0·314	0·193	0·096
Paratype, female carapace	HU.62.C.25	Text-fig. 7*c*	0·332	0·195	0·192

Description. Valves rounded triangular in side view with the greatest height slightly posterior of the mid-length. Both anterior and posterior margins with infracurvature the anterior part of the valve tapering more sharply than the posterior. In dorsal view elliptical with pointed extremities and the greatest width at mid-length. Surface smooth with small, white, scattered normal pore canals. The larger left valve has a locellate bar with small terminal loculate sockets and a dorsal accommodation groove to take the dorsal margin of the right. Right valve hinge complementary, the terminal tooth plates each carrying about five small teeth. Marginal pore canals less numerous and longer than is generally the case in *Uroleberis* and *Xestoleberis.* Marginal zone of medium width with a well-developed vestibule anteriorly with which are associated usually nine, straight, radial pore canals. Five more radial pore canals occur ventrally and about ten posteriorly. A vertical row of four adductor scars is placed centrally in the valve. Neither frontal scar(s) nor the xestoleberid 'spot' have been seen. Sexual dimorphism very marked, the males, which are very rare, having a length:height ratio of 1·802 compared with that of the higher females where the ratio averages 1·631.

Affinities and differences. This species is very distinct and comparison is limited to a few Cretaceous species. Some specimens of *U. supplanata* (Van Veen, 1936) from the European Maastrichtian are similar in side view but the majority tend to be lower in proportion to their length, and the species is also wider in dorsal view. Van Veen's figures are small but the illustrations by Deroo (1966) and Herrig (1966) confirm this. Some species of *U. marssoni* (Bonnema 1941), also from the European Maastrichtian, compare closely in side view. As figured by Bonnema (1941), Deroo (1966), and Herrig (1966) there is considerable variation in shape but in all cases *U. marssoni* is



TEXT-FIG. 7. *Uroleberis batei* sp. nov. Paratypes ×160. *a*, internal view of female left valve. Composite but based mainly on HU.62.C.23. *b*, internal view of female right valve. Composite but based mainly on HU.62.C.24. *c*, dorsal view of female carapace, HU.62.C.25.

consistently fatter in dorsal view. *Xestoleberis*? *dimorpha* Donze, 1964 and *X.*? *alta* Donze, 1964 from the Berriasian of the subalpine massifs differ respectively in the less acuminate posterior part in lateral view (although the dorsal aspect is closely similar) and in the dorsal aspect (although the lateral view is similar). These French species apparently have no accommodation groove. The shape of the *Uroleberis* illustrated by Apostolescu (1961) from the Palaeocene of West Africa is more typical of the genus as exemplified by the type species. They show little resemblance to the present species. When the small Mesozoic Xestoleberididae are known in detail it will almost certainly be found advisable to remove *U. batei*, *U. marssoni*, and *U. supplanata* from *Uroleberis* s.s. and place them in a separate genus.

Family SCHIZOCYTHERIDAE Mandelstam, 1960
Subfamily SCHIZOCYTHERINAE Mandelstam, 1960
Genus APATELOSCHIZOCYTHERE Bate, 1972
Apateloschizocythere geniculata Bate, 1972

Plate 9, fig. 8

1972 *Apateloschizocythere geniculata* Bate, pp. 30–32, pl. 7, figs. 5–8; pl. 8, figs. 1–10; pl. 15, fig. 7; text-fig. 17A, B.

1973 *Apateloschizocythere geniculata* Bate; Neale, pp. 297–304.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Female left valve	HU.64.C.2	Pl. 9, fig. 8	0·442	0·260	0·121

Other material. Many valves and carapaces including fifteen mounted as HU.65.C.10.1–15.

Remarks. This species is common at Gingin and may make up as much as 9% of the specimens obtained in any one sample. Bate (1972) recorded this species in all his Santonian and Campanian samples from the Carnarvon Basin and gave a fully illustrated description. All that needs adding is that the abundant Gingin material shows that sexual dimorphism occurs in the adult, the longer, lower forms being interpreted as males (Neale 1973*a*).

Genus ROSTROCYTHERIDEA Dingle, 1969

Rostrocytheridea westraliensis (Chapman, 1917)

Plate 2, figs. 1, 2; Plate 6, fig. 4; Plate 7, figs. 1–3

1917 *Cythere westraliensis* sp. nov.; Chapman, p. 54, pl. XIII, figs. 7, 8.

Holotype. Chapman figured two specimens from Gingin, a male left valve and a female left valve. The slide of his male (CPC 7137), the original of his pl. XIII, fig. 7 (here Pl. 2, fig. 1) carries a red spot and must be regarded as the holotype.

Other material. Valves of adults and a wide range of instars, thirty of which are mounted as HU.65.C.35. 1–30.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, male left valve	CPC 7137 (Chapman, pl. XIII, fig. 7)	Pl. 2, fig. 1	0·99	0·45	0·24
Female left valve	CPC 7138 (Chapman, pl. XIII, fig. 8)	Pl. 2, fig. 2	0·88	0·48	0·24
Male carapace	HU.65.C.32	Pl. 7, fig. 1	0·970	0·406	0·312
Female left valve	HU.65.C.33	Pl. 7, fig. 2	0·877	0·455	0·260
Male left valve	HU.65.C.34	Pl. 7, fig. 3	0·955	0·416	0·234
Juvenile left valve	HU.65.C.36	Pl. 6, fig. 4	0·383	0·253	0·130

Description. Chapman (1917) gave a brief description. The following notes draw attention to a number of salient features. Three well-developed spines occur on the posterior margin (Pl. 7, figs. 1*a*, 2*a*). Chapman's specimens are somewhat eroded in this region and whilst the bases of the upper two spines may be made out, only the ventral one is reasonably well preserved. Traces of this spination may be traced back into the early instars. The anterior margin also bears seven marginal denticles in well-preserved material but these are more susceptible to breakage and attrition (cf. Pl. 7, figs. 1*a*, 2*a*). Sexual dimorphism is very marked, the presumed males being longer and lower than the females.

Ornamentation consists of a number of large pits and a well-developed marginal sulcus anteriorly and posteriorly. Normal pore canals are of sieve type (Pl. 7, fig. 2*d*) with peripheral perforations and central foramen. These are closest to Type C of Puri and Dickau (1969) and are of a type commonly found in the Cytherideinae. Radial pore canals simple, eight posteriorly, nine anteriorly with an additional three

along the anterior part of the ventral margin. Muscle-scar pattern (Pl. 7, fig. 3*b*) of four vertical adductors, large sub-triangular frontal scar, and well-developed, rounded mandibular scar.

Remarks. Rostrocytheridea has only been recorded in the Cretaceous of South Africa and Australia up to the present, and in two of the three species sexual dimorphism is very marked. The present species is unlikely to be confused with Dingle's *R. chapmani* from the Neocomian of South Africa. In 1972 Bate described *R. canaliculata* from the Santonian Toolonga calcilutite of the Carnarvon Basin, a species which is very similar to *R. westraliensis* and is obviously very closely related. His material is small (1 = 0·54–0·60 mm) and no sexual dimorphism was apparent. Nevertheless, like some other species from the Santonian of the Carnarvon Basin, comparison of the material side by side shows a number of differences at comparable sizes. There is no trace of the triple spination posteriorly which is apparent at this size in the Gingin material, the lateral outline of the ventral margin is more convex in Bate's species and the posterior part of the valves gives the impression of being more drawn out in lateral view, allied to which the postero-dorsal margin is more sloping.

R. westraliensis is common at Gingin and usually makes up between 3 and 6% of the specimens recovered.

Family PECTOCYTHERIDAE Hanai, 1957
Genus GINGINELLA gen. nov.

Type species. Ginginella ginginensis sp. nov.

Derivation of name. From its occurrence at Gingin.

Diagnosis. A small pectocytherid genus with well-developed anterior and posterior vestibules, modified pentodont hinge, costate ornamentation, and marked sexual dimorphism. Radial pore canals sparse, straight, about eleven in the anterior half and nine in the posterior half of the valve; possibly better regarded as pseudo-radial pore canals. Marked flange groove anteriorly in the left valve to accommodate the selvage ridge of the right valve.

Remarks. This genus agrees well with the general characters of the family but differs from other genera in the striking costate ornamentation of a type not seen in other pectocytherids. However, the type *Munseyella*, *M. hyalokystis* (Munsey, 1953) from the Palaeocene of Alabama shows vestiges of the basic pattern of costation seen in *G. ginginensis* but with the costation reduced at the expense of the accentuated reticulation. There are other considerable differences, as in the interruption of the anterior marginal sulcus by the ribbing. Nevertheless, the similar development of the anterior and posterior vestibules coupled with the ornamentation leaves little doubt that the two are closely related. Nearer in both space and time, but less close morphologically, is *M. huantraiconensis* (Bertels, 1969) from beds in Argentina regarded as Danian. The postero-dorsal ornamentation shows some similarity to that in *Ginginella* but any affinity is tenuous and at a considerable remove.

The addition of this third new pectocytherid genus to *Paramunseyella* Bate, 1972 and *Premunseyella* Bate, 1972 also confined to Australian Santonian, suggests that Australia was a centre of evolution of the family at this time.

Ginginella ginginensis sp. nov.

Plate 1, fig. 8; Plate 6, figs. 1–3

1917 *Cythereis quadrilatera*, Roemer sp.; Chapman, p. 56, pl. XIV, fig. 14.
1972 Genus A sp. Bate, p. 78, pl. 9, figs. 8–13.

Derivation of name and diagnosis. See above.

Holotype. A male left valve, HU.63.C.6.

Paratypes. A female carapace and two female left valves, HU.63.C.7–9.

Other material. Sixteen valves and carapaces from the Gingin Chalk mounted as HU.65.C.2.31–46.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, male left valve	HU.63.C.6	Pl. 6, fig. 3	0·420	0·212	0·104
Paratype, female carapace	HU.63.C.7	Pl. 6, fig. 2	0·416	0·220	0·192
Female right valve	Specimen lost	Pl. 6, fig. 1	0·403	0·202	—
Female right valve	CPC 7144 (Chapman, pl. XIV, fig. 14)	Pl. 1, fig. 8	0·43	0·24	0·09

Description. Valves small, in side view elongate, tapering posteriorly with the greatest height at the anterior cardinal angle. Dorsal margin gently convex but with a concavity at about three-quarters length which sets off the posterior part of the valve to some extent. Anterior margin symmetrically rounded, ventral margin gently concave to about two-thirds length at which point it swings dorsally to about mid-height where it turns vertically into the posterior margin which curves to join the dorsal margin at the posterior cardinal angle. Ornamentation consists of a marginal rim and costae. The former is not present postero-dorsally and is highest anteriorly and antero-ventrally, lying some distance in from the margin and joining with the end of the lower rib at about two-thirds the length (Pl. 1, fig. 8 and Pl. 6, fig. 1*c*, *d*). The costate pattern is unique. Three ribs form an arrowhead directed anteriorly, meeting in a low swelling which is separated from the marginal rim anteriorly by a well-developed sulcus. The lower rib runs to the postero-ventral corner where the outline of the valve shows the change in orientation of the ventral margin. The median rib is roughly horizontal and gently convex upwards, becoming concave at its posterior end where there is a marked thickening of the rib. The dorsal rib rises upwards posteriorly, turning downwards abruptly at the posterior cardinal angle and also showing a thickening at its posterior extremity.

Surface appears generally smooth under the ordinary optical microscope but S.E.M. examination shows that the intercostal surface may develop reticulation in some well-preserved specimens (Pl. 6, fig. 1*d*). The swelling at the anterior end of the costae is associated particularly with the lower two ribs. Here two marked pits occur, one between the middle and ventral ribs, the other on the ventral side of the ventral rib (Pl. 1, fig. 8; Pl. 6, fig. 1*c*, *d*).

Left valve with well-developed flange groove anteriorly which is reminiscent of *Cypris*, and into which fits the selvage of the right valve. In dorsal view, carapace is rather rectangular with superimposed sagittal outline, the 'arrow' being stepped posteriorly, the more anterior step being formed by the median rib, the posterior one

by the dorsal rib, and the posterior extremity by the ventral margins. Greatest width occurs just behind mid-length.

Sexual dimorphism marked, females higher in proportion to the length than the males in side view, and wider in dorsal view. Hinge modified pentodont. In the left valve large, rounded terminal sockets take the complementary teeth of the right valve, and the median element is a crenulate bar with terminal expansions of which the posterior is the better developed (Pl. 6, fig. 3*c*). These expansions do not show the split into dorsal and ventral parts of the true pentadont hinge, and both expansions turn slightly downwards with respect to the median section of the bar and are crenulate showing evidence of approximately five original denticles. The nature of the teeth in the right valve has been difficult to establish as such a strong hinge, coupled with the small size, means that the majority of specimens are carapaces. Of the remainder the left valves are well preserved but the teeth of the right valves appear to suffer at the time the valves are separated. As far as it is possible to tell, the right valve teeth are rounded, equi-dimensional, and undivided. Anterior and posterior vestibules well developed, the anterior not restricted as in *Paramunseyella* Bate but agreeing more in this respect with some of the Japanese species of *Munseyella* figured by Hanai (1957*a*).

Radial pore canals short, straight, eleven anteriorly (two of which may be considered ventral) and nine posteriorly (three or four of which may be considered ventral). Anteriorly the pore canals do not run to open at the valve margin but to the marginal ridge. Muscle-scar pattern of four vertical adductor scars with a hook-shaped scar anteriorly. The latter was only clearly seen in one specimen (Pl. 6, fig. 3*b*) and suggests two original scars which have scarcely fused. There is also apparently an additional scar between this scar and the dorsal adductor scar.

Remarks. Bate's Genus A sp. belongs here, the largest specimen (Io 4592) being a typical male. The two smaller specimens (Io 4590, 4591) are immature (length 0·37 mm compared with 0·416 mm of typical Gingin females) and show a type of ornamentation found in some immature specimens at Gingin. Here the anterior costation is absent or subdued and the posterior ornamentation relatively accentuated with a curved ridge anteriorly between the posterior parts of the mid- and dorsal rib (Bate 1972, pl. 9, fig. 9). This forms an oblique C in the postero-dorsal quarter of the left valve and a reversed oblique C in the same area of the right valve (Bate 1972, pl. 9, fig. 12).

Neither the genus nor the species is likely to be confused with any other. *Ginginella* is a characteristic but relatively uncommon element in the fauna at Gingin where it generally accounts for between 1 and 2% of the ostracod fauna.

Genus MUNSEYELLA Van den Bold, 1957

Munseyella tuberculata sp. nov.

Plate 1, fig. 6; Plate 22, figs. 2, 4; text-fig. 8*a–d*

1917 *Cythereis tuberosa*, Jones and Hinde; Chapman, p. 56, pl. xiv, fig. 16.

Derivation of name. Tuberculum, Latin—a small swelling or protuberance.

Diagnosis. A species with two medio-dorsal tubercles and generally 'smoothed-out' appearance.

Holotype. A female right valve, HU.62.C.30.

Paratypes. Twenty juvenile and adult valves, HU.62.C.31–35, HU.62.C.36.1–15.

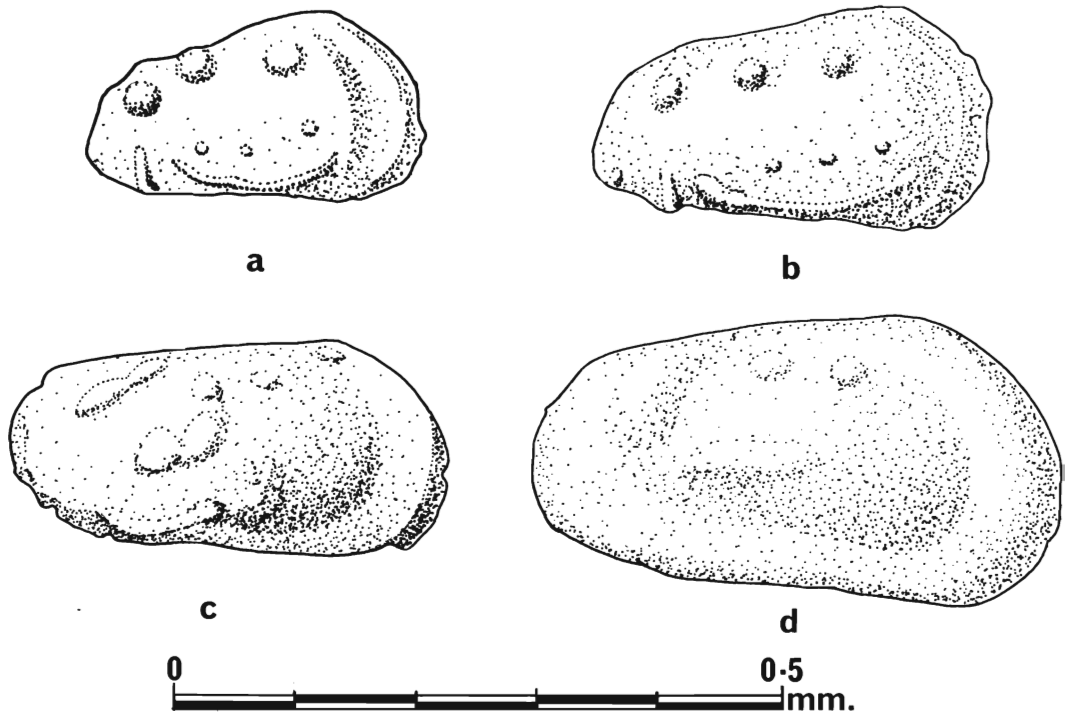
Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female right valve	HU.62.C.30	Pl. 22, fig. 4	0·408	0·231	0·117
Paratype, male left valve	HU.62.C.31	Pl. 22, fig. 2	0·441	0·227	0·120
Paratype, juvenile right valve	HU.62.C.32	Text-fig. 8*a*	0·278	0·160	0·078
Paratype, juvenile right valve	HU.62.C.33	Text-fig. 8*b*	0·324	0·184	0·091
Paratype, juvenile right valve	HU.62.C.34	Text-fig. 8*c*	0·360	0·180	0·110
Paratype, female right valve	HU.62.C.35	Text-fig. 8*d*	0·436	0·240	0·123
Juvenile right valve	CPC 7146 (Chapman, pl. XIV, fig. 16)	Pl. 1, fig. 6	0·30	0·18	0·08

Description. Valves robust, tapering posteriorly with gently convex dorsal margin and slightly concave ventral margin. Anterior margin well rounded with some infracurvature, posterior margin somewhat angular. Greatest height at the anterior cardinal angle, greatest length below mid-height. Adults have a smoothed-out appearance with strong, rounded marginal rim anteriorly and ventrally, a postero-dorsal swelling, two dorsal tubercles in the median part of the valve, and a swollen median ridge in the posterior part of the valve. In dorsal view rather slim with prominent anterior rim; strong, triangular, postero-dorsal tubercle and vaulted median part of the valve associated with the swollen ridge. In this view the two medio-dorsal tubercles are also noticeable. Hinge of pectocytherid type. Nature of marginal areas not worked out because of the thickness of the valves. Sexual dimorphism marked, the rarer males being more elongate in proportion to their height than the females.

Juveniles of this species are commoner than the adults and show considerable variation. They all agree in having the postero-dorsal tubercle and two dorsal tubercles. The smallest instars (text-fig. 8*a*) have an anterior marginal rib and a ventral rib. These do not fuse to form a continuous marginal rib until the immediate pre-adult instar and it is only at this late stage that the postero-median ridge develops and the postero-dorsal tubercle starts to expand to form the more diffuse swelling of the adult (text-fig. 8*c*, *d*). With increase in size, the relative importance of the dorsal tubercles declines so that in the adult they are very subdued and sometimes scarcely discernible. The typical pectocytherid hinge is developed at an early stage.

Affinities and differences. Like *M. tuberculata* a number of species retain traces of two medio-dorsal tubercles through into the adult. *M. morrisi* Triebel, 1957 from the Lower Pleistocene of California has small vertical ridges rather than tubercles and with *M. pedroensis* Triebel, 1957 from the same horizon differs in the absence of a swollen postero-median ridge. Among Japanese species the Upper Pliocene *M. hokkaidoana* Hanai, 1957*a* tapers more strongly posteriorly and lacks the swollen postero-median ridge, while the Recent *M. japonica* Hanai, 1957*a* has the postero-median rib fused to the postero-dorsal swelling. The last species also differs considerably in details of ornamentation and is most easily distinguished by the posterior spine-like projections. The presence of two medio-dorsal tubercles seems fairly widespread in juveniles and can be seen in the *Munseyella* sp. figured by Szczechura (1971) from the Palaeocene of Greenland whose size (1 = 0·39 mm) corresponds to



TEXT-FIG. 8. *Munseyella tuberculata* sp. nov. × 160. Paratypes, right valves in external lateral view. *a*, juvenile, HU.62.C.32. *b*, juvenile, HU.62.C.33. *c*, immediate pre-adult instar, HU.62.C.34. *d*, adult female, HU.62.C.35.

that of the immediate pre-adult of the present species. As in *M. tuberculata* the typical hinge is developed at this small size (Szczechura 1971, pl. 1, fig. 2). As with other genera, the South American species *M. huantraiconensis* Bertels (1969) from the Formacion Roca (regarded as Lower Danian) of Argentina shows less resemblance to the Australian species than other species much further removed such as the Greenland form.

The discovery of this species of *Munseyella* brings the number of pectocytherid genera recognized in the Gingin Chalk to four.

At Gingin this species is rare, on average making up about 0·3% of the fauna.

Genus PARAMUNSEYELLA Bate, 1972 emend. hic

Bate's published diagnosis is here emended to dispense with the anterior marginal ridge with deep furrow behind and the denticulate postero-ventral margin as diagnostic features of the genus.

Paramunseyella austracretacea Bate, 1972

Plate 2, fig. 8; Plate 19, fig. 1; text-fig. 9*a*, *b*

1917 *Cythere lineatopunctata* Chapman and Sherborn; Chapman, p. 54, pl. XIV, fig. 9.
1972 *Paramunseyella austracretacea* Bate, pp. 32–34, pl. 10, figs. 5–13; text-fig. 18A–C.

Unlike other species of Australian pectocytherids, sexual dimorphism has not been recognized in this distinctive species. Some of the more slender forms may be interpreted as males as suggested below but the differences are not clear cut and such suggestions must be regarded with caution. At Gingin *P. austracretacea* is common and forms up to 8% of the ostracod fauna, averaging about 5%. Twenty valves are mounted as HU.67.C.24.1–20.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Female(?) right valve	HU.67.C.21	Pl. 19, fig. 1	0·493	0·292	0·133
Female(?) right valve	HU.67.C.22	Text-fig. 9*a*	0·480	0·286	0·130
Male(?) right valve	HU.67.C.23	Text-fig. 9*b*	0·464	0·268	0·127
Female(?) right valve	CPC 7139 (Chapman, pl. XIV, fig. 9)	Pl. 2, fig. 8	0·41	0·24	0·11

Paramunseyella prideri sp. nov.

Plate 19, fig. 3; Plate 20, figs. 1, 2; text-fig. 9*c–f*

Derivation of name. In honour of Professor Rex Prider of the University of Western Australia for his kindness and help during my stay in Perth.

Diagnosis. A species of *Paramunseyella* with strongly dependent anterior part reflected in the strong infracurvature of the anterior margin and lacking anterior and ventral marginal ridges.

Holotype. A female right valve, HU.67.C.14.

Paratypes. Forty-five specimens mounted as HU.67.C.15–19 and HU.67.C.20.1–40.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female right valve	HU.67.C.14	Pl. 19, fig. 3	0·467	0·266	0·130
Paratype, female left valve	HU.67.C.15	Pl. 20, figs. 1, 2	0·454	0·260	0·123
Paratype, female right valve	HU.67.C.16	Text-fig. 9*c*	0·480	0·279	0·127
Paratype, male right valve	HU.67.C.17	Text-fig. 9*d*	0·483	0·266	0·117
Paratype, female carapace	HU.67.C.18	Text-fig. 9*e*	0·493	0·286	0·232
Paratype, male carapace	HU.67.C.19	Text-fig. 9*f*	0·483	0·260	0·204

Description. Valves slightly reniform in lateral outline, highest at the anterior cardinal angle, which lies at about one-third the length, and tapering posteriorly. Anterior margin dependent with marked infracurvature. Ventral margin slightly concave. No marginal ridge is developed anteriorly or ventrally. In dorsal view sub-hexagonal. Surface punctate (best seen in stained or coated specimens) on the main body of the valve which is demarcated ventrally and separated from the flatter anterior and posterior parts by a curved ridge which corresponds with the ventral outline at mid-length and rises gently anteriorly and posteriorly (Pl. 19, fig. 3). Anterior and posterior parts of the valve smooth and lacking very coarse punctae. Internal structure similar to the type species of the genus. Hinge with rounded terminal sockets in the left valve with a smooth bar between and an accommodation shelf above (Pl. 20, figs. 1, 2). A large tooth occurs at the posterior end of the bar, and the anterior end carries three small

teeth immediately posterior of the anterior socket. Right valve hinge complementary. Large duplicature anteriorly and posteriorly with a small antero-ventral vestibule. Marginal areas very like *P. austracretacea*. Best preserved forms show seven to eight radial pore canals with two or three more false radial pore canals anteriorly and about five posteriorly with again two or three false radial pore canals. Muscle-scar pattern consists of a vertical row of four closely packed adductor scars (Pl. 20, fig. 1) set low in the valve. A rounded frontal scar is present and Plate 20, fig. 2 suggests that there may be two scars between and above the frontal and adductor scars and lying at about mid-height. The interpretation of these last two features as muscle scars is open to doubt however. Sexual dimorphism is clearly marked, the males being slimmer in proportion to the length in both lateral and dorsal view (text-fig. 9*e–f*).

Affinities and differences. P. prideri is unlikely to be confused with any other species. It differs from *P. austracretacea* Bate in lacking the anterior and ventral marginal ridge of that species, in lacking the medioventral projection of the right valve in lateral view, and in the lack of strong lineation on the anterior part of the valve. Bate's Genus B (1972, pp. 78–79) shows a number of features reminiscent of *P. prideri* but differs from the type species of *Paramunseyella* in the weak hinge, weak ornamentation, and lack of an antero-ventral marginal ridge. The necessity for the latter has been removed by the emended diagnosis above, and the weak ornamentation is not considered significant at the generic level. Re-examination of the Carnarvon Basin material confirms that the hinge figured by Bate (1972, pl. 21, fig. 2; pl. 22, fig. 8) is indeed weak and apparently unbroken. Nevertheless, another right valve Io 4621 shows the development of a *Paramunseyella*-type hinge, and what can be seen of the hinge in the left valve Io 4625 agrees well with the situation in *P. prideri* when specimens are placed side by side. Further, the medio-ventral projection (text-fig. 9*g* and Bate 1972, pl. 21, figs. 2, 3; pl. 22, fig. 7) is very reminiscent of that seen in *P. austracretacea*, whilst the tendency to form a ventral bulge of the valve about the mid-length is very like that seen in other members of the genus. There is little doubt in my mind that this should be considered a new species of *Paramunseyella*. Differences from the type species are obvious. It differs from *P. prideri* principally in the more evenly rounded anterior margin which has a gentler antero-dorsal slope and lacks the infracurvature of the former, and the ornamentation of pitting is also less marked, the valves often appearing smooth. It is not proposed to name this form at present.

P. prideri is the commonest of the Pectocytheridae at Gingin where it can form up to 12% of the ostracod fauna recovered and over all accounts for about 7%.

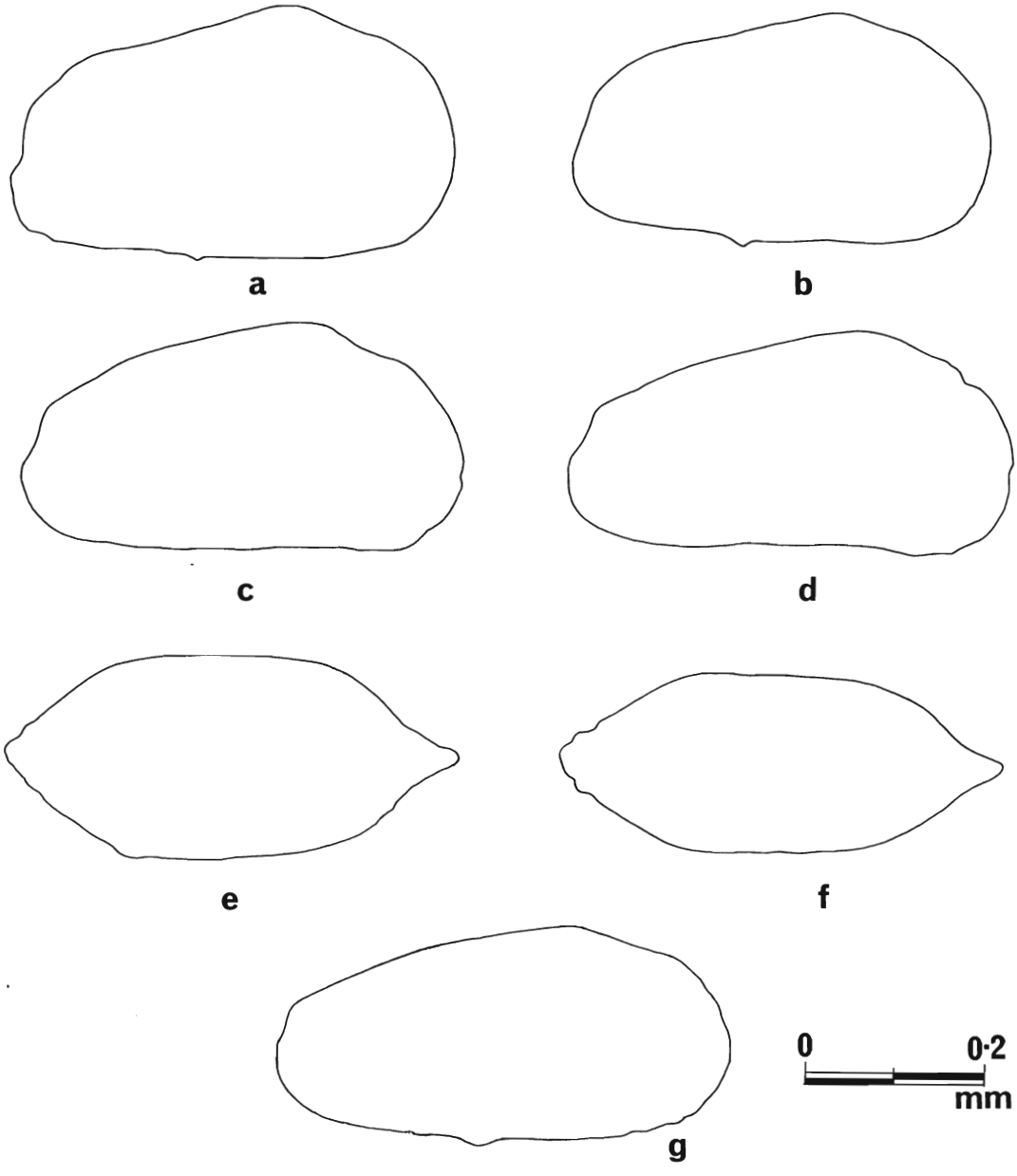
Genus PREMUNSEYELLA Bate, 1972

Premunseyella imperfecta Bate, 1972

Plate 19, fig. 2

1972 *Premunseyella imperfecta* Bate, pp. 36–38, pl. 9, figs. 5–7; pl. 11, figs. 5, 6, 10; text-figs. 19c, 20.

This easily recognizable species was first described from the Campanian further north but not from the Santonian rocks of that area. It does, however, occur at Gingin where it is much rarer than the two species of *Paramunseyella*. On average it makes up just under 1% of the fauna, its maximum incidence being about 1·5%. Ten specimens are deposited as HU.67.C.13.1–10.



TEXT-FIG. 9. Magnification in all cases × 125. 9. *Paramunseyella*. *a–d*, *g*, lateral outlines of right valves. *e*, *f*, dorsal outlines of carapaces. *a*, *Paramunseyella austracretacea* Bate, 1972. Female (?), HU.67.C.22. *b*, *Paramunseyella austracretacea* Bate, 1972. Male (?), HU.67.C.23. *c*, *Paramunseyella prideri* sp. nov. Female, HU.67.C.16. *d*, *Paramunseyella prideri* sp. nov. Male, HU.67.C.17. *e*, *Paramunseyella prideri* sp. nov. Female, HU.67.C.18. *f*, *Paramunseyella prideri* sp. nov. Male, HU.67.C.19. *g*, 'Genus B' Bate, 1972. B.M. (N.H.) No. Io. 4621.

Dimensions of figured specimen.

			Length mm	Height mm	Width mm
Male right valve	HU.67.C.12	Pl. 19, fig. 2	0·493	0·263	0·107

Family PENNYELLIDAE fam. nov.

Type genus. Pennyella Neale, 1974 (Santonian–Maastrichtian).

Other genera. Agulhasina Dingle (1971) (Maastrichtian) and *Agrenocythere* Benson, 1972 (Eocene–Recent).

Diagnosis. Strongly reticulate genera of general trachyleberid shape but without an eye tubercle.

Remarks. This family is introduced for a group of ostracods which stand apart from the typical trachyleberids in their strong reticulation and blindness. The earliest member is *Pennyella* which is a small genus in the Santonian ranging in length from about 0·56 to 0·61 mm in the adult, but increasing in size to reach a length of 0·83 mm in the specimen recorded by Swain (1973) as *Cletocythereis*? from the Maastrichtian of the western Pacific. This and the larger *Agulhasina* (length 1·03 to 1·17 mm) are confined to the South Africa–Australia–Western Pacific area in the Upper Cretaceous. The family become more widespread in Tertiary and Recent times with the development of the genus *Agrenocythere* Benson, 1972. Except for the Recent *A.*? *cadoti*, known from a single locality south of Australia, this genus also shows a general increase in size from lengths of 1·14 to 1·17 mm in the three Eocene to Miocene species to 1·25 to 1·49 mm in the four Pliocene to Recent species. Benson (1972) has shown that *Agrenocythere* becomes a cosmopolitan and deep-water genus from the Oligocene onwards. The muscle-scar pattern in the various genera shows some variation and reference should be made to the original descriptions and figures and text-fig. 11.

Genus PENNYELLA Neale, 1974
Pennyella pennyi Neale, 1974

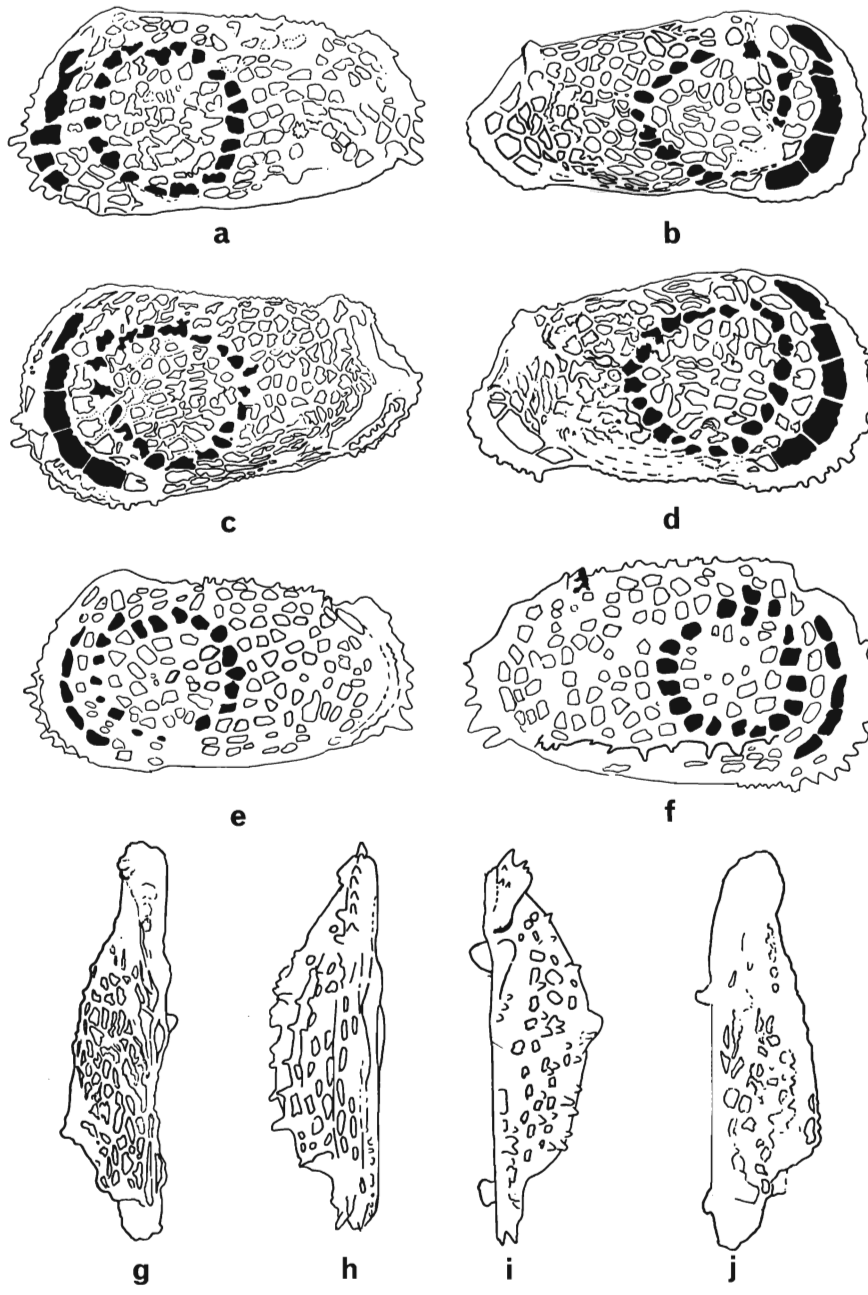
Plate 21, figs. 1, 2; text-figs. 10*b–d, g, j*; 11*a, b*; 16*b–d, f*

1974 *Pennyella pennyi* gen. et sp. nov. Neale, pp. 125–132.

Dimensions of figured specimens.

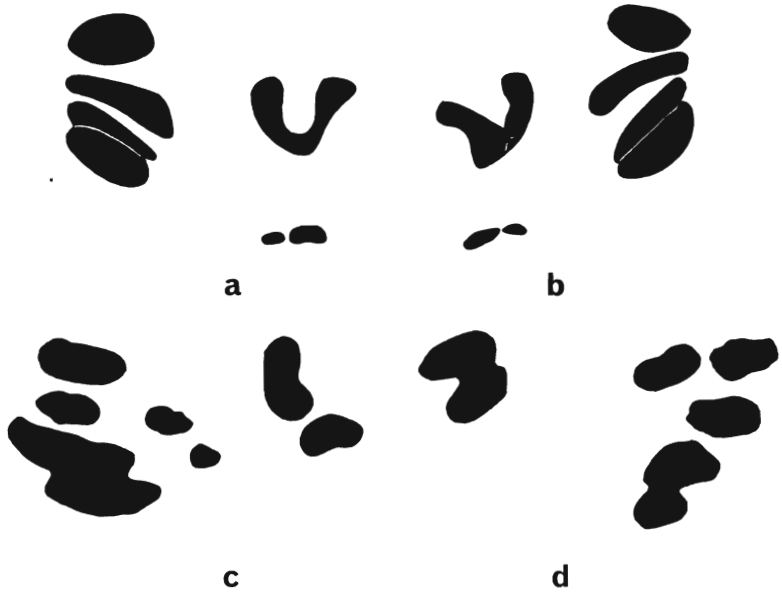
			Length mm	Height mm	Width mm
Holotype, female left valve	HU.67.C.1	Pl. 21, fig. 1; text-fig. 10*c*	0·558	0·351	0·182
Paratype, female left valve	HU.67.C.5	Pl. 21, fig. 2	0·603	0·338	0·156
Paratype, male right valve	HU.67.C.4	Text-fig. 10*b*	0·603	0·286	0·136
Paratype, female right valve	HU.67.C.3	Text-fig. 10*d*	0·584	0·312	0·156
Paratype, female left valve	HU.67.C.9	Text-fig. 10*g*	0·584	0·331	0·156
Paratype, female right valve	HU.67.C.10	Text-fig. 10*j*	0·610	0·331	0·147
Paratype, juvenile left valve	HU.67.C.7	Text-fig. 16*b, d*	0·532	0·314	0·138
Paratype, male left valve	HU.67.C.6	Text-fig. 16*c, f*	0·640	0·336	0·162

Remarks. This beautiful genus is characterized by its typical trachyleberid shape, raised and spinose muri giving a lacework effect, and by the absence of an eye tubercle. The reasons for not regarding *Hystricocythere imitata* Bate as the juvenile of this



TEXT-FIG. 10. Shape and patterns of ornamentation in *Agulhasina quadrata* Dingle, 1971 and *Pennyella pennyi* Neale, 1974. *a*, *e*, *f*, *h*, *i*, *Agulhasina quadrata* Dingle, 1971. *a*, left valve (Dingle, pl. VIII, *b*), *c*. ×47. *e*, left valve (Dingle, fig. 15*g*), *c*. ×44. *f*, right valve (Dingle, fig. 15*a*), *c*. ×47. *h*, ventral view of right valve (Dingle, fig. 15*e*), *c*. ×50. *i*, dorsal view of right valve (Dingle, fig. 15*d*), *c*. ×51. *b*, *c*, *d*, *g*, *j*, *Pennyella pennyi* Neale, 1974. *b*, male right valve, HU.67.C.4, ×88. *c*, female left valve, HU.67.C.1, ×97. *d*, female right valve, HU.67.C.3, ×92. *g*, female left valve, HU.67.C.9, ×92. *j*, female right valve, HU.67.C.10, ×87.

species are given later (p. 68 and text-fig. 16). A number of genera show some similarity. *Spinicythereis* Pokorny, 1964 differs most obviously in possessing an eye tubercle, a dorsal rib, and a downturned postero-ventral termination to the ventral ridge, features well seen in the species figured by Babinot (1973) who regarded *Spinicythereis* as a subgenus of *Trachyleberidea*. *Agulhasina* Dingle, 1971, from the Maastrichtian of Agulhas Bank, is close to the present genus but differs in a number of important features (text-fig. 10*a*, *e*, *f*). It agrees in lacking the eye tubercle and in being generally reticulate and spinose but is less elongate, and in dorsal view the greatest width lies at about the mid-length and not posteriorly as in the arrow-head shaped *Pennyella*. In *Pennyella* the vertical postero-dorsal ridge, the small postero-ventral spine, and the marked anterior and posterior sulci separating the marginal rims are notable features; with thirty radial pore canals anteriorly and twelve posteriorly *Pennyella* has approximately double the number seen in *Agulhasina* where there are fourteen and seven respectively. The muscle-scar pattern also differs, the upper central adductor in *Pennyella* being a long elongate scar and the frontal scar a hook-shaped scar which shows evidence of division into two scars of which the anterior one is the larger and stronger (text-fig. 11*a*, *b*). In *Agulhasina* the upper central adductor is the smallest of the adductor scars, there are two additional scars in front of the two central adductors, and the frontal scars are clearly divided, the posterior one being the stronger and more important (text-fig. 11*c*). The pattern shown in the right valve of *Agulhasina quadrata* differs more widely (text-fig. 11*d*) there being two dorsal adductor scars and the frontal scar having a hemicytherid aspect although



TEXT-FIG. 11. Muscle-scar patterns in *Pennyella* Neale, 1974 and *Agulhasina* Dingle, 1971. *a*, *b*, *Pennyella pennyi* Neale, 1974. *a*, female left valve, HU.67.C.5. *b*, male right valve, HU.67.C.2. *c*, *d*, *Agulhasina quadrata* Dingle, 1971. *c*, left valve (Dingle 1971, fig. 15*k*). *d*, right valve (Dingle 1971, fig. 15*c*). *a*, *b*, × 464. *c*, *d*, enlarged from the published original to approximately × 420.

the original figure is so small that reinvestigation of this valve would be useful. These differences enable the two genera to be easily distinguished although they must be regarded as closely akin. Dingle, himself, regarded *Agulhasina* as most closely related to *Limburgina*, and certainly in *Agulhasina* the central ornamentation of pits is easily considered as a spiral on the same lines as *Limburgina* although the posterior pitting differs considerably (cf. text-figs. 10 and 12). In *Pennyella*, on the other hand, the spiral is much less clear and easy to resolve and a distinct vertical element is becoming apparent in the inner part of the spiral (text-fig. 10*c*, *d*). Other differences in the distribution of ornamentation may be ascertained by reference to the relevant figures. *Agrenocythere* Benson, 1972 is most easily distinguished by its ventral rib and more evenly rounded postero-ventral outline in lateral view. In 1973 Swain described a small fauna from the north-west Pacific on the crest of the Shatsky Plateau. A drill core at 32° 24·5′ N., 158° 01·3′ E. yielded two specimens from Maastrichtian deposits which Swain assigned to *Cletocythereis*? whilst noting that in the beaded reticulate surface ornamentation and small size of the median nodes they were unlike any described species of *Cletocythereis*. These specimens are not *Cletocythereis* and clearly belong in *Pennyella*.

Pennyella pennyi is fairly common in the Gingin Chalk where it forms on average about 1% of the ostracod fauna.

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Genus CYTHEREIS Jones, 1849

This genus is one of the most important in both Lower and Upper Cretaceous rocks, but the type species has been a source of some difficulty. Designated as *Cytherina ciliata* Reuss, one of Jones's originally listed species, by Sylvester-Bradley (1948), this species was regarded as synonymous with *C. ornatissima* Reuss in the Treatise (Sylvester-Bradley 1961). However, the position has been shown to be one of considerable complexity by Pokorny (1963*a*) who found that *C. ciliata* is a *nomen dubium* and that its identity with *C. ornatissima* cannot be proved. Pokorny (1963*a*) gives a full account of the problem and concludes that the genus must be interpreted in the light of *C. ornatissima* Reuss from the Coniacian of Bohemia. This species shows what all workers would regard as typical *Cythereis* features of shape, eye tubercle, central node, and median rib, etc. Reticulation is apparent but not a diagnostic feature of the genus. The strongly amphidont hinge has the anterior and posterior teeth divided into five denticles, i.e. paramphidont (but see p. 56).

Using the hinge structure in diagnosis, however, one encounters considerable difficulty. Typically paramphidont in Lower Cretaceous species, the hinge in what must otherwise be regarded as typical *Cythereis* species, approaches holamphidont in many Upper Cretaceous forms. In many of the Turonian and Senonian species described from France by Damotte (1962, 1964) the anterior tooth in the right valve becomes high and cannot properly be described as crenulate. Bate (1972) notes that *C. brevicosta* from the Santonian in the Carnarvon Basin, Australia, has barely perceptible crenulation in the teeth of the right valve and that it approaches the holamphidont condition. These, and the present sub-species which is

hemi-/holamphidont are so typically *Cythereis* in all other features that it seems unnecessary to coin a new name for them. It is suggested that the diagnosis of the hinge in *Cythereis* be broadened somewhat to include all types of amphidont hinge.

Cythereis brevicosta Bate, 1972, *obtusa* subsp. nov.

Plate 2, figs. 5, 6; Plate 7, figs. 4–7; Plate 8, figs. 1–4

1917 *Cythereis ornatissima*, Reuss sp., var. *nuda*, Jones and Hinde; Chapman, p. 55, pl. XIII, fig. 5; pl. XIV, fig. 11.
1972 *Cythereis brevicosta* Bate (pars); Bate, pp. 57–59, Chapman specimens only.

Derivation of name. Obtusus, Latin—blunt, a reference to the posterior outline in side view.

Diagnosis. A sub-species of *Cythereis brevicosta* with obtuse, almost right-angled posterior outline in side view. Hinge approaching holamphidont with obscure division seen only occasionally in the posterior tooth in the right valve.

Holotype. A male carapace, HU.64.C.3.

Paratypes. Sixteen valves and carapaces HU.64.C.4–7, HU.64.C.8.1–12.

Other material. Over forty other valves and carapaces from the Gingin Chalk.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, male carapace	HU.64.C.3	Pl. 7, fig. 7	0·923	0·507	0·442
Paratype, female right valve	HU.64.C.4	Pl. 7, fig. 4; Pl. 8, fig. 1	0·819	0·442	0·247
Paratype, male right valve	HU.64.C.5	Pl. 7, fig. 5; Pl. 8, fig. 2	0·887	0·442	0·260
Paratype, female carapace	HU.64.C.7	Pl. 8, fig. 3	0·793	0·487	0·416
Paratype, male left valve	Specimen lost	Pl. 7, fig. 6; Pl. 8, fig. 4	0·884	0·507	0·235
Female right valve	CPC 7135 (Chapman, pl. XIII, fig. 5)	Pl. 2, fig. 5	0·83	0·45	0·23
Female left valve	CPC 7141 (Chapman, pl. XIV, fig. 11)	Pl. 2, fig. 6	0·84	0·53	0·25

Description. Shape typical of the genus with straight postero-dorsal margin and gently convex postero-ventral margin which together form an obtuse angle. Surface smooth (non-reticulate) with well-developed sub-central node and a short, straight median rib. The latter is horizontal, median in position, separated from the node, and only about one-fifth the length of the valve. A ventral rib with four or five denticles and a rather flat ventral surface occupies the middle half of the ventral margin; it expands posteriorly where it projects down to form a triangular termination. Anterior marginal inflation not developed (Pl. 7, fig. 6) but there are between eight and twelve small denticles developed along the anterior margin and four or five along the gently convex postero-ventral margin. Flat topped 'ear' well developed in the left valve, its margin swinging round posteriorly to join the marked eye tubercle. Dorsal rib disjunct, separated from the eye tubercle by a smooth sulcus and divided into a short oblique anterior section and an inflated, tuberculate posterior section, the two separated by another smooth area. Hinge hemi-/holamphidont; in the right valve with a massively

buttressed anterior tooth which is narrow and parallel-sided in dorsal view. The rounded, reniform posterior tooth is generally smooth but may occasionally show vestiges of crenulation. Median hinge element in the right valve a deep, round anterior socket with finely locellate groove posteriorly. Marginal areas typical of the genus with about forty radial pore canals anteriorly and twenty posteriorly. Muscle-scar pattern of four vertical adductor scars and anterior hook-shaped scar opening upwards with the long limb of the hook posterior (Pl. 7, fig. 4*b*). Sexual dimorphism very marked.

Remarks. This type of *Cythereis* with non-reticulate surface and well-developed sub-central node and mid-rib is very characteristic in Europe from the Albian onwards.

Bate's *C. brevicosta* is from the Carnarvon Basin further north, and whilst including Chapman's specimens in his species, he noted that they differed in lateral posterior outline which he attributed to their smaller size. Chapman's specimens are, however, full grown and this difference in outline is consistent and the easiest way of differentiating the two sub-species. In the new sub-species the postero-dorsal and postero-ventral margins meet at more than 90°, whilst in *C. brevicosta* s.s. this angle is acute and less than 90°. The differences Bate noted between *C. brevicosta* and *C. nuda* Jones and Hinde (1890) and *C. blanda* Kaye (1963) apply in the case of *C. brevicosta obtusa* also. Damotte's (1962) *C. cuvillieri* from the Turonian of France differs in the more elongate sub-central node and more oblique mid-rib. *C. glabrella minuera* Gründel subsp. (1964) appears similar in side view but is very different in dorsal view (cf. Gründel, pl. 1, fig. 2 with Pl. 7, fig. 6). *C. arabica* Bischoff (1963) and its subspecies from the Albian of the Lebanon is most easily distinguished by the great development of the marginal rim anteriorly. Other species are less close. *C. brevicosta obtusa* is a consistent element in the Gingin fauna of which it makes up 1–3%.

Genus HERMANITES s.l. Puri, 1955

Hermanites, based on *H. reticulatus* (Puri) 1953*b*, presents considerable difficulties in interpretation. *H. volans*, described below, differs considerably from the type species but is close to forms such as *H. haidingeri* (Reuss) which Van Hinte (1962) placed in this genus and figured from the Burdigalian of Bazadais, France, although lacking the reticulate ornamentation. In dealing with *H. sagitta* from the Carnarvon Basin, a species showing a number of similar features and presumably related to *H. volans*, Bate discussed the problems in the interpretation of Puri's genus. His remarks are applicable in the present case. In addition, in the present instance one should draw attention to the marked alation, the lack of reticulation on the main body of the valve, together with the development of spinose ornamentation all more reminiscent of genera such as *Alatacythere* or *Pterygocythereis*. From those two genera, *H. volans* differs in the development of a prominent sub-central tubercle. The new species appears to be the earliest known representative of the essentially Tertiary and Recent *Hermanites* plexus with hook-shaped frontal scars. The differences from *Hermanites* are such that when more abundant material is available and the Tertiary forms of *Hermanites* have been studied in detail, it will probably be worthy of a new generic name.

Hermanites volans sp. nov.

Plate 11, fig. 4; Plate 12, figs. 5–7; Plate 13, fig. 3

Derivation of name. Volans, Latin—flying, a reference to the alate ventral rib.

Diagnosis. A species with well-marked alae formed by the ventral ribs which have six depressions between short vertical costae on their dorsal side and terminate posteriorly in a short spine; surface with small scattered spines.

Holotype. A female left valve, HU.64.C.14.

Paratypes. A male left valve, HU.64.C.15; a female right valve, HU.64.C.16; a male left valve and juvenile left and right valves, HU.64.C.17.1–3; juvenile right valve, HU.65.C.2 and ten adults and juveniles, HU.65.C.1.1–10.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female left valve	HU.64.C.14	Pl. 12, fig. 6	0·747	0·416	0·292
Paratype, male left valve	HU.64.C.15	Pl. 11, fig. 4; Pl. 12, fig. 5	0·780	0·416	0·273
Paratype, female right valve	HU.64.C.16	Pl. 12, fig. 7	0·741	—	—
Juvenile right valve	HU.67.C.11	Pl. 13, fig. 3	0·389	0·221	0·110

Description. Carapace rectangular in side view with prominent eye tubercles. A narrow blade-like ridge follows the anterior margin, with inside it a row of well-developed denticles (Pl. 12, fig. 5*c*) and there are five or six short spines along the posterior margin. The sub-central tubercle carries a short spine. Dorsal ridge not developed, being replaced by a mediodorsal, stumpy, flat, triangular spine and a short postero-dorsal spine. Ventral rib expanded to form a flat-bottomed ala, whose dorsal side shows six pits or depressions between seven short vertical costae. This ventral rib terminates posteriorly in a flat spine which affects the outline, and the posterior margin of the ala carries one or two additional spines. Surface not reticulate but with scattered small spines or pustules.

Hinge holamphidont. Muscle-scar pattern of typical trachyleberidinid type (Pl. 12, fig. 5*b*) with hook-shaped frontal scar in front of four vertical adductor muscles. About twenty straight, radial pore canals are present anteriorly, associated with the fine spination along the anterior margin. Sexual dimorphism occurs with the presumed males longer and lower in proportion to the length than the females.

The immediate pre-adult stage resembles the adult but the earlier instars are much simpler. Their valves are relatively thin and the scattered normal pore canals appear white but they have the characteristic postero-dorsal spine and the ventral and lateral surfaces meet in a curved ridge which represents the developing ala (Pl. 13, fig. 3). At this stage they are very reminiscent of the young of *Pterygocythereis phylloptera* (Bosquet) as figured by Herrig (1966, fig. 80*c*).

Remarks. Bate's *H. sagitta*, which is essentially Campanian, is related but differs in many respects. It is noticeably different in developing reticulate ornamentation, in the lesser development of the alae, and the lesser separation of the anterior and posterior parts of the shell from the ala in dorsal view (cf. Pl. 12, figs. 5*a*, 6*b* and Bate 1972, pl. 24, fig. 5 and text-fig. 32c).

H. volans is rare at Gingin.

Genus LIMBURGINA Deroo, 1966

Limburgina aurora sp. nov.

Plate 2, fig. 9; Plate 11, figs. 5–7; Plate 21, fig. 3; text-fig. 12*e*, *g*

1917 *Cythereis ornatissima*, Reuss sp.; Chapman, p. 55, pl. XIV, fig. 10.

Derivation of name. *Aurora*, Greek—goddess of the dawn, a reference to its early occurrence compared with other species of the genus.

Diagnosis. A species with strong reticulation and spinose muri, sub-central tubercle with accentuated vertical element and posterior sulcus, and short, median longitudinal rib.

Holotype. A male left valve, HU.63.C.27.

Paratypes. Two female left valves, HU.63.C.28.30; male right valve, HU.63.C.29; male left valve, HU.63.C.31; and twenty specimens mounted as HU.63.C.32.1–20.

Other material. A considerable number of specimens both unmounted and in faunal slides HU.64.C.1, HU.65.C.5, 6.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, male left valve	HU.63.C.27	Pl. 11, fig. 6	0·861	0·435	0·240
Paratype, female left valve	HU.63.C.28	Pl. 11, fig. 7	0·825	0·458	0·202
Paratype, male right valve	HU.63.C.29	Pl. 11, fig. 5	0·861	0·435	0·240
Paratype, female left valve	HU.63.C.30	Pl. 21, fig. 3; text-fig. 12*e*	0·805	0·460	0·266
Paratype, male left valve	HU.63.C.31	Text-fig. 12*g*	0·974	0·497	0·299
Female right valve	CPC 7140 (Chapman, pl. XIV, fig. 10)	Pl. 2, fig. 9	0·91	0·49	0·23

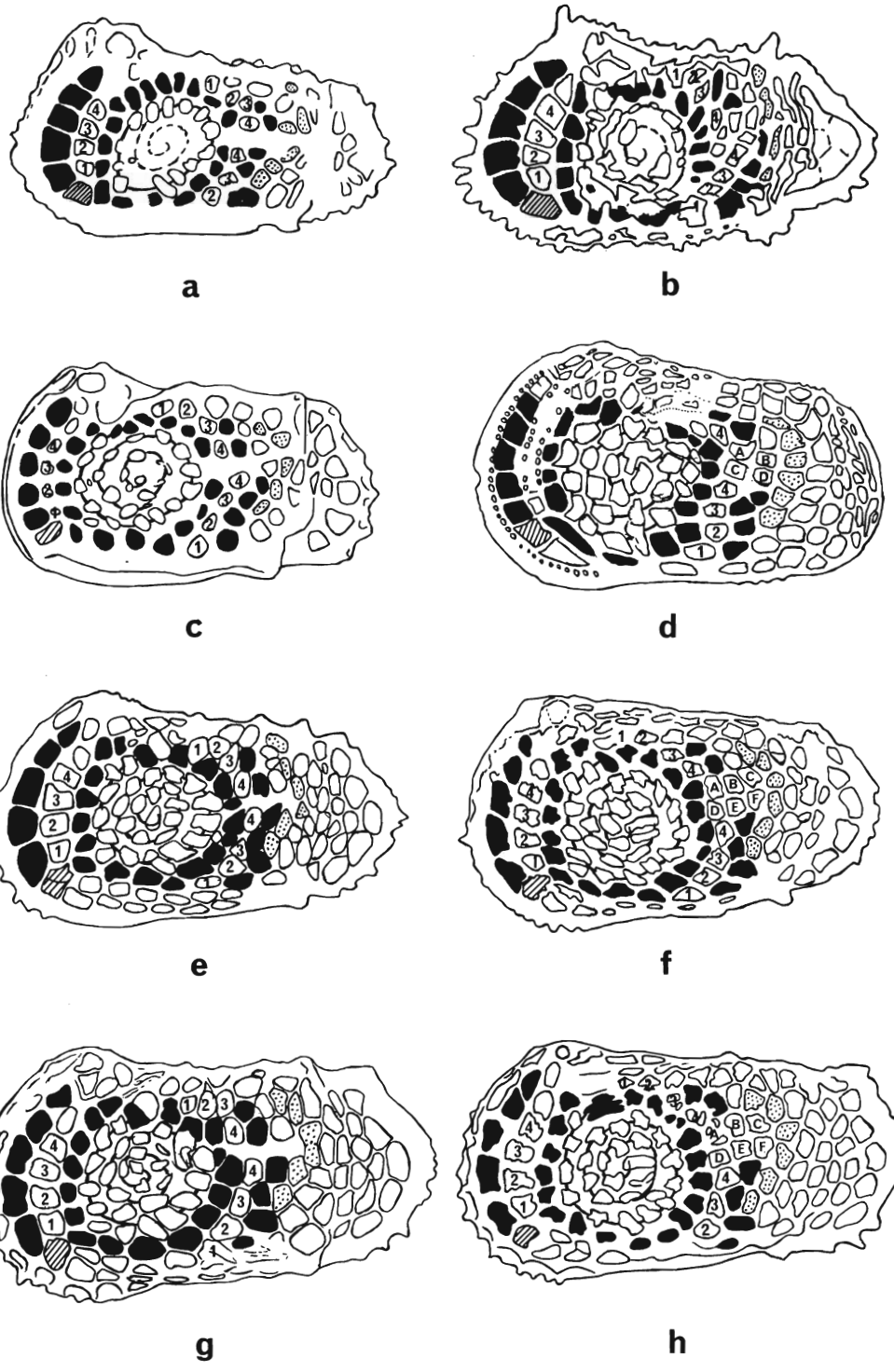
Description. In lateral view of typical '*Cythereis*' shape tapering slightly posteriorly with sub-parallel dorsal and ventral margins, rounded anterior margin with slight infracurvature and triangular posterior extremity. Anterior margin and anterior marginal rib armed with short spines and there is a similar development posteriorly. Surface ornamentation of strong reticulation, the muri developing short spines which project into the fossae. The sub-central tubercle is accentuated posteriorly with a dominant vertical element with sulcus posterior to it (Pl. 11, figs. 6*b*, 7*b*). There is a prominent short, median, longitudinal ridge in the posterior part of the valve (Pl. 2, fig. 9; Pl. 11, figs. 6*c*, 7*c*) which is characteristic. A ventro-lateral ridge is developed with two downturned tubercular spines posteriorly and there are three short dorsal spines. The eye tubercle is large and well developed.

In dorsal view the general sub-hexagonal shape is modified by the post-tubercular sulcus and the compressed anterior and posterior extremities. Hinge holamphidont with rounded knob-like anterior tooth in the right valve (Pl. 11, fig. 5*b*), rounded elliptical tooth posteriorly (Pl. 11, fig. 5*a*) and median element of anterior socket and smooth postjacent groove. Left valve hinge complementary. Vestibules absent; between thirty and forty fine marginal pore canals present anteriorly (thirty-eight to forty in large adults) and about fifteen posteriorly. Muscle-scar pattern difficult to see clearly but in at least one specimen the development of a separate small scar postero-dorsally of the frontal scar, a characteristic of *Limburgina*, seems to occur. Sexual dimorphism very marked, the more elongate forms being interpreted as males.

Remarks. The generic assignment of this new species is difficult. A large number of species of this general shape and ornamentation has been described from the Cretaceous System, most commonly under the generic appellation *Cythereis*. Sylvester-Bradley (1961) in the Treatise cites as characteristic the paramphidont hinge, the general ornamentation varying widely from reticulate through costate to spinose. Whilst Lower Cretaceous species such as the Hauterivian *C. senckenbergi* have strongly divided terminal hinge elements, this is not so in the case of Upper Cretaceous forms which include the type species. Pokorny (1963*a*) gave a very detailed description of *Cythereis ornatissima* (Reuss, 1846) the type species from the Coniacian of Lužice. Pokorny describes the hinge as 'right valve at both ends with a terminal tooth. The median element is subdivided into an anterior socket and a posterior groove. The anterior tooth is well preserved only in two left female valves of the typical locality in our material. In dorsal view they have a roughly symmetrical, highly parabolic outline, or an outline of a parabola with truncated apex. They are divided by four incisions into five denticles. Two of the denticles are on the anterior slope and three form the apex. The posterior outline of the tooth is smooth in dorsal view. Posterior tooth strong, in dorsal view asymmetrical, with its anterior slope inclined towards the contact of the valve under an angle of 45° and with a nearly perpendicular posterior slope. In one specimen its division into five denticles can be seen.' From this the hinge may be regarded as paramphidont, but to judge from the description and figures the division of the terminal elements is slight and difficult (sometimes impossible) to make out and the distinction from holamphidont is a fine one. In 1966 Deroo established the genus *Limburgina*, based on *Cypridina ornata* Bosquet, 1847, for European Maastrichtian forms in which the hinge has a higher than long anterior tooth with a smooth apex and a trilobed posterior tooth, and in which the hook-shaped anterior muscle scar has an oval scar above it posteriorly, formed by the hook-shaped scar of *Cythereis* type splitting into two. Whilst the distinction between Lower Cretaceous species of *Cythereis* and Maastrichtian species of *Limburgina* is clear and easy to make on these grounds, the distinction between the latter and the type *Cythereis* from the Coniacian is so fine as to be very subjective.

L. aurora was placed in *C. ornatissima*, the type species of *Cythereis*, by Chapman (1917) and reference to Pokorny's figures shows that it is very close to members of the *C. ornatissima* plexus. It differs principally in the accentuation of the reticulate ornamentation and the suppression of the tuberculation. Stratigraphically it occupies an intermediate position between the Coniacian horizon of the *Cythereis* type species and the Maastrichtian of the type *Limburgina*. *L. aurora* most resembles a species from the Carnarvon Basin of Western Australia which Bate called *Limburgina formosa*.

TEXT-FIG. 12. Patterns of ornamentation in left valves of *Cythereis*, *Limburgina*, and *Scepticocythereis*. *a*, *Cythereis longaeva longaeva* Pokorny, 1963*a*. Upper Turonian, Kostice, Bohemia, *c.* ×61. From Liebau 1969, pl. 2, fig. 2. *b*, *Cythereis ornatissima* Reuss, 1846. Coniacian, Sicily, *c.* ×65. From Benson 1971, pl. 5, fig. 2. *c*, *Limburgina ornata* (Bosquet, 1847). Upper Maastrichtian, Maastrichter Tuffkreide, Holland, *c.* ×61. From Liebau 1969, pl. 2, fig. 1. *d*, *f*, *h*, *Scepticocythereis ornata* Bate, 1972. Santonian, Gingin Chalk, Gingin, Western Australia. *d*, juvenile, HU.63.C.36, ×118. *f*, female, HU.63.C.33, ×77. *h*, male, HU.63.C.34, ×70. *e*, *g*, *Limburgina aurora* sp. nov. Santonian, Gingin Chalk, Gingin, Western Australia. *e*, female, HU.63.C.30, ×75. *g*, male, HU.63.C.31, ×67.


a
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Whilst agreeing with this generic placing, the original reasons for it were not made clear since the supposedly characteristic oval muscle scar associated with the posterior part of the hook-shaped anterior muscle scar was not observed in *L. formosa*, and although Bate remarks that the genus differs from *Cythereis* in possessing a hemi-amphidont hinge, he notes that in *L. formosa* the hinge is paramphidont but not very far removed from holamphidont. From the above remarks it may be concluded that minor variations in hinge structure and muscle-scar pattern are poor discriminators between the two genera at this intermediate level (Santonian and Campanian). On the evidence so far outlined both Australian species could well be placed in either genus. However, Liebau (1969, 1971) has published detailed analyses of ornamentation patterns in trachyleberids and related ostracods and it would seem that detailed studies of this nature offer the best chance of splitting the species of *Cythereis* and its allies up into groups of manageable size. Liebau published excellent figures of *L. ornata* (Bosquet) and *C. longaeva longaeva* Pokorny which have been utilized here in text-fig. 12*a*, *c*. Ornamentation in Pokorny's figure of *C. ornatissima* from the type area is so faint that it cannot be used, but Benson (1972) in his work on the *Bradleya* problem adopted a similar approach to Liebau and figured *C. ornatissima* from the same general horizon (Coniacian) as the type but from Sicily. This figure has been used in text-fig. 12*b*. Liebau's notation for the fossae has not been employed since in this study of a limited number of genera a somewhat different approach proved more convenient in bringing out the essential differences. Here the fossae are considered as a spiral centred on the sub-central tubercle. The first three and a half whorls of the spiral consist of twenty-five or twenty-six fossae and the following whorl is indicated in black on the figure. In addition two rows of fossae may be discerned anteriorly and a number of rows posteriorly. This basic pattern is common to *Cythereis*, *Limburgina*, and *Scepticocythereis* but in *Cythereis* the spiral pattern is not so clearly developed. This is due to both the lesser development of the reticulate pattern and the greater accentuation of the sub-central tubercle. It may be recognized to a greater degree in *C. ornatissima* which is nearer to *Limburgina*, than in *C. longaeva longaeva* where this central field might even be better regarded as a series of concentric circles than as a spiral. Other obvious differences occur in the development of the second anterior row of fossae which in *L. ornata* continues dorsally towards the eye tubercle, and in the greater regularity of the posterior rows of fossae. In all these features the Australian species agree more with *Limburgina* than *Cythereis* and the new species is placed in Deroo's genus. *Scepticocythereis* is discussed later.

Affinities and differences. L. aurora agrees with *L. formosa* Bate in having spinose muri but differs in the greatest length lying somewhat lower in proportion to the height, in a lower over-all height : length ratio and in the postero-dorsal margin being less steep. Among the species of *Cythereis* from the Lebanon figured by Bischoff (1963) only the Albian *C. fahrioni* shows any resemblance and besides detailed differences in the ornamentation it is most easily distinguished from the present species by the convex posterior half of the dorsal margin in lateral view. Among European species the greatest resemblance is with *C. zygopleura* Pokorny (1965) and the various subspecies figured by Herrig (1967*b*). Dorsal outlines are exceedingly close, particularly with the Upper Coniacian *C. zygopleura* (cf. Herrig 1967*b*, fig. 5*a* with Pl. 11,

figs. 6*a*, 7*b*). In lateral view the general pattern of ornamentation is similar although differing in detail and the two species are most easily distinguished by reference to the anterior margin which in lateral view is steeper in its dorsal section in *C. zygopleura* than in *L. aurora*. *L. aurora* is not close to any of Herrig's (1966) Lower Maastrichtian species nor to any of Deroo's (1966) Maastrichtian *Cythereis*. Ornamentation is nearer to Deroo's *Limburgina* species but the left valves of *L. aurora* are more triangular posteriorly in side view. Differences from the *C. ornatissima* plexus have already been noted.

L. aurora is common at Gingin where it may, on occasion, form almost 10% of the fauna. Its usual abundance appears to lie between 2 and 5%.

Genus RAYNERIA gen. nov.

Type species. Rayneria ginginensis sp. nov.

Derivation of name. In honour of Dr. D. H. Rayner of the University of Leeds for her work on Upper Palaeozoic stratigraphy.

Diagnosis. A hemi- to holamphidont, strongly tricostate genus with smooth intercostal areas which carry a few pustules. The carapace is rather narrow in dorsal view and the inner margin and line of concrescence appear coincident; the anterior and posterior radial pore canals are long, narrow, and flexuous. The genus exhibits sexual dimorphism.

Remarks. Rayneria bears a general resemblance to a number of earlier tricostate genera such as *Protocythere* and *Cythereis* but differs in the lack of a strong subcentral tubercle and in the hinge. As is common in this type of hinge, the posterior element in the right valve causes some difficulty in interpretation. In well-developed specimens the posterior tooth in dorsal view presents a smooth, elliptical appearance. In side view it appears triangular or rhomboidal and there is a suggestion that it was formed by the fusion of two or three original denticles. This suggestion of subdivision is accentuated in eroded and weathered specimens. Consequently the hinge is here considered to be dominantly holamphidont but with hemiamphidont vestiges. The anterior marginal spination and anterior part of the hinge are reminiscent of Triebel's *Platycythereis* as is the rather narrow carapace, but the pattern of ornamentation is completely different and the nature of the anterior marginal area is much more akin to that of *Cythereis bekumensis* figured by Triebel (1940). The new genus differs from *Phacorhabdotus* in a number of features, most particularly in the costation being centrally and not posteriorly placed. This latter feature is quite characteristic of both the original material of Howe and Laurencich (1958) and of the European specimens figured by Pokorny (1963*b*). The presence of a glassy eye tubercle in *Rayneria* is a further differentiating criterion.

Ornamentation is more akin to some of the Tertiary trachyleberidinids such as *Costa* and its allies covered by Sissingh (1971) of which it appears to be a harbinger. The pustules found on the intercostal surfaces are reflected in recent species of *Carinocythereis* figured by Uffenorde (1972). The new genus is most easily differentiated from *Costa* by the short median rib and nature of the intercostal areas, from *Falunia* by the hinge and much simpler rib pattern, from *Hiltermannicythere*

and *Cistacythereis* by the lack of any connection between the median and anterior ribs, and from *Carinocythereis* by the lack of fenestrate costae. Comparisons with other genera are not close and *Rayneria* appears to occupy an intermediate position between the older Mesozoic genera and the more modern taxa of the *Costa* plexus.

Rayneria ginginensis sp. nov.

Plate 1, fig. 7; Plate 12, figs. 1–4

1917 *Cythereis ornatissima*, Reuss sp., var. *stricta*, Jones and Hinde; Chapman, p. 55, pl. XIV, fig. 13.

Diagnosis. A species of *Rayneria* with high, blade-like ribs.

Holotype. A female left valve, HU.64.C.9.

Paratypes. Twelve valves and carapaces mounted as HU.64.C.10–13, HU.65.C.6.8–15.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, female left valve	HU.64.C.9	Pl. 12, fig. 1	0·663	0·377	0·182
Paratype, male right valve	HU.64.C.10	Pl. 12, fig. 2	0·663	0·351	0·195
Paratype, female right valve	HU.64.C.11	Pl. 12, fig. 3	0·663	0·370	0·182
Paratype, female left valve	HU.64.C.12	Pl. 12, fig. 4	0·663	0·364	0·182
Male carapace	CPC 7143 (Chapman, pl. XIV, fig. 13)	Pl. 1, fig. 7	0·69	0·38	0·32

Description. In side view rounded rectangular with sub-parallel dorsal and ventral margins, rounded anterior margin, convex postero-ventral margin, and concave postero-dorsal margin. Anterior margin with seven or eight flat, triangular, downward-curving spines of which six are clearly visible in external lateral view. Spines are developed antero-dorsally and postero-ventrally, and in well-preserved material a small spine is developed at the junction of the postero-dorsal and postero-ventral margins. The postero-ventral margin is armed with some six short spines directed externally. Costae high and knife-like. A prominent marginal ridge follows the anterior half of the dorsal margin, the anterior margin, and the anterior two-thirds of the ventral margin. It carries prominent, glassy eye tubercles at the anterior cardinal angles (Pl. 12, fig. 4*a*, *e*). Thin, sharp dorsal, median, and ventral sub-horizontal costae complete the principal ornamentation and occupy approximately the middle third of the valve. Surface with a few pustules (Pl. 1, fig. 7; Pl. 12, figs. 3*a*, 4*a*, *e*) but otherwise smooth. Sub-central tubercle not noticeable in lateral view but appearing as a subdued bulge of the general surface in oblique view (Pl. 12, fig. 4*e*). In dorsal view the carapace is parallel sided with the anterior and posterior third very compressed (Pl. 12, figs. 1*b*, 4*c*). In this view the dorsal rib flares posteriorly and is armed with a small spine (Pl. 12, fig. 1*b*) and the median and ventral ribs terminate abruptly posteriorly and each end in a short point. Internally the valves have a deep sub-central pit with four vertically disposed adductor muscle scars on the posterior side. The anterior muscles have not been clearly seen although it is believed that the frontal scar is hook-shaped. Marginal areas relatively wide, but inner margin and line of concrescence apparently coincident with consequent lack of vestibules. Radial pore canals fine, flexuous, and long. About twenty anteriorly and half that number

posteriorly. Hinge holamphidont with vestiges of the hemiamphidont condition. Anterior tooth strongly buttressed, parallel-sided in dorsal view, with rounded postjacent socket and median locellate groove. Posterior tooth as described above. Marked sexual dimorphism, the higher forms being interpreted as females.

Remarks. R. ginginensis is unlikely to be confused with any other species. Never very common, it can on occasion make up to 2% of the Gingin Chalk fauna.

Genus SCEPTICOCYTHEREIS Bate, 1972

Scepticocythereis is a monotypic genus established by Bate (1972) for *Cythereis*-type forms with indistinct sub-central swelling, lacking the anterior marginal ridge of that genus and with the lateral ridges virtually absent. In addition Bate thought that the radial canals were short and few and that the muscle-scar pattern was distinctive. Excellent material from Gingin has permitted the observation of the marginal areas in a considerable range of material and these are virtually indistinguishable from those of *Limburgina aurora* with some thirty-five to thirty-six marginal pore canals anteriorly and fifteen to seventeen posteriorly. The pattern of ornamentation is also very similar to that species, the posterior median rib of *L. aurora* being replaced by two rows of three pits in *S. ornata*. The muscle-scar pattern appears to be the only useful distinguishing feature and because of the smoothed out sub-central tubercle, the four adductor scars, which have a very characteristic fused appearance, can often be seen on the outside of the shell. The frontal scar is essentially as described by Bate but its interpretation presents difficulties. It may simply represent a fused version of the situation seen in *L. pseudosemicancellata* (van Veen) as figured by Deroo (1966, pl. XXIV, fig. 750). Here, Bate's taxon is retained at generic level for this original species but in future it may be found advisable to emphasize its affinities by regarding it merely as a sub-genus of *Limburgina*.

Scepticocythereis ornata Bate, 1972

Plate 2, fig. 10; Plate 21, fig. 4; text-fig. 12*d*, *f*, *h*

1917 *Cythereis ornatissima* Reuss sp., var. *reticulata* Jones and Hinde; Chapman, p. 55, pl. XIV, fig. 12.

1972 *Scepticocythereis ornata* Bate, pp. 68–70, pl. 26, figs. 1–8; pl. 27, figs. 11, 12; text-fig. 37A–F.

This species is easily recognized by its straight dorsal margin, absence of a prominent anterior cardinal 'ear', together with characteristic reticulate pattern of ornamentation (text-fig. 12*f*, *h*).

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Female left valve	HU.63.C.33	Pl. 21, fig. 4; text-fig. 12*f*	0·779	0·441	0·260
Male left valve	HU.63.C.34	Text-fig. 12*h*	0·915	0·467	0·247
Juvenile left valve	HU.63.C.36	Text-fig. 12*d*	0·493	0·312	0·130
Male carapace	CPC 7142 (Chapman, pl. XIV, fig. 12)	Pl. 2, fig. 10	1·00	0·50	0·45

Remarks. Detailed studies of ornamentation have proved invaluable in determining the juveniles of this species. Small, spinose, reticulate specimens which were at first confused with *Hystrichocythere imitata* Bate, were found on analysis to have the pattern of ornamentation characteristic of the present species (text-fig. 12*d*), the only difference being that at the stage investigated pits C and F of the two median rows had not developed. The adults are not likely to be confused with any other species.

S. ornata is a common species at Gingin and is restricted to the Santonian in the Carnarvon Basin further north. At Gingin it forms about 5% of the fauna on average. Besides the figured specimen, twenty valves are mounted as HU.63.C.35.1–20.

Genus TRACHYLEBERIS Brady, 1898

Bate (1972) recorded the genus from the Campanian and Coniacian. The present work extends its range back into the Australian Santonian. *Trachyleberis* presents difficulties in interpretation because of the considerable difference between the early instars and the adults, the varying spination and its susceptibility to erosion, dimorphism, and the varying preservation. Two species are recognized at Gingin.

Trachyleberis raynerae sp. nov.

Plate 2, fig. 7; Plate 10, figs. 1–5; text-fig. 13*c–e*

1917 *Cythereis rudispinata* Chapman and Sherborn; Chapman, p. 56, pl. XIV, fig. 15.

Derivation of name. In honour of Dr. D. H. Rayner for her contributions to Upper Palaeozoic stratigraphy.

Diagnosis. A species of *Trachyleberis* with prominent eye tubercles, a double row of spines anteriorly, and a single, trifid, well-developed postero-dorsal spine in front of the postero-dorsal angle. Surface of valve with cylindrical, castellated spines resembling a castle tower, ventro-lateral row of spines with accentuated posterior spine which is generally bifid or trifid. Sub-central tubercle usually tri-spinose. Marked sexual dimorphism.

Holotype. A male right valve, HU.63.C.10.

Paratypes. Female right valves, HU.63.C.11, HU.65.C.5.13; female left valves, HU.63.C.12.13; male carapace, HU.65.C.5.14; and five valves mounted as HU.63.C.14.1–5.

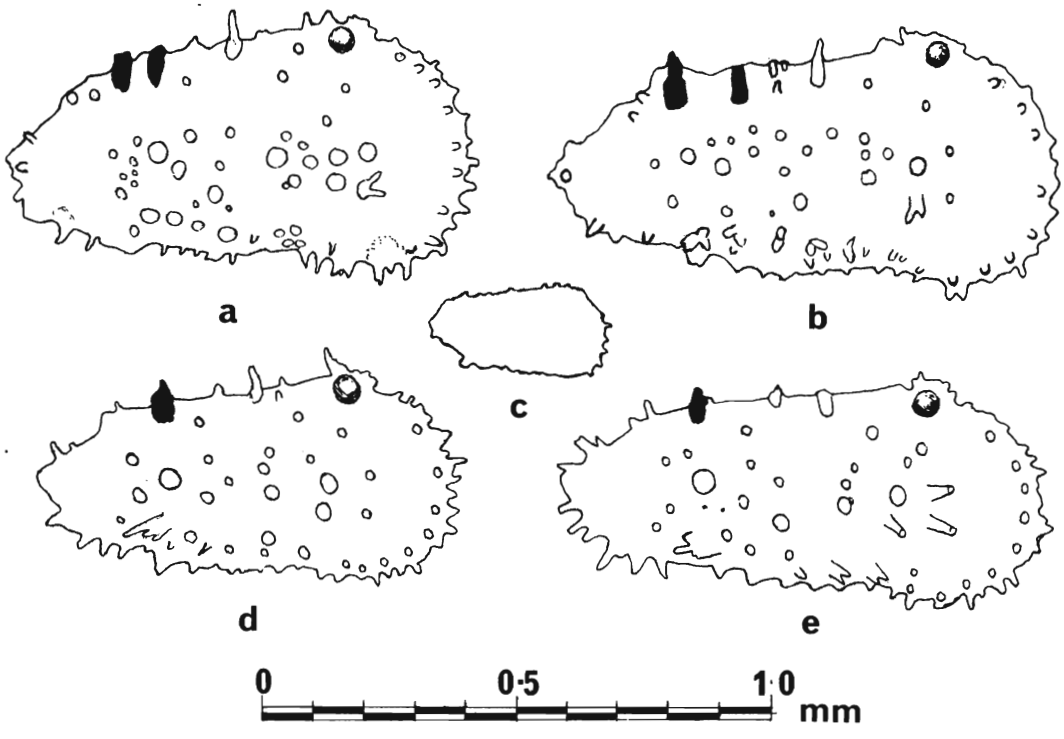
Other material. A considerable number of valves and fragments including twenty-nine mounted as HU.65.C.25.26 and fifteen juvenile valves as HU.63.C.16.1–15.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, male right valve	HU.63.C.10	Pl. 10, fig. 3; text-fig. 13*e*	0·942	0·461	0·247
Female left valve, penultimate instar	Specimen lost	Pl. 10, fig. 1	0·845	0·455	—
Paratype, female right valve, penultimate instar	HU.63.C.11	Pl. 10, fig. 2; text-fig. 13*d*	0·845	0·468	0·266
Paratype, female left valve	HU.63.C.12	Pl. 10, fig. 4	0·965	0·546	0·325
Paratype, female left valve	HU.63.C.13	Pl. 10, fig. 5	0·910	0·507	0·247
Juvenile right valve	HU.63.C.15	Text-fig. 13*c*	0·365	0·180	0·117
Male left valve, ?penultimate instar	CPC 7145 (Chapman, pl. XIV, fig. 15)	Pl. 2, fig. 7	0·88	0·45	0·20

Description. Shape typically trachyleberid. In lateral view, anterior margin evenly rounded in right valve, but with straighter antero-dorsal portion in left valve. Posterior part triangular with greatest length at about mid-height. Prominent eye tubercle. Two sturdy rows of spines occur anteriorly, one marginal, the other external to this and projecting outwards. Marginal spination is also well developed postero-ventrally. Surface of valve armed with strong spines which are generally tower-like and castellated (Pl. 10, figs. 1*e*, 2*c*), but the spine in front of the postero-dorsal angle and the spine associated with the sub-central tubercle are trifid and the strong postero-ventral spine is generally bifid or trifid. A prominent dorsal spine directed posteriorly occurs associated with the eye tubercle (Pl. 10, figs. 1*c*, 2*a*, 5*a*) and a strong dorso-median spine is present. Two spines occur at the postero-dorsal angle, one of which is sometimes accentuated and curved posteriorly (Pl. 10, fig. 4*a*). Valve surface between the spines smooth but often with fine, hair-like ridges forming a faint reticulation (Pl. 10, fig. 3*a*). In dorsal view notably spinose with the compressed anterior and posterior ends separated from the more vaulted median part of the valve; greatest width posterior of mid-length.

Sexual dimorphism strongly marked, the males being less high in proportion to their length than the females.



TEXT-FIG. 13. Lateral outlines and spination in Australian *Trachyleberis*. All ×67. *a*, *b*, *Trachyleberis anteplana* Bate, 1972. *a*, holotype, female right valve, B.M. (N.H.) Io 4614. *b*, paratype, male right valve, B.M. (N.H.) Io 4615. Campanian, Carnarvon Basin, Australia. *c–e*, *Trachyleberis raynerae* sp. nov. *c*, juvenile right valve, HU.63.C.15. Lateral outline only. *d*, paratype, female right valve, penultimate instar, HU.63.C.11. *e*, holotype, male right valve, HU.63.C.10.

Strong holamphidont hinge. Inner margin and line of concrescence coincide. About thirty-four fine, fan-like radial pore canals occur in the anterior half of the valve, and fourteen in the posterior half. Early juveniles, if interpreted correctly (text-fig. 13*c*), are quadrate, densely spinose with a well-developed postero-ventral spine, a strongly pitted/reticulate shell, and have been recognized first at lengths of about 0·36 mm.

Remarks. Trachyleberis raynerae bears some resemblance to the later *T. anteplana* Bate from the Campanian of the Carnarvon Basin, to which it is clearly related, although it differs in a number of ways. Both males and females are less high in proportion to their length than their respective counterparts in *T. anteplana* (text-fig. 13) and whilst the pattern and density of spination are generally similar, *T. raynerae* usually shows a lesser development of spines in the median area of the lateral surface. The inner row of spines along the anterior margin is also more robust in the present species and on the surface of the valve the spines are tubular with castellated tops whilst the ventro-lateral spines are strong and often bifid. The most diagnostic difference in ornamentation lies in the postero-dorsal spination which shows the presence of two strong spines in *T. anteplana* compared with a single one in *T. raynerae* as shown in text-fig. 13. On this and other criteria, *Cythereis rudispinata* Chapman, 1917 (*non* Chapman and Sherborn, 1893) belongs here and not in *T. anteplana*. *T. schizospinosa* Dingle, 1971 from rocks of probably Middle to Upper Maastrichtian age from the Agulhas Bank off South Africa shows a similar basic pattern of spination (cf. text-fig. 13 and Dingle 1971, figs. 9, 10) but *T. raynerae* is easily differentiated by its slimmer lateral outline and its much more triangular posterior part in lateral view. *Cythereis* (*Trachyleberis*) *incerta* Szczechura, 1965 from the Upper Maastrichtian of Poland has a comparable spine pattern but the spination differs in the degree of development and the valves are much less slim in side view; her Lower and Upper Maastrichtian *T. aculeata* (Bosquet) differs in the greater spination and the considerable development of spines anteriorly between the sub-central tubercle and the anterior margin; the other Polish species are less close. *T. weiperti* Bertels, 1969 from beds in Neuquen Province, Argentina, assigned to the Lower Danian is distantly related but differs in having a convex ventral margin in the left valve. *Actinocythereis allisoni* Holden, 1964 from the Upper Cretaceous of California differs notably in the coarse spines aligned in a median row posteriorly. Other species are less closely akin. *T. raynerae* is a consistent element in the Gingin fauna where on average it accounts for 2% of individuals recovered.

Trachyleberis pennyi sp. nov.

Plate 9, fig. 4; Plate 11, figs. 1–3; text-figs. 14*a–f*, 15*a–c*

Derivation of name. In honour of Dr. L. F. Penny for his contributions to Quaternary stratigraphy.

Diagnosis. A species of *Trachyleberis* with four prominent upstanding dorsal spines and large sub-central tubercle with one principal spine.

Holotype. A male carapace, HU.63.C.17.

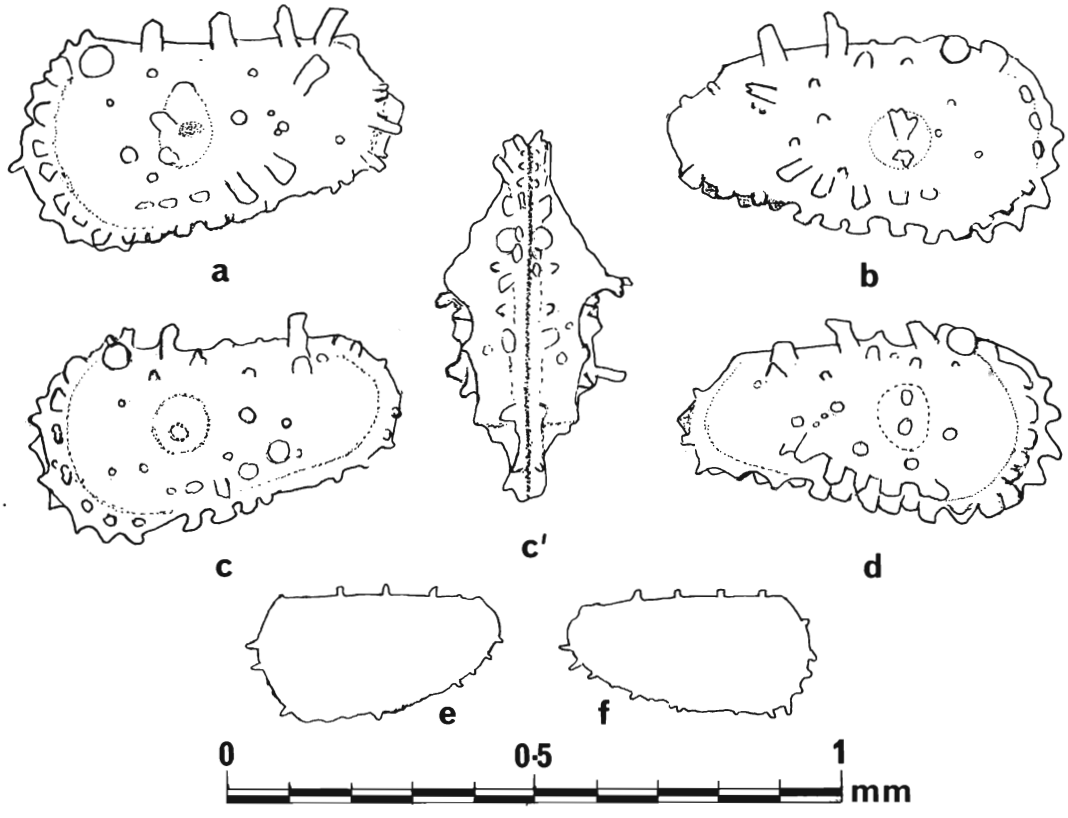
Paratypes. Twelve valves, HU.63.C.18–21, 23–25, HU.63.C.22.1–6.

Other material. Various adult and juvenile valves of which thirteen are mounted as HU.64.C.1.36, HU.65.C.5.11, and HU.65.C.6.30.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Holotype, male carapace	HU.63.C.17	Pl. 11, fig. 3	0·656	0·357	0·325
Paratype, male right valve	HU.63.C.18	Pl. 11, fig. 1; text-fig. 14*d*	0·614	0·312	0·208
Paratype, female left valve	HU.63.C.19	Pl. 11, fig. 2; text-fig. 14*a*	0·656	0·357	0·325
Paratype, female right valve	HU.63.C.20	Text-fig. 14*b*	0·648	0·332	0·185
Paratype, male carapace	HU.63.C.21	Text-fig. 14*c*	0·600	0·345	0·320
Paratype, female left valve	HU.63.C.25	Text-fig. 15*a–c*	0·600	0·368	0·204
Juvenile left valve	HU.63.C.23	Text-fig. 14*e*	0·415	0·224	0·130
Juvenile right valve	HU.63.C.24	Text-fig. 14*f*	0·415	0·208	0·121
Juvenile left valve	Specimen lost	Pl. 9, fig. 4	0·403	0·216	—

Description. In lateral view, shape rounded quadrangular, tapering posteriorly with the greatest height at the anterior cardinal angle. Anterior margin evenly rounded,



TEXT-FIG. 14. *Trachyleberis pennyi* sp. nov. Outlines and spination. All ×81. *a*, paratype, female left valve, HU.63.C.19. *b*, paratype, female right valve, HU.63.C.20. *c*, paratype, male carapace, HU.63.C.21. *c'*, paratype, male carapace, HU.63.C.21, dorsal view. *d*, paratype, male right valve, HU.63.C.18. *e*, juvenile left valve, HU.63.C.23. *f*, juvenile right valve, HU.63.C.24.

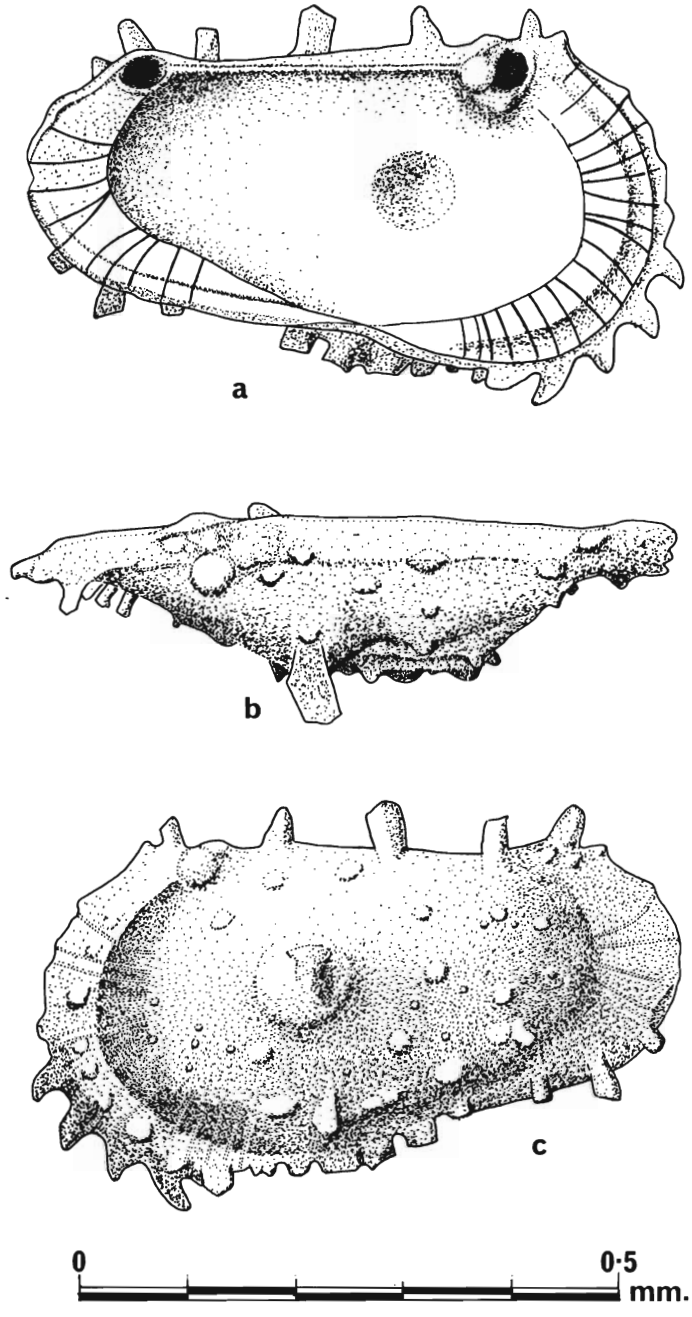
with triangular, plate-like marginal spines antero-ventrally; posterior margin fairly evenly rounded but with a straighter postero-dorsal section which is more accentuated and cut away in the right valve. A glassy eye tubercle is present and dorsally there are four strong upstanding spines which are generally widest at their distal ends. There is a row of plate-like spines along the ventral margin and a further five spines form a row sub-parallel to the ventral margin and a short distance above it. The very large sub-central tubercle carries one large, principal spine and sometimes an additional subsidiary spine ventral to it. A ridge with sulcus behind follows the anterior margin and is also armed with somewhat flattened spines. Body of the valve with scattered spines/tubercles; surface otherwise smooth. Scattered, large normal pore canals appear white and translucent in the Gingin specimens. In dorsal view spinose sub-hexagonal in shape the spinose sub-central tubercle forming the widest part of the carapace.

Hinge holamphidont and strong. Marginal areas with seventeen to twenty gently curved, radial pore canals anteriorly and about ten posteriorly. Vestibules absent. Sexual dimorphism marked (text-fig. 14*a–d*) with the females higher in proportion to the length than the males. Early instars of this species are reticulate (Pl. 9, fig. 4), but the four dorsal spines are easily recognizable and the outline follows the body of the adult valve, excluding the rather wide posterior rim.

Remarks. At the generic level *T. pennyi* differs from typical *Trachyleberis* in its small size (length *c.* 0·650 mm) compared with lengths of 1·0 to 1·2 mm commonly reached in the genus. Its shape is also stumpier and less elongate. It resembles a number of species placed by various authors in *Actinocythereis* Puri, 1953*a* (regarded as a subgenus of *Trachyleberis* by Morkhoven 1963), but whilst there is some dorsal and ventral lineation of the spines there is no lineation of the spines on the main body of the valve. Asymmetry in the right valve which Hazel (1967) found to be diagnostic of the species that he dealt with has not been detected either. On all the usual criteria, clearly the Australian species cannot be placed in *Actinocythereis*. Despite the differences noted above, there seems little merit in separating this species as a new genus or subgenus and thus adding to the burden of trachyleberid nomenclature and it is placed in *Trachyleberis* for the present.

At the specific level there is little comparable in the literature except in the most general terms, species of *Actinocythereis* such as those figured by Holden (1964) and Howe and Howe (1973) being easily differentiated by the lineation of the spines on the body of the valve behind the sub-central tubercle. There is an interesting comparison with the ?*Acanthocythereis* aff. *A. horridula* (Bosquet) of Dingle 1969*b*, from the Pondoland Upper Senonian, which has a similar strong spine in conjunction with a large sub-central tubercle forming the widest part of the carapace. There is also some similarity in the antero-ventral marginal spination but Dingle's species is reticulate and there are few other points of resemblance.

T. pennyi is relatively common at Gingin and may form up to 2% of the fauna in some samples.



TEXT-FIG. 15. *Trachyleberis pennyi* sp. nov. Paratype, female left valve, HU.63.C.25. *a*, internal lateral view. *b*, dorsal view. *c*, external lateral view. All × 143.

INCERTAE SEDIS

Genus HYSTRICOCYTHERE Bate, 1972

Hystricocythere imitata Bate, 1972

Plate 2, fig. 3; text-fig. 16*a*, *e*

1917 *Cythere harrisiana* Jones var. *reticosa* Jones and Hinde; Chapman, p. 53, pl. XIII, fig. 6.
1972 *Hystricocythere imitata* Bate, pp. 76–78, pl. 24, fig. 7; pl. 27, figs. 1–10; text-fig. 42A, B.

Dimensions of figured specimens.

			Length mm	Height mm	Width mm
Carapace	CPC 7136 (Chapman, pl. XIII, fig. 6)	Pl. 2, fig. 3	0·43	0·28	0·21
Holotype, right valve	Io 4669	Text-fig. 16*a*, *e*	0·52	0·32	0·15

Bate established this taxon for small spinose forms from the Santonian and Campanian of the Carnarvon Basin which showed some similarity to *Echinocythereis* Puri (1953*b*). He placed *Cythere harrisiana reticosa* Jones and Hinde (Pl. 2, fig. 3) of Chapman (1917) in the synonymy. The typical forms have spinosity coupled with reticulation of medium strength and taper posteriorly in side view. The small size, weak hinge, and simple marginal areas of *Hystricocythere imitata* automatically lead one to consider the possibility that it may be the juvenile of other forms. Very similar spinose forms occur at Gingin in which the reticulation is well developed. These show a pattern of ornamentation like that of *Scepticocythereis ornata* but lacking pits C and F (text-fig. 12*d*), and are interpreted as juveniles of that species. The distinction between these and *H. imitata* is not easy but seems best made on the lateral outline of the posterior margin which is more evenly rounded and vertical in the juvenile *S. ornata* compared with the more tapered posterior of *H. imitata*.

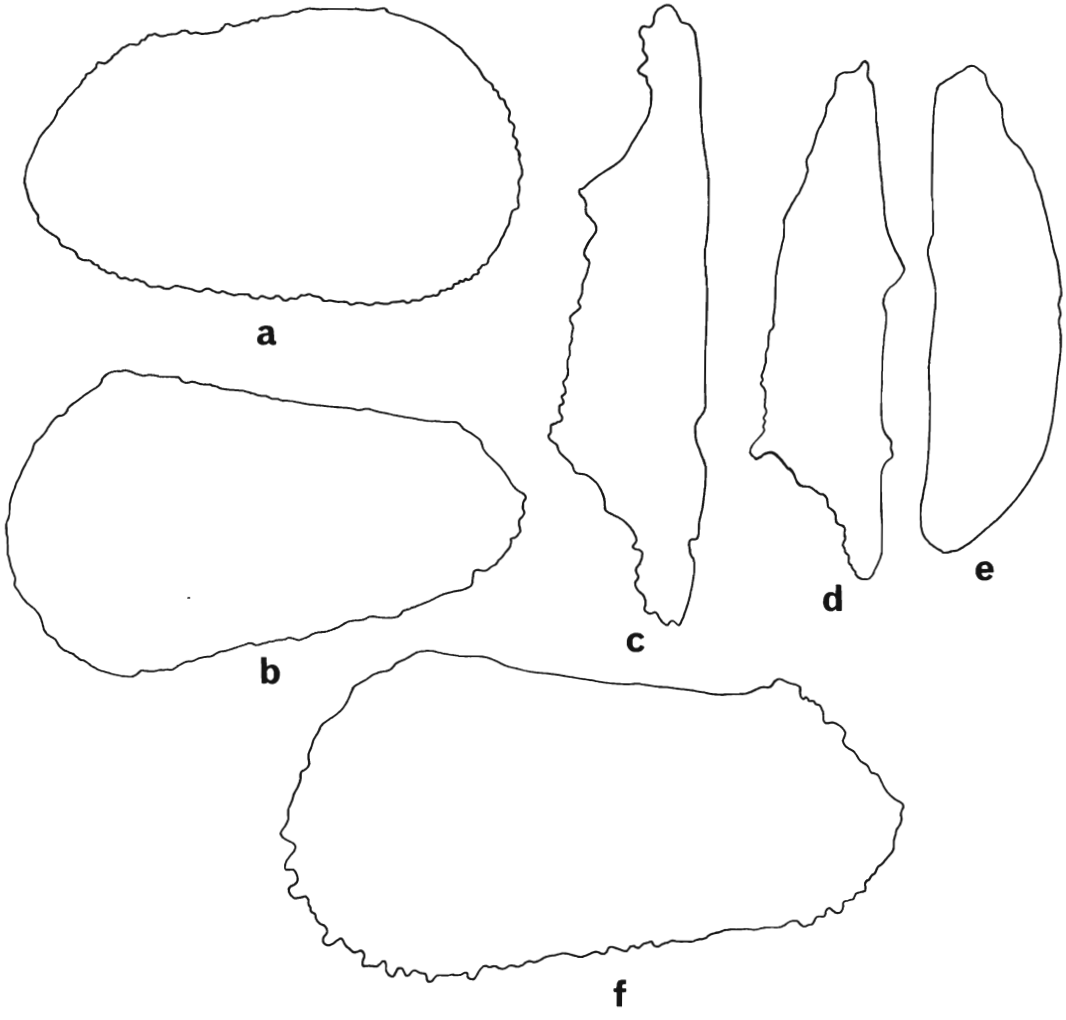
The possibility that *H. imitata* might be the juvenile form of *Pennyella pennyi* was also considered. The adult female *P. pennyi* has a length of about 0·61 mm whereas the holotype of *H. imitata* is 0·52 mm long and the largest three paratypes are 0·54 mm long. The shape appears to be too globose posteriorly for Bate's species to be the juvenile of the larger one. Fortunately a complete left valve of the penultimate instar of *P. pennyi* which is smaller than the largest paratypes of *H. imitata* was available and shows that the possibility can be discounted. The young *P. pennyi* is much narrower posteriorly and very much more akin to the adult in shape than to *H. imitata* (text-fig. 16). The young of *P. pennyi* are also obviously more fragile than the robust reticulate species. Additionally, the fossae are smaller than in either *H. imitata* or juvenile *S. ornata*.

Bate's taxon has been retained although it has not been possible to shed any further light on its affinities. It needs careful discrimination to separate it from the young of other reticulate species and is rare at Gingin.

Genus A sp.

Plate 22, fig. 1

A number of small specimens were obtained which could not be placed generically with any confidence. These were elongate valves which tapered strongly posteriorly



TEXT-FIG. 16. Outlines of *Hystricocythere* Bate, 1972 and *Pennyella* Neale, 1974. *a*, *e*, *Hystricocythere imitata* Bate, 1972. Holotype, right valve, Io 4669. *a*, lateral outline. *e*, dorsal outline. *b*, *d*, *Pennyella pennyi* Neale, 1974. Juvenile left valve, HU.67.C.7. *b*, lateral outline. *d*, dorsal outline. *c*, *f*, *Pennyella pennyi* Neale, 1974. Male left valve, HU.67.C.6. *c*, dorsal outline. *f*, lateral outline. *a*, *e*, ×123; *b*, *d*, ×158; *c*, *f*, ×128.

in side view, with surface ornamentation of weak costae giving a somewhat irregular reticulate appearance. The anterior marginal rim ends abruptly antero-ventrally in a triangular expansion, there is an elongate postero-dorsal node and a ventral ridge with strong postero-ventral tubercle behind it. The latter is separated from the ventral ridge by a strong excavation. The terminal hinge elements in the right valve are triangular in dorsal view.

The pattern of ornamentation suggests that this is a member of the Pectocytheridae. The size suggests that it is probably a juvenile but it has not been possible to link it with any larger specimens and it is here left under open nomenclature.

Dimensions of figured specimen.

		Length mm	Height mm	Width mm
Right valve	HU.65.C.24	0·325	0·146	0·068

DISCUSSION

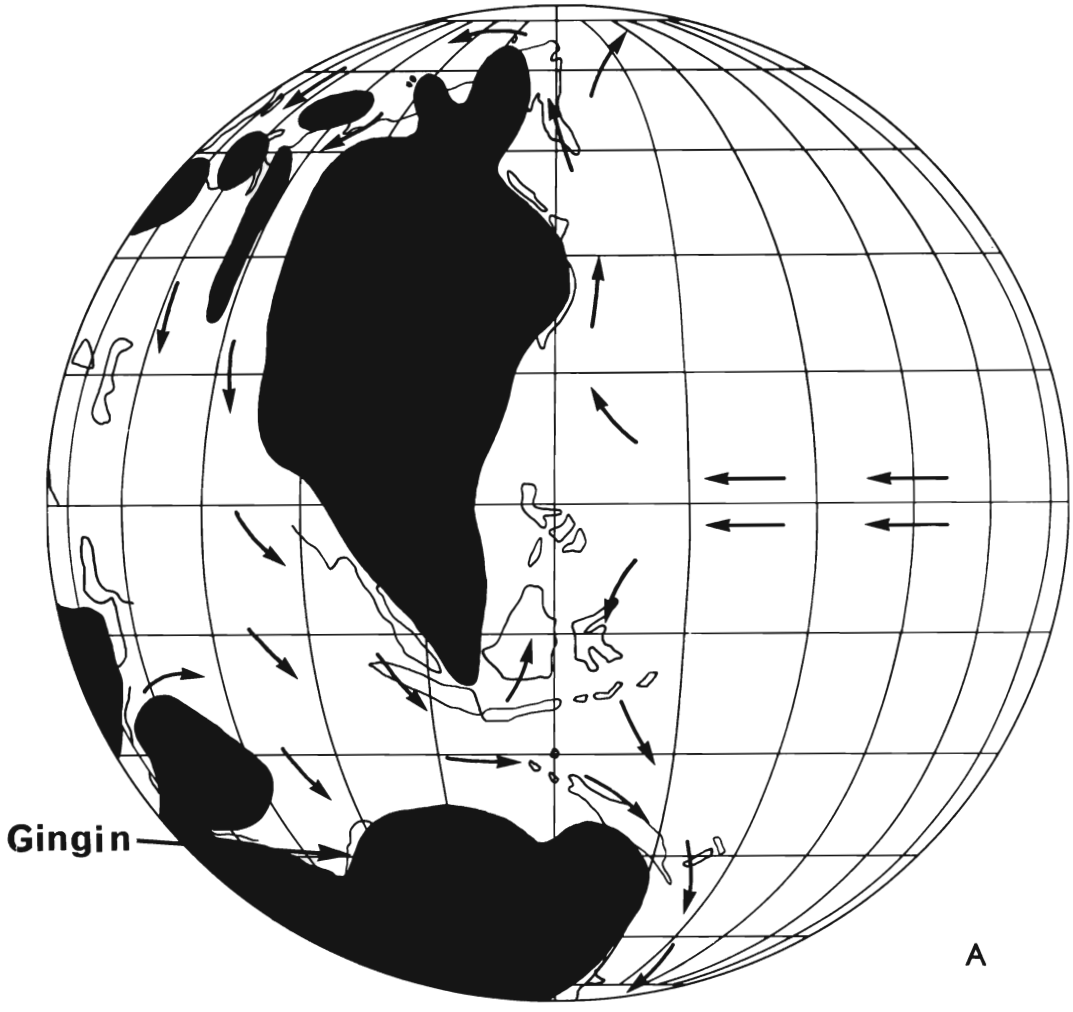
The Gingin ostracod fauna described here consists of forty-nine species of which thirty species and one subspecies are new, two are species named by Chapman (1917), nine are species established by Bate (1972), one was described by Neale (1974), and six are left under open nomenclature. The twenty species and varieties of Chapman are considered to belong to seventeen species, two of which were named by him, five by Bate in 1972, and nine here, leaving one under open nomenclature (Table 1).

None of the forty-nine species can be assigned to extra-Australian forms and the only close comparison is with the fauna from the Santonian of the Carnarvon Basin described by Bate. Of his twenty-two Santonian species, twelve have been found in the present work. Of the remaining ten, *Cythereis brevicosta* Bate is represented by the new subspecies *obtusa*; *Cytheropteron* (*C.*) *carinoalatum* Bate and *Rostrocytheridea canaliculata* Bate are close to *C.* (*C.*) *collisarboris* sp. nov. and *R. westraliensis* (Chapman) respectively. Bate left three more under open nomenclature and of the remaining four, the genera *Karsteneis* and *Toolongella* do not appear to occur at Gingin, *Hermanites* is represented by *H. volans* sp. nov. which is not close to Bate's *H. sagitta*, and *Cytherelloidea cobberi* Bate has not been found. This correspondence between the fauna from the lower part of the Toolonga Calcilutite of the Carnarvon Basin and the Gingin Chalk is so close as to put their correlation beyond doubt.

In general, comparisons outside Australia were closer with northern European, usually Maastrichtian forms, than with South American species. This is due partly to the greater knowledge and more detailed work on the faunas of the former, but also in part to the development of similar genera; possibly also to the fact that the South American faunas so far described mostly lie somewhat higher stratigraphically near the Cretaceous–Tertiary boundary. In general the only close affinities appeared to be with the European species of *Cytherella*, *Cytherelloidea*, and *Cytheropteron*, but this seems due as much to the difficulty of species discrimination in these genera as to any real kinship. In any study of a relatively remote area, new species are to be expected but seven new genera have also been established if one includes *Pennyella* Neale, 1974. Apart from *Cretaceratina* which is cosmopolitan and rationalizes a problem well known to Cretaceous workers who have had to use the Upper Carboniferous 'dustbin' genus *Monoceratina* Roth to accommodate these forms hitherto, four of the new genera are not yet known outside Australia, *Pennyella* occurs in the northwestern Pacific in the Maastrichtian of the Shatsky Plateau and *Collisarboris* probably also in that area. In addition, Bate recognized eight new genera in the Carnarvon Basin, Santonian, seven of which occur at Gingin and six of which are not represented in the northern hemisphere. This all confirms the impression of a high degree of endemism in the fauna. Furthermore, the genus here referred to as *Uroleberis* strains the interpretation of that genus and should almost certainly be considered as new, and two new trachyleberid genera might also have been established although this course of action would be of doubtful merit at the present time.

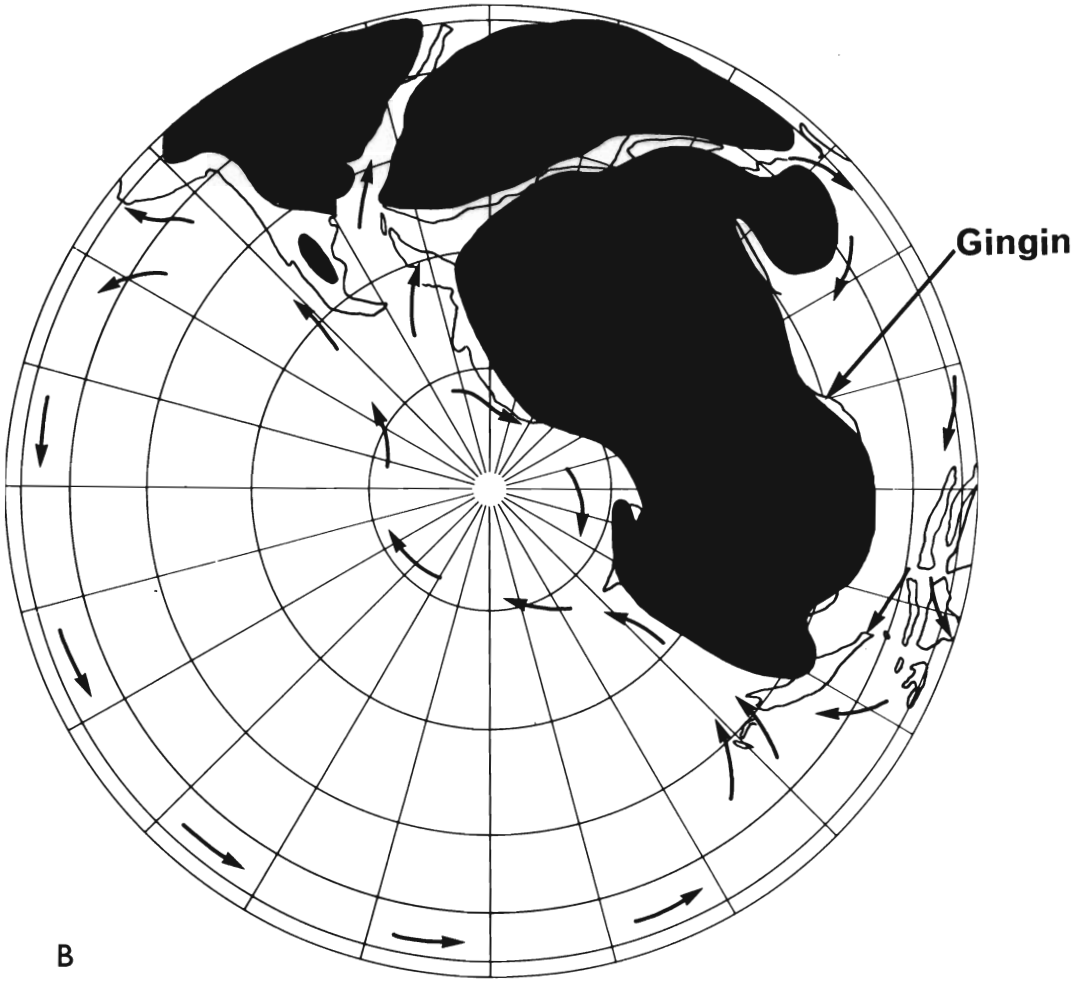
TABLE 1. Santonian species of Chapman (1917) and Bate (1972) and nomenclature used in the present work.

	CHAPMAN 1917 SANTONIAN GINGIN	PRESENT WORK	BATE 1972 SANTONIAN CARNARVON BASIN
1.	*Paracypris siliqua* Jones & Hinde	*Paracypris* sp.	
2.	*Bairdia arquata* Münster sp.	*Bythocypris chapmani* sp. nov.	?*Bythocypris* sp., Type A
3.	*Macrocypris simplex* Chapman var. *africana* var. nov.	*Macrocypris australiana* sp. nov.	
4.	*Bythocypris howchiniana* sp. nov.	*Bythocypris howchiniana* Chapman	
5.	*Cythere harrisiana* Jones, var. *reticosa* Jones & Hinde	*Hystricocythere imitata* Bate	*Hystricocythere imitata* gen. et sp. nov.
6.	*Cythere westraliensis* sp. nov.	*Rostrocytheridea westraliensis* (Chapman)	
7.	*Cythere lineatopunctata* Chapman & Sherborn	*Paramunseyella austracretacea* Bate	*Paramunseyella austracretacea* gen. et sp. nov.
8.	*Cythereis ornatissima* Reuss sp.	*Limburgina aurora* sp. nov.	
9.	*Cythereis ornatissima* Reuss sp. var. *nuda* Jones & Hinde	*Cythereis brevicosta* Bate subsp. *obtusa* subsp. nov.	
10.	*Cythereis ornatissima* Reuss sp. var. *reticulata* Jones & Hinde	*Scepticocythereis ornata* Bate	*Scepticocythereis ornata* gen. et sp. nov.
11.	*Cythereis ornatissima* Reuss sp. var. *stricta* Jones & Hinde	*Rayneria ginginensis* gen. et sp. nov.	
12.	*Cythereis quadrilatera*, Römer sp.	*Ginginella ginginensis* gen. et sp. nov.	Genus A sp.
13.	*Cythereis rudispinata* Chapman & Sherborn	*Trachyleberis raynerae* sp. nov.	
14.	*Cythereis tuberosa* Jones & Hinde	*Munseyella tuberculata* sp. nov. juv.	
15.	*Cytheropteron concentricum* Reuss sp.	*Majungaella verseyi* sp. nov.	
16.	*Cytherella muensteri* Römer sp.	*Cytherella ludbrookae* sp. nov.	
17.	*Cytherella ovata* Römer sp.	" " "	
18.	*Cytherella williamsoniana* Jones	*Cytherelloidea westaustraliensis* Bate	*Cytherelloidea westaustraliensis* sp. nov.
19.	*Cytherella williamsoniana* Jones var. *stricta* Jones & Hinde	" "	" "
20.	*Cytherella chapmani* Jones & Hinde	" "	" "
21.		*Tickalaracythere annula* (Bate)	*Majungaella annula* sp. nov.
22.		*Premunseyella ornata* Bate	*Premunseyella ornata* gen. et sp. nov.
23.		*Eorotundracythere compta* Bate	*Eorotundracythere compta* gen. et sp. nov.
24.		*Apateloschizocythere geniculata* Bate	*Apateloschizocythere geniculata* gen. et sp. nov.
25.		*Oculocytheropteron praenuntatum* Bate	*Oculocytheropteron praenuntatum* gen. et sp. nov.
26.		*Cytherella jonesi* sp. nov.	*Cytherella* Type B
27.			*Rostrocytheridea canaliculata* sp. nov.
28.			*Cythereis brevicosta* sp. nov.
29.			*Hermanites sagitta* sp. nov.
30.			*Karsteneis aspericava* sp. nov.
31.			*Toolongella mimica* gen. et sp. nov.
32.			*Cytheropteron carinoalatum* sp. nov.
33.			*Cytherelloidea cobberi* sp. nov.
34.			*Cytherella* sp. Type A
35.			?*Toolongella* sp.
36.			Genus B sp.



TEXT-FIG. 17. Suggested distribution of land and sea and pattern of ocean currents in Upper Cretaceous times. Orthographic Projection. A, Eastern Land Hemisphere, Western Sea Hemisphere centred on the equator. B, centred on the South Pole.

In contrast there are a number of cosmopolitan genera such as *Cytherella*, *Cytherelloidea*, *Cythereis*, *Cytheropteron*, *Eucytherura*, *Hemiparacytheridea*, *Limburgina*, *Pedicythere*, *Saida*, *Semicytherura*, and *Trachyleberis*, the first two of which form a high proportion of the fauna. It appears that with the extension of the marine areas in the Upper Cretaceous these cosmopolitan genera found it easy to migrate in and colonize the West Australian seas, whereas the endemic Australian genera developing at this time found dispersal difficult. The lesser development of endemic genera in the northern hemisphere at this time compared with Australia suggests that the distribution of land and sea during the Upper Cretaceous set up ocean currents that effected easy migration in the one direction and prohibited it in the other. As already



noted, links with South America are not close and that area has its own, albeit slightly later, endemic genera in the Rocaleberidinae and others of Bertels (1969). Similarly, connection with West Africa is not apparent as seen in the work of Apostolescu (1961, 1963), Reyment (1960–1966), and others and this area too had its own endemic genera. Connections with East and South Africa are closer and *Rostrocytheridea* and *Majungaella*, described by Dingle (1969*a*) from South Africa and Grekoff (1963) from Madagascar respectively, are common to the two areas and fit in with a picture of dispersal by ocean currents on the lines suggested in text-fig. 17 (for an expanded treatment of this theme see Neale, in press).

At this time the Afro-Australian-Pacific area was the locus of the new family

Collisarborisidae, related to the neocytherids but developing strong sexual dimorphism and confined to the southern hemisphere.

The family Pennyellidae is also confined to the South Africa–Australia–Western Pacific area in the Upper Cretaceous. It continues in the Tertiary and up to the present day, however, with the genus *Agrenocythere* which diversifies into various species and in the Oligocene becomes a deep-water cosmopolitan genus. *Pennyella* is the earliest typical member of this family, and like the other members lacks the eye tubercle and is presumably a blind form.

The most striking feature among the new genera is the great development of Pectocytheridae. These Santonian deposits provide the earliest members of the family so far known and besides Bate's new genera *Paramunseyella* and *Premunseyella* the present study has shown the presence of the new genus *Ginginella* as well as a new species of *Munseyella*. This rich development suggests that Australia was the cradle of pectocytherid evolution. Of these four genera only *Munseyella* is known outside Australia and the other three appear to have died out before the Atlantic ocean opened up sufficiently to modify the oceanic circulation and allow the dispersal of *Munseyella* in the early Tertiary.

The new trachyleberid *Rayneria* has a relatively modern look and, as an early member of the typical Tertiary and Recent plexus of tricostate ostracods leading to *Carinocythereis* and *Costa* amongst others, forms a link between these and the older Mesozoic tricostate genera such as *Cythereis* and *Isocythereis*.

The cytherurids *Hemingwayella* and *Verseya* show interesting developments of shape and ornamentation. The wide ventral area in *Hemingwayella* suggests a load-spreading device of use on the fine-grained substrate, the pitted postero-dorsal tubercle in *Verseya* the concentration of a battery of sensory receptors. These two relatively small-sized genera emphasize the advantages of modern techniques of S.E.M. examination.

The composition of the fauna gives some insight into the environment of that time. Obviously euhaline, the Platycopina form a considerable proportion (30–40%) of the species recovered and include both *Cytherella* (14–36%) the most abundant single genus at Gingin, and *Cytherelloidea* (9–13%). By analogy with its present-day habitats the latter is a good indication that the water temperature was fairly high throughout the year, the lower limit being not less than 10 °C. All the other ostracods belong to the Podocopina. Bairdiacea (3–6%) and Cypridacea (<1%) are minor elements in the fauna. The Cypridacea are probably under-represented compared with the original living fauna since the valves in this superfamily are generally lightly calcified and fragile. The Cytheracea account for the remaining 56–67% of the fauna. Of these, the Pectocytheridae and Trachyleberididae are the most notable for their all-round development and abundance, but one of the commonest species is the schizocytherid *Apateloschizocythere geniculata* Bate which is always well represented and forms up to 9% of the ostracod fauna. There are five other species which are common and generally make up 5% or more of the specimens found. *Paramunseyella prideri* sp. nov. (average 7% and up to 12%) and *P. austracretacea* Bate (average 5% and up to 8%), both pectocytherids, are notable in any sample examined, while the cytherideid *Rostrocytheridea westraliensis* (Chapman) is always well preserved and reaches a large size forming 3–6% of the fauna. *Rostrocytheridea* seems equally important in

TABLE 2. Guide to the relative abundance of ostracods in the Gingin Chalk.

	%		
1. *Cytherella ludbrookae* sp. nov.	10–24	14–36%	30–40%
2. *Cytherella jonesi* sp. nov.	4–12		
3. *Cytherelloidea colemani* sp. nov.	1–6	9–13%	
4. *Cytherelloidea lunata* sp. nov.	1–1·5		
5. *Cytherelloidea westaustraliensis* Bate, 1972	5–8		
6. *Bairdia* cf. *austracretacea* Bate, 1972	<1	Very rare	3–6%
7. *Bythocypris chapmani* sp. nov.	Av. 2	Up to 5%	
8. *Bythocypris howchiniana* Chapman, 1917	1–2		
9. *Macrocypris australiana* sp. nov.	<1	Very rare	
10. *Paracypris* sp.	<1	Very rare	<1%
11. *Pontocyprella*? sp.	<1	Very rare	
12. *Saida rhomboidea* sp. nov.	<1		56–67%
13. *Cretaceratina trispinosa* gen. et sp. nov.	<1		
14. *Tickalaracythere annula* (Bate, 1972)	<1		
15. *Majungaella verseyi* sp. nov.	<1		
16. *Collisarboris cooki* gen. et sp. nov.	1·5		
17. *Eucytherura* (*E.*) *antipodum* sp. nov.	Up to 2		
18. *Eucytherura* (*E.*) *fissipunctata* sp. nov.	<1	Very rare	
19. *Semicytherura augusta* sp. nov.	<1	Very rare	
20. *Semicytherura cretae* sp. nov.	<1		
21. *Verseya pulchra* gen. et sp. nov.	Av. 0·3		
22. *Cytheropteron* (*C.*) *collisarboris* sp. nov.	Av. 0·2	Up to 0·6%	
23. *Cytheropteron* (*A.*) *mccomborum* sp. nov.	<1	Very rare	
24. *Cytheropteron* (*A.*) cf. *C. mccomborum*	<1	Very rare	
25. *Cytheropteron* (*A.*) *westaustraliense* sp. nov.	Up to 2		
26. *Oculocytheropteron praenuntatum* Bate, 1972	<1	Av. *c.* 0·3%	
27. *Hemingwayella ornata* gen. et sp. nov.	Av. 0·66		
28. *Hemiparacytheridea hemingwayi* sp. nov.	Max. 0·66		
29. *Pedicythere australis* sp. nov.	Up to 1		
30. *Pedicythere* sp.	<1	Very rare	
31. *Eorotundracythere compta* Bate, 1972	*c.* 2		
32. *Uroleberis batei* sp. nov.	Up to 2		
33. *Apateloschizocythere geniculata* Bate, 1972	Up to 9		
34. *Rostrocytheridea westraliensis* (Chapman, 1917)	3–6		
35. *Ginginella ginginensis* gen. et sp. nov.	1–2		
36. *Munseyella tuberculata* sp. nov.	0·3		
37. *Paramunseyella austracretacea* Bate, 1972	Av. 5	Up to 8%	
38. *Paramunseyella prideri* sp. nov.	Av. 7	Up to 12%	
39. *Premunseyella imperfecta* Bate, 1972	Av. <1	Up to 1·5%	
40. *Pennyella pennyi* Neale, 1974	Av. 1		
41. *Cythereis brevicosta* Bate, 1972, *obtusa* subsp. nov.	1–3		
42. *Hermanites volans* sp. nov.	<1		
43. *Limburgina aurora* sp. nov.	2–5	Up to 10%	
44. *Rayneria ginginensis* gen. et sp. nov.	Up to 2		
45. *Scepticocythereis ornata* Bate, 1972	Av. 5		
46. *Trachyleberis raynerae* sp. nov.	Av. 2		
47. *Trachyleberis pennyi* sp. nov.	Up to 2		
48. *Hystricocythere imitata* Bate, 1972	<1		
49. Genus A sp.	<1		

South Africa, the only other area outside Australia from which it has been reported so far, unlike *Majungaella*, another characteristic genus from South Africa and Madagascar which at Gingin accounts for well under 1% of the ostracods recovered. The strongly reticulate *Limburgina aurora* sp. nov. (2–5% but up to 10% on occasion) and *Scepticocythereis ornata* Bate which averages 5%, complete the commoner species in the fauna (Table 2). Some of the more spectacular trachyleberids form a fairly common and persistent element without ever becoming abundant. Among these are *Cythereis brevicosta* Bate *obtusa* subsp. nov. (1–3%), *Trachyleberis raynerae* sp. nov. (average 2%), *Rayneria ginginensis* gen. et sp. nov. (up to 2%), and *Trachyleberis pennyi* sp. nov. (up to 2%). *Pennyella pennyi* Neale averages 1% and of the bairdiids *Bythocypris chapmani* sp. nov. forms on average 2% (and sometimes up to 5%) and *B. howchiniana* (Chapman) 1–2%. Other species in this category include the pectocytherids *Ginginella ginginensis* gen. et sp. nov. (1–2%) and *Premunseyella imperfecta* Bate (up to 1·5%), the xestoleberid *Uroleberis batei* sp. nov. (about 2%), the eucytherid *Eorotundracythere compta* Bate (up to 2%), the collisarborisid *Collisarboris cooki* gen. et sp. nov. (*c.* 1·5%), and the cytherurids *Cytheropteron westaustraliense* sp. nov. (up to 2%) and *Eucytherura antipodum* sp. nov. (up to 2%). With the exception of the two last-named species, cytherurids are usually rather rare at Gingin, particularly the two species of *Semicytherura*. Other species form less than 1% of the fauna and vary much in their rarity.

The well-developed trachyleberid species suggest a relatively shallow-shelf sea area which fits in with what is known of the geological development of the region. After the very shallow-water deposits and plant-bearing beds of the late Jurassic–early Cretaceous the sea spilled over on to the flanks of the continent and the clastic, shallow-water Molecap Greensand has yielded an ichthyosaur and a plesiosaur near Dandaragan and belemnites and a pecten at Gingin. The sea cleared and probably deepened slightly for the deposition of the Gingin Chalk, before the subsequent regression brought about the deposition of the clastic Poison Hill Greensand above. The Platycopina confirm this picture of warm, clear, shallow seas. In similar environments at the present day, ranging from the Caribbean to the Mediterranean and on to south-east Asia, they are most marked as an element in the warm-water faunas at depths between about 20 and 250 m with their greatest abundance occurring at perhaps 80 to 100 m. In consequence it is suggested that the Gingin Chalk may be regarded as a warm-water deposit laid down in a shallow-shelf sea whose depth may be tentatively thought of in terms of about 100 m and whose minimum temperature was not less than 10 °C.

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J. W. NEALE

Department of Geology
The University
Hull, HU6 7RX

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EXPLANATION OF PLATE 1

External lateral views of Chapman's figured specimens. All figures $\times 73 \pm 3$ except where stated.

Fig. 1. *Cytherella ludbrookae* sp. nov. Female left valve, CPC 7148. (Chapman, pl. XIV, fig. 18.) $\times 60$.

Fig. 2. *Cytherelloidea westaustraliensis* Bate, 1972. Female right valve, CPC 7150. (Chapman, pl. XIV, fig. 20.)

Fig. 3. *Cytherella ludbrookae* sp. nov. Juvenile right valve, CPC 7149. (Chapman, pl. XIV, fig. 19.) $\times 55$.

Fig. 4. *Cytherelloidea westaustraliensis* Bate, 1972. Juvenile right valve, CPC 7151. (Chapman, pl. XIV, fig. 21.) $\times 57$.

Fig. 5. *Cytherelloidea westaustraliensis* Bate, 1972. Juvenile right valve, CPC 7152. (Chapman, pl. XIV, fig. 22.) $\times 58$.

Fig. 6. *Munseyella tuberculata* sp. nov. Juvenile right valve, CPC 7146. (Chapman, pl. XIV, fig. 16.) $\times 150$.

Fig. 7. *Rayneria ginginensis* gen. et sp. nov. Male carapace from right, CPC 7143. (Chapman, pl. XIV, fig. 13.)

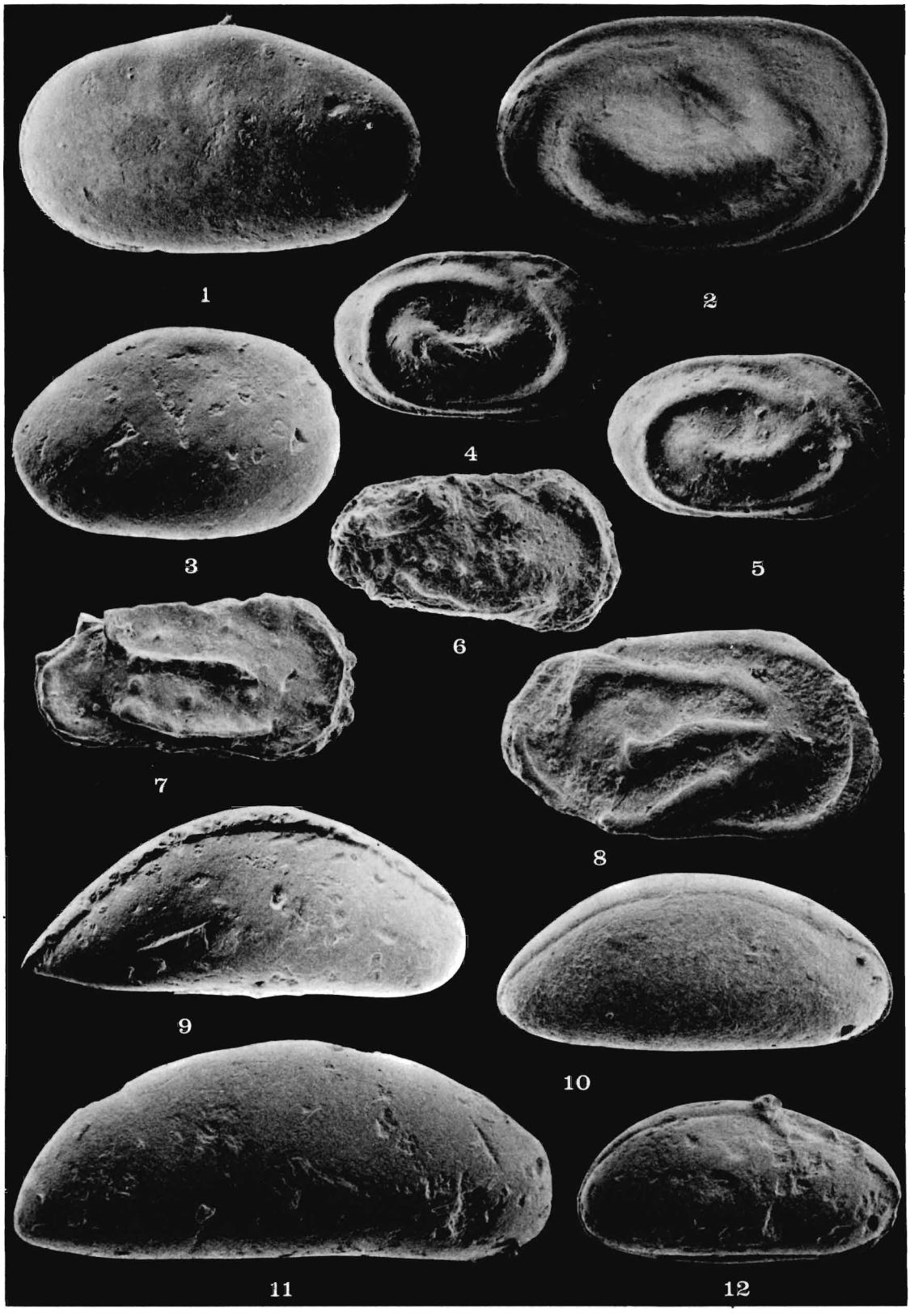
Fig. 8. *Ginginella ginginensis* gen. et sp. nov. Female right valve, CPC 7144. (Chapman, pl. XIV, fig. 14.) $\times 137$.

Fig. 9. *Paracypris* sp. nov. Carapace from right, CPC 7131. (Chapman, pl. XIII, fig. 1.) $\times 57$.

Fig. 10. *Bythocypris chapmani* sp. nov. Carapace from right, CPC 7133. (Chapman, pl. XIII, fig. 3.)

Fig. 11. *Macrocypris australiana* sp. nov. Holotype, right valve, CPC 7134. (Chapman, pl. XIII, fig. 4.)

Fig. 12. *Bythocypris howchiniana* Chapman, 1917. Holotype, carapace from right, CPC 7132. (Chapman, pl. XIII, fig. 2*a–c*.)



NEALE, Chapman 1917. Type specimens

EXPLANATION OF PLATE 2

External lateral views of Chapman's figured specimens. All figures $\times 73 \pm 3$ except where stated.

Fig. 1. *Rostrocytheridea westraliensis* (Chapman, 1917). Holotype, male left valve, CPC 7137. (Chapman, pl. XIII, fig. 7.)

Fig. 2. *Rostrocytheridea westraliensis* (Chapman, 1917). Female left valve, CPC 7138. (Chapman, pl. XIII, fig. 8.)

Fig. 3. *Hystricocythere imitata* Bate, 1972. Carapace, CPC 7136. (Chapman, pl. XIII, fig. 6.) $\times 150$.

Fig. 4. *Majungaella verseyi* sp. nov. Carapace, CPC 7147. (Chapman, pl. XIV, fig. 17.)

Fig. 5. *Cythereis brevicosta* Bate, 1972 *obtusa* subsp. nov. Female right valve, CPC 7135. (Chapman, pl. XIII, fig. 5.) $\times 56$.

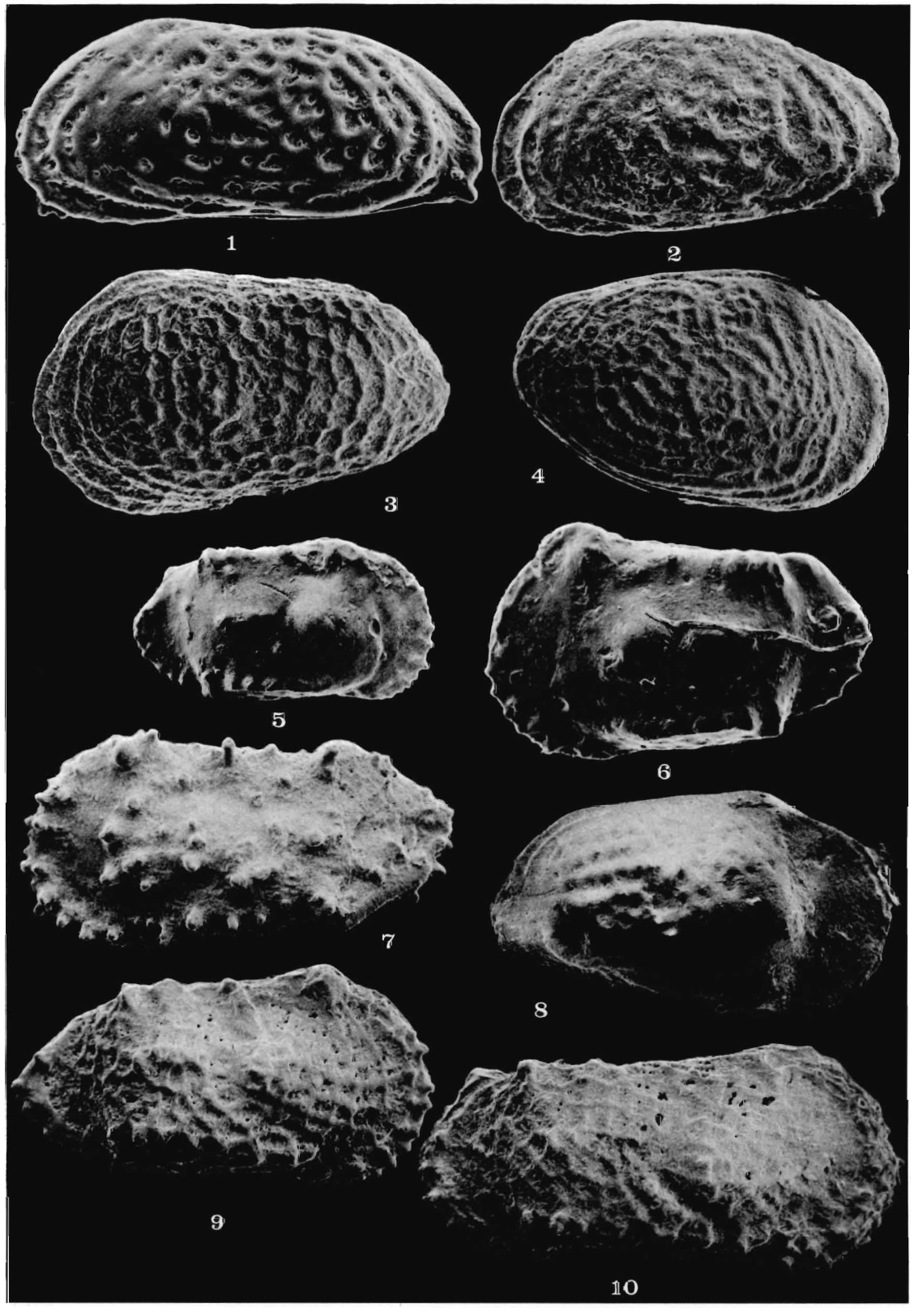
Fig. 6. *Cythereis brevicosta* Bate, 1972 *obtusa* subsp. nov. Female left valve, CPC 7141. (Chapman, pl. XIV, fig. 11.)

Fig. 7. *Trachyleberis raynerae* sp. nov. Male left valve, ?penultimate instar, CPC 7145. (Chapman, pl. XIV, fig. 15.)

Fig. 8. *Paramunseyella austracretacea* Bate, 1972. Female(?) right valve, CPC 7139. (Chapman, pl. XIV, fig. 9.) $\times 153$.

Fig. 9. *Limburgina aurora* sp. nov. Female right valve, CPC 7140. (Chapman, pl. XIV, fig. 10.)

Fig. 10. *Scepticocythereis ornata* Bate, 1972. Male carapace, CPC 7142. (Chapman, pl. XIV, fig. 12.)



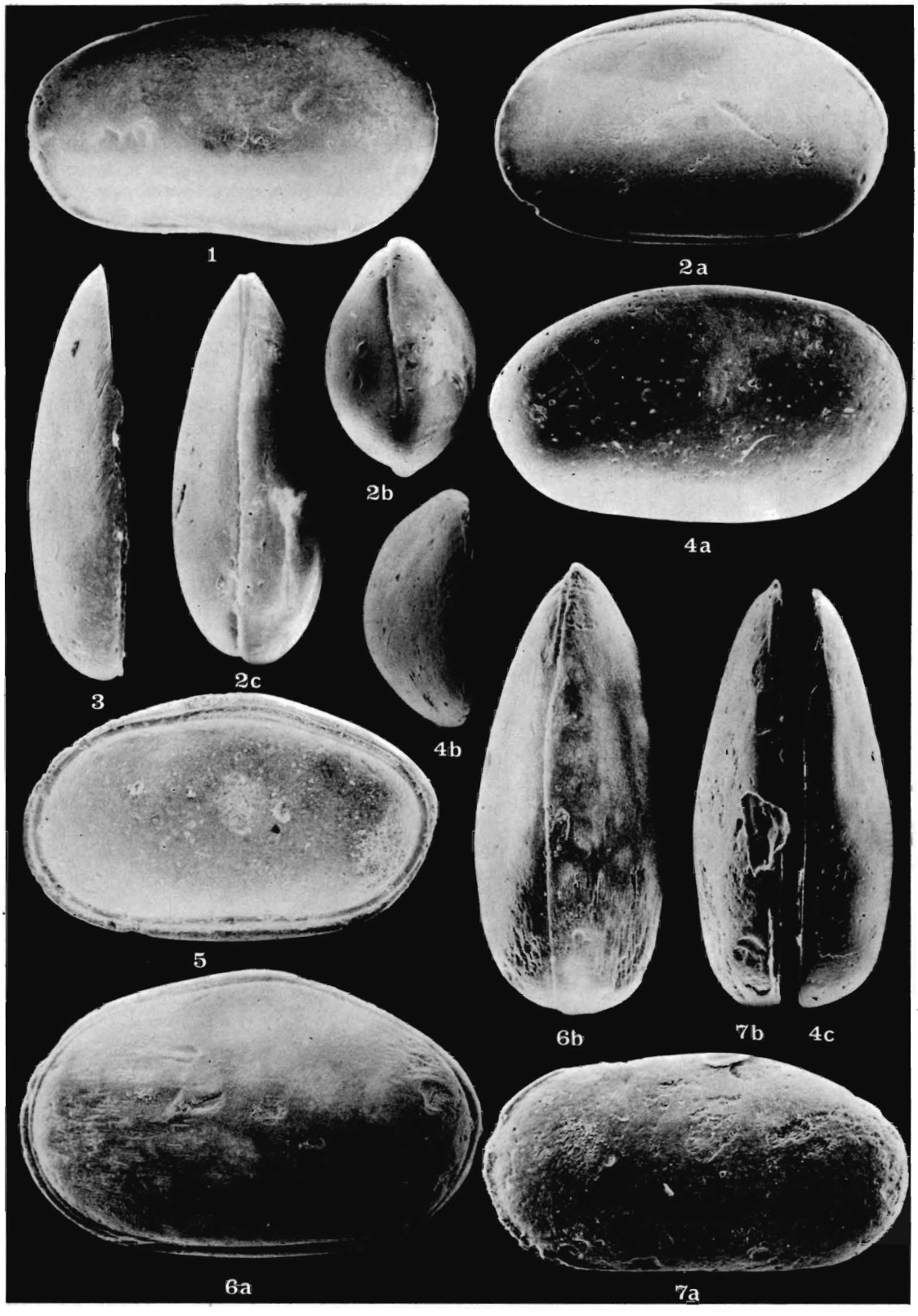
NEALE, Chapman 1917. Type specimens

EXPLANATION OF PLATE 3

All figures $\times 75$.

Figs. 1–3. *Cytherella jonesi* sp. nov. 1, paratype, male right valve, HU.65.C.3.1. External lateral view. 2, holotype, female carapace, HU.65.C.7. *a*, lateral view from left. *b*, posterior view. *c*, dorsal view. 3, paratype, male left valve, HU.65.C.3.2. Dorsal view.

Figs. 4–7. *Cytherella ludbrookae* sp. nov. 4, paratype, male right valve, HU.65.C.4.3. *a*, external lateral view. *b*, anterior view. *c*, dorsal view. 5, female right valve. Specimen lost. Internal lateral view. 6, holotype, female carapace, HU.65.C.30. *a*, lateral view from left. *b*, dorsal view. 7, paratype, male left valve, HU.65.C.4.6. *a*, external lateral view. *b*, dorsal view.



NEALE, Gingin Ostracoda

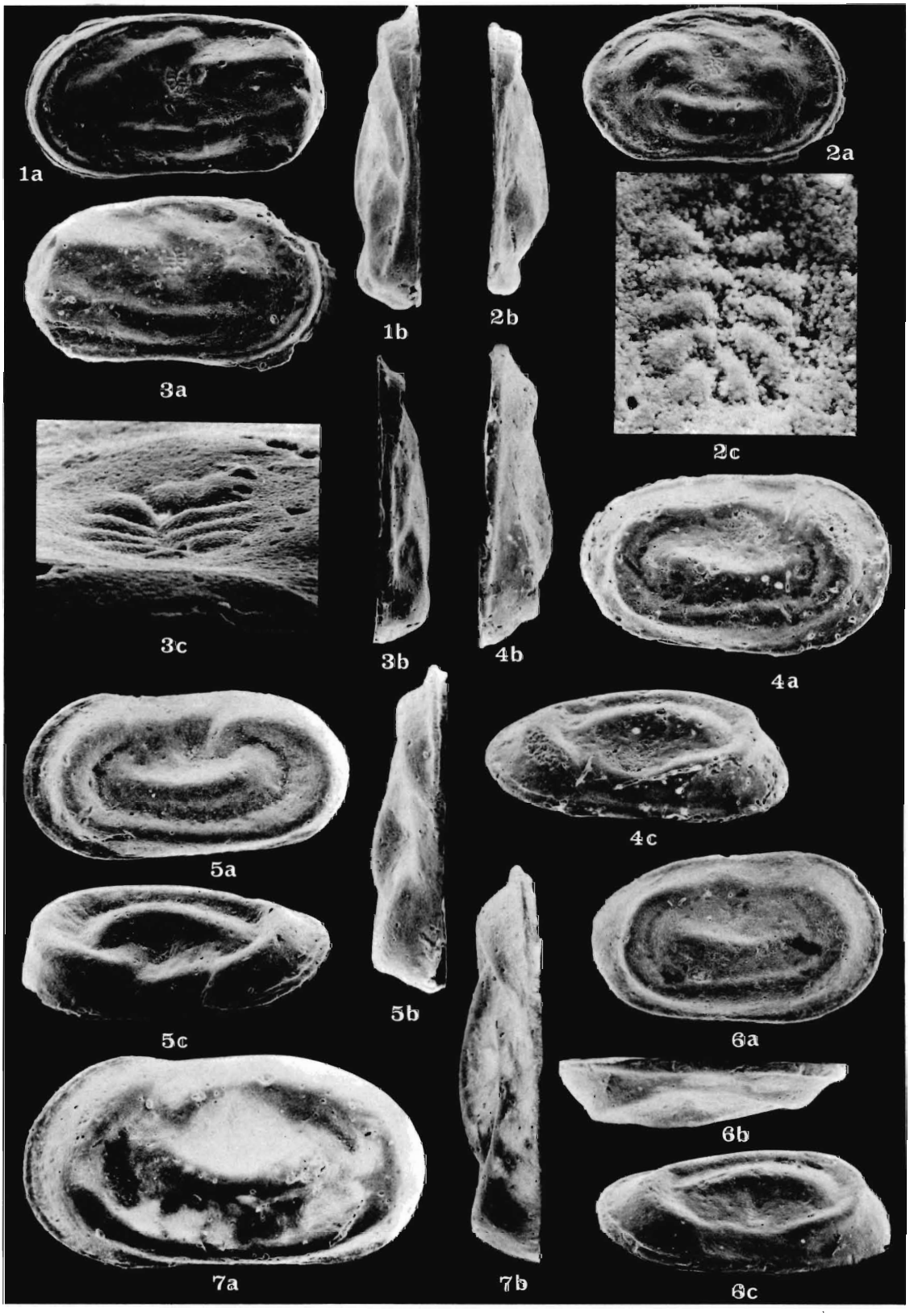
EXPLANATION OF PLATE 4

All figures $\times 75$ except where stated.

Figs. 1–3. *Cytherelloidea colemani* sp. nov. 1, holotype, left valve, HU.65.C.20. *a*, external lateral view. *b*, dorsal view. 2, paratype, juvenile right valve, HU.65.C.11. *a*, external lateral view. *b*, dorsal view. *c*, muscle-scar pattern, $\times c.$ 600. 3, paratype, right valve, HU.65.C.16. *a*, external lateral view. *b*, dorsal view. *c*, muscle-scar pattern, $\times c.$ 525.

Figs. 4–6. *Cytherelloidea lunata* sp. nov. 4, paratype, right valve, HU.65.C.18.6. *a*, external lateral view. *b*, dorsal view. *c*, oblique dorsal view. 5, holotype, left valve, HU.65.C.15. *a*, external lateral view. *b*, dorsal view. *c*, oblique dorsal view. 6, paratype, right valve, HU.65.C.18.9. *a*, external lateral view. *b*, dorsal view. *c*, oblique dorsal view.

Fig. 7. *Cytherelloidea westaustraliensis* Bate, 1972. Male left valve, HU.65.C.31. *a*, external lateral view. *b*, dorsal view.



NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 5

All figures $\times 75$ except where stated.

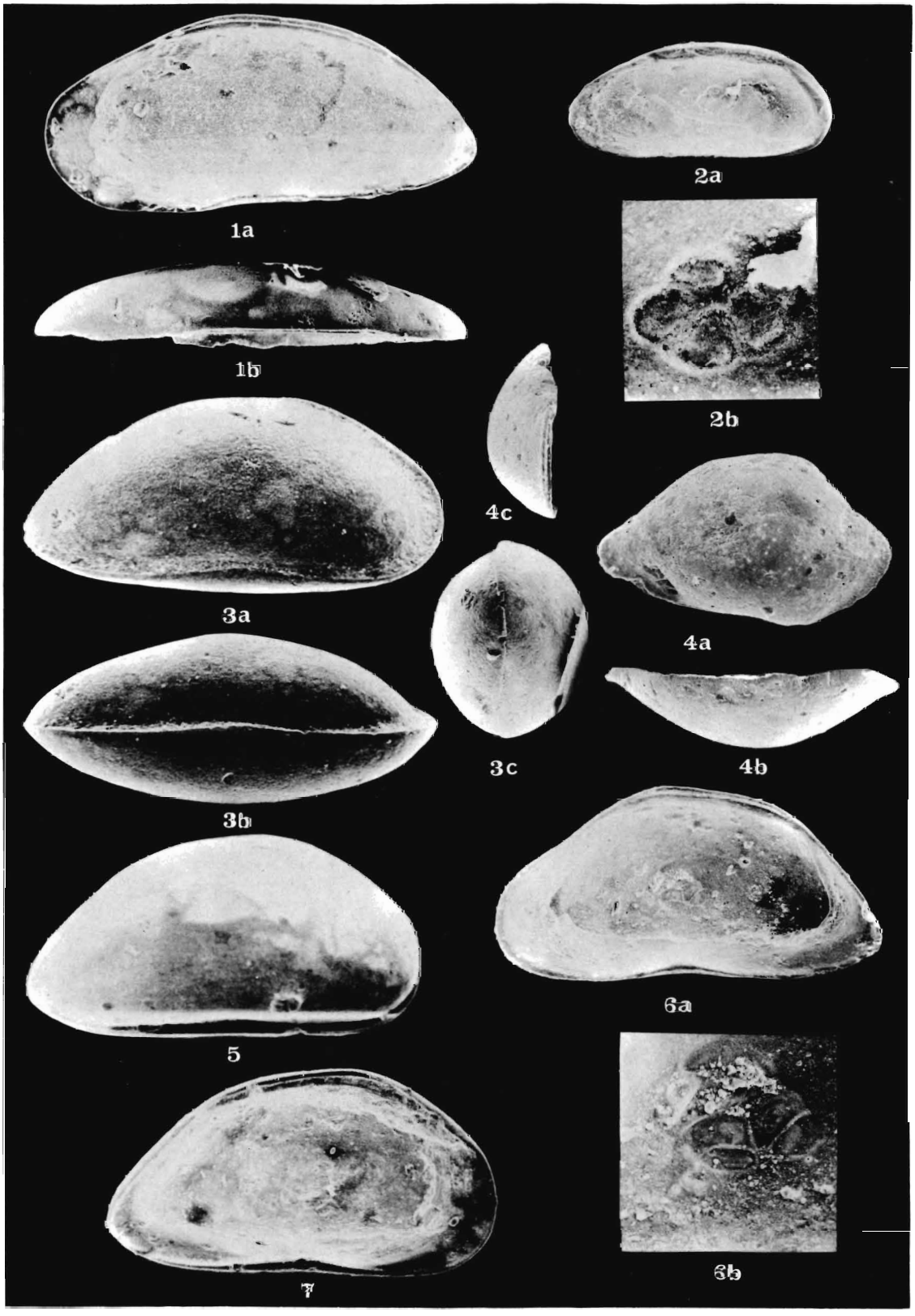
Fig. 1. *Pontocyprella*? sp. Right valve, HU.65.C.29 (now fragmentary). *a*, internal lateral view. *b*, dorsal view.

Fig. 2. *Bythocypris howchiniana* Chapman, 1917. Right valve, HU.65.C.27. *a*, internal view. *b*, detail of muscle-scar pattern, $\times c$. 160.

Fig. 3. *Bythocypris chapmani* sp. nov. Carapace. Specimen lost. *a*, lateral view from right. *b*, ventral view. *c*, anterior view.

Fig. 4. *Bairdia* cf. *B. austracretacea* Bate, 1972. Juvenile right valve, HU.65.C.26. *a*, external lateral view. *b*, dorsal view. *c*, anterior view.

Figs. 5–7. *Bythocypris chapmani* sp. nov. 5, holotype, carapace, HU.65.C.14.3. Lateral view from right. 6, paratype, right valve, HU.65.C.14.1. *a*, internal view. *b*, detail of muscle-scar pattern, $\times c$. 210. 7, paratype, left valve, HU.65.C.14.2. Internal view.



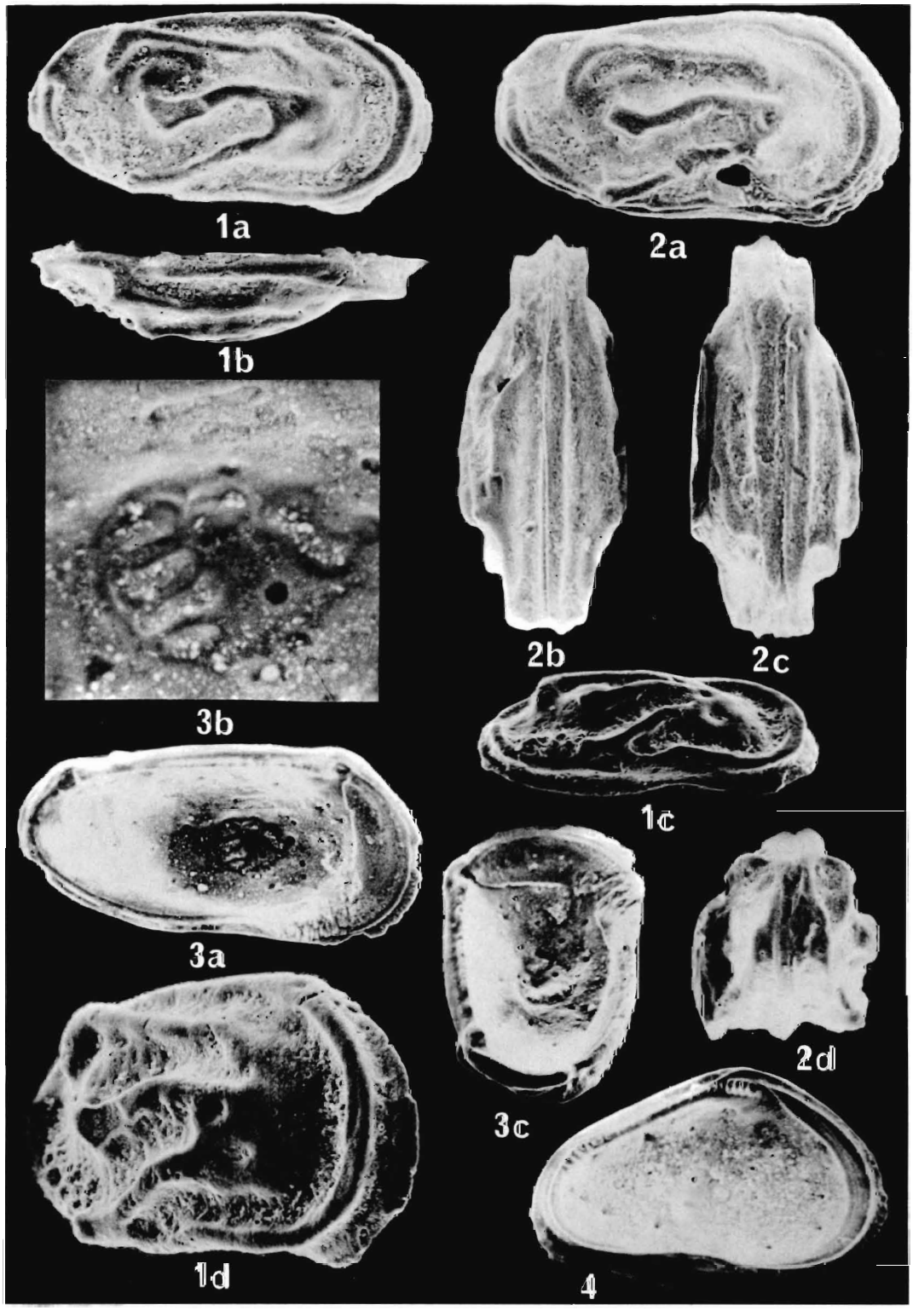
NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 6

All figures $\times 131 \pm 3$ except where stated.

Figs. 1–3. *Ginginella ginginensis* gen. et sp. nov. 1, female right valve. Specimen lost. *a*, external lateral view. *b*, dorsal view. *c*, oblique ventral view, $\times 115$. *d*, three-quarter anterior view, $\times 186$. 2, paratype, female carapace, HU.63.C.7. *a*, external lateral view from right. *b*, ventral view. *c*, dorsal view. *d*, posterior view. 3, holotype, male left valve, HU.63.C.6. *a*, inside lateral view. *b*, detail of muscle-scar pattern, $\times 450$. *c*, oblique internal view from posterior.

Fig. 4. *Rostrocytheridea westraliensis* (Chapman, 1917). Juvenile left valve, HU.65.C.36. Internal lateral view, $\times 124$.



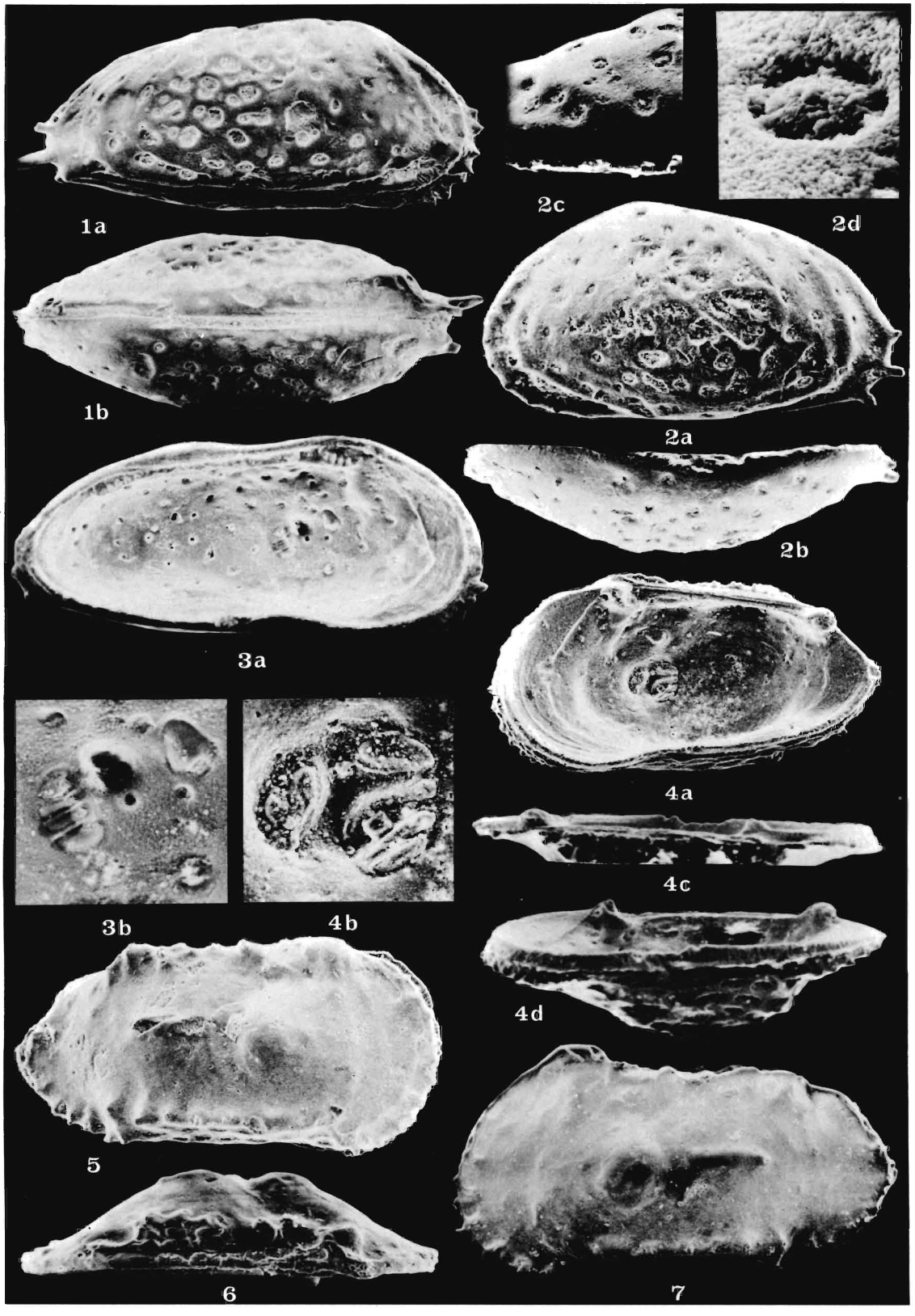
NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 7

All figures $\times 71$ except where stated.

Figs. 1–3. *Rostrocytheridea westraliensis* (Chapman, 1917). 1, male carapace, HU.65.C.32. *a*, lateral view from right. *b*, ventral view. 2, female left valve, HU.65.C.33. *a*, external lateral view. *b*, dorsal view. *c*, part of valve showing normal pore canals, $\times 164$. *d*, detail of normal pore canal, $\times 925$. 3, male left valve, HU.65.C.34. *a*, internal lateral view. *b*, muscle-scar pattern, $\times 195$.

Figs. 4–7. *Cythereis brevicosta* Bate, 1972, *obtusa* subsp. nov. 4, paratype, female right valve, HU.64.C.4. *a*, internal lateral view. *b*, muscle-scar pattern, $\times 245$. *c*, dorsal view of hinge. *d*, oblique ventral view. 5, paratype, male right valve, HU.64.C.5. External lateral view. 6, paratype, male left valve, specimen lost. Dorsal view. 7, holotype, male carapace, HU.64.C.3. Lateral view from left.



NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 8

All figures $\times 77 \pm 3$ except where stated.

Figs. 1–4. *Cythereis brevicosta* Bate, 1972, *obtusa* subsp. nov. 1, paratype, female right valve, HU.64.C.4. *a*, inside lateral view of anterior part of hinge, $\times c.$ 250. *b*, inside lateral view of posterior tooth, $\times c.$ 250. 2, paratype, male right valve, HU.64.C.5. Anterior view. 3, paratype, female carapace, HU.64.C.7. Anterior view, $\times 89$. 4, paratype, male left valve, specimen lost. Anterior view.

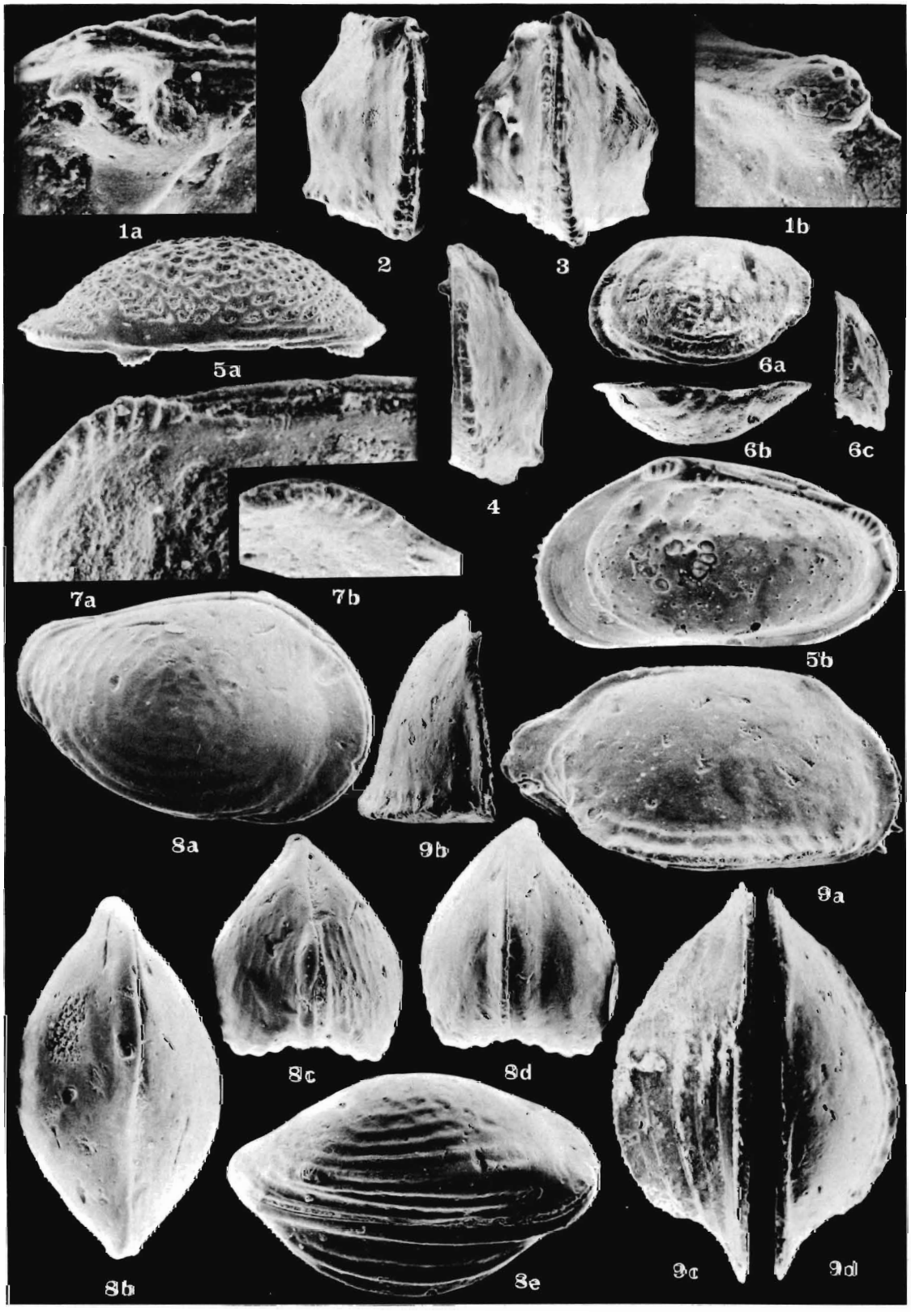
Fig. 5. *Majungaella verseyi* sp. nov. Holotype, right valve, HU.66.C.11. *a*, dorsal view. *b*, internal lateral view.

Fig. 6. *Collisarboris cooki* gen. et sp. nov. Holotype, female left valve, HU.67.C.30. *a*, external lateral view. *b*, dorsal view. *c*, anterior view.

Fig. 7. *Cytheropteron collisarboris* sp. nov. Holotype, right valve, HU.67.C.26. Internal view. *a*, anterior teeth. *b*, posterior teeth, $\times$ *c.* 250.

Fig. 8. *Tickalaracythere annula* (Bate, 1972). Carapace. Specimen lost. *a*, lateral view from right. *b*, dorsal view. *c*, posterior view. *d*, anterior view. *e*, ventral view.

Fig. 9. *Cytheropteron collisarboris* sp. nov. Paratype, right valve, HU.67.C.27. *a*, external lateral view. *b*, anterior view. *c*, ventral view. *d*, dorsal view.



NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 9

All figures $\times 100 \pm 4$ except where stated.

Figs. 1–2. *Cretaceratina trispinosa* gen. et sp. nov. 1, right valve, specimen lost. *a*, external lateral view. *b*, dorsal view. *c*, anterior view. *d*, posterior view. *e*, ventral view. *f*, detail of anterior dorsal surface spination, $\times$ *c.* 351. 2, left valve, specimen lost. *a*, external lateral view. *b*, dorsal view. *c*, posterior view. *d*, anterior view. *e*, ventral view. *f*, anterior oblique view.

Fig. 3. *Eucytherura* (*E.*) *fissipunctata* sp. nov. Paratype, right valve, HU.66.C.21. External lateral view, $\times 66$.

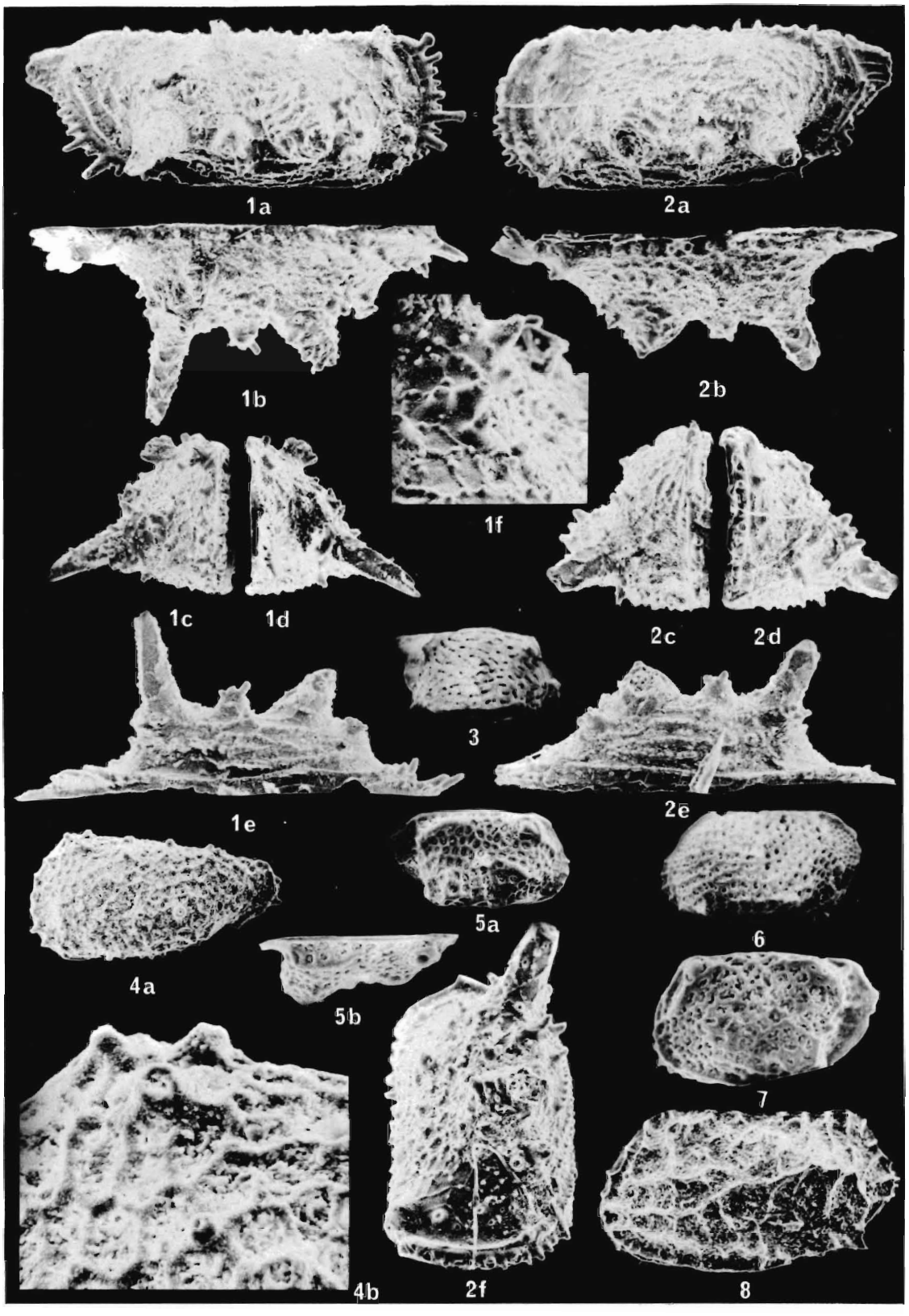
Fig. 4. *Trachyleberis pennyi* sp. nov. Juvenile left valve, specimen lost. *a*, external lateral view, $\times 95$. *b*, detail of anterior cardinal area, $\times c.430$.

Fig. 5. *Eucytherura* (*E.*) *antipodum* sp. nov. Paratype, juvenile right valve, HU.66.C.15. *a*, external lateral view. *b*, dorsal view, $\times 107$.

Fig. 6. *Saida rhomboidea* sp. nov. Paratype, left valve, HU.63.C.3. External lateral view.

Fig. 7. *Eucytherura* (*E.*) *antipodum* sp. nov. Holotype, left valve, HU.66.C.14. External lateral view, $\times 93$.

Fig. 8. *Apateloschizocythere geniculata* Bate, 1972. Female left valve, HU.64.C.2. External lateral view.

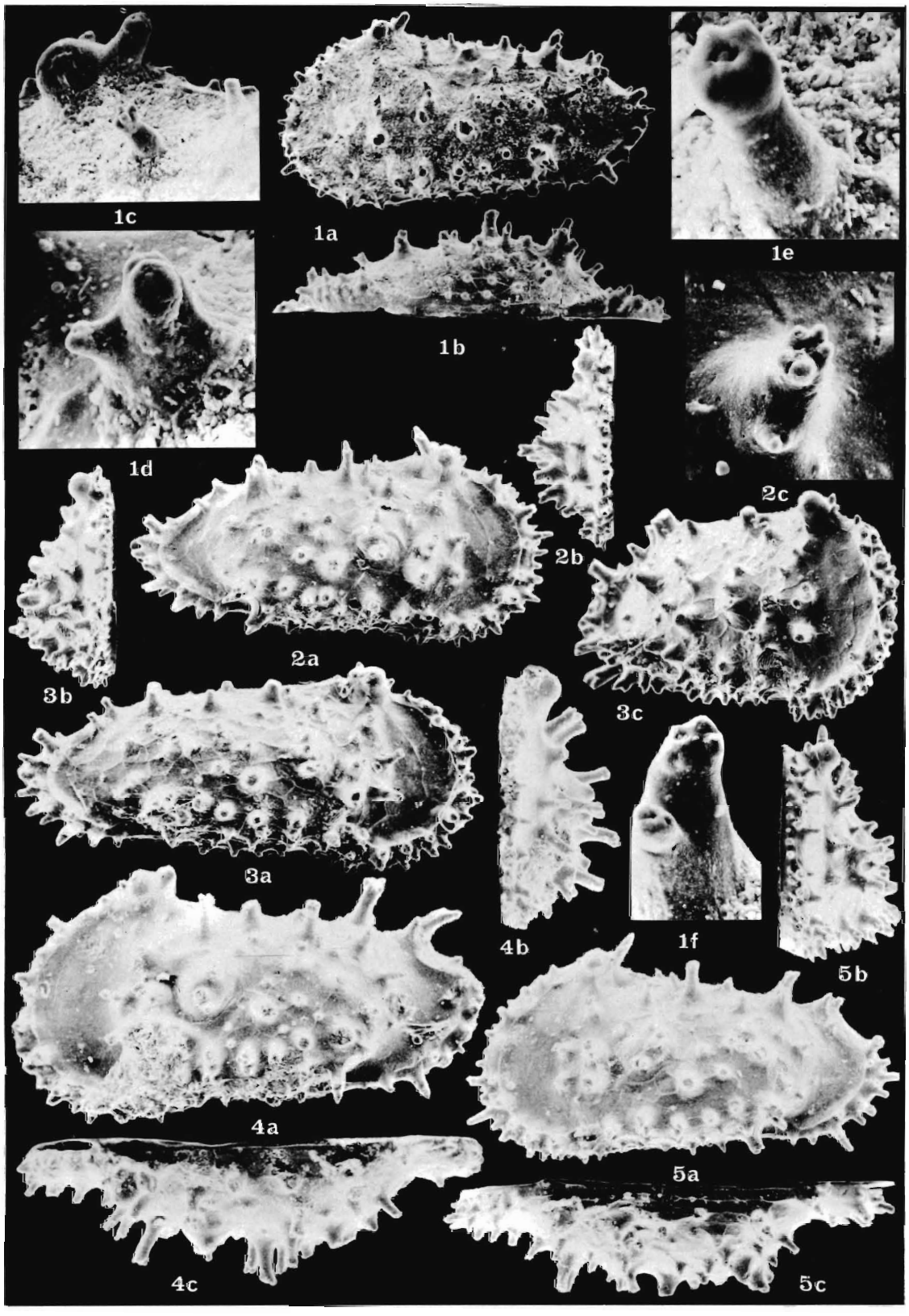


NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 10

All figures $\times 73 \pm 5$ except where stated.

Figs. 1–5. *Trachyleberis raynerae* sp. nov. 1, female left valve, pre-adult instar, specimen lost. *a*, external lateral view. *b*, ventral view. *c*, eye tubercle, $\times 210$. *d*, typical trifid spine, $\times c.$ 350. *e*, columnar 'castellated' spine, $\times c.$ 350. *f*, trifid, branched postero-dorsal 'castellated' spine, $\times c.$ 350. 2, paratype, female right valve, pre-adult instar, HU.63.C.11. *a*, external lateral view. *b*, anterior view. *c*, typical columnar 'castellated' spine, $\times c.$ 300. 3, holotype, male right valve, HU.63.C.10. *a*, external lateral view. *b*, anterior view. *c*, oblique antero-ventral view. 4, paratype, female left valve, HU.63.C.12. *a*, external lateral view. *b*, anterior view. *c*, dorsal view. 5, paratype, female left valve, HU.63.C.13. *a*, external lateral view. *b*, anterior view. *c*, dorsal view.



NEALE, Gingin Ostracoda

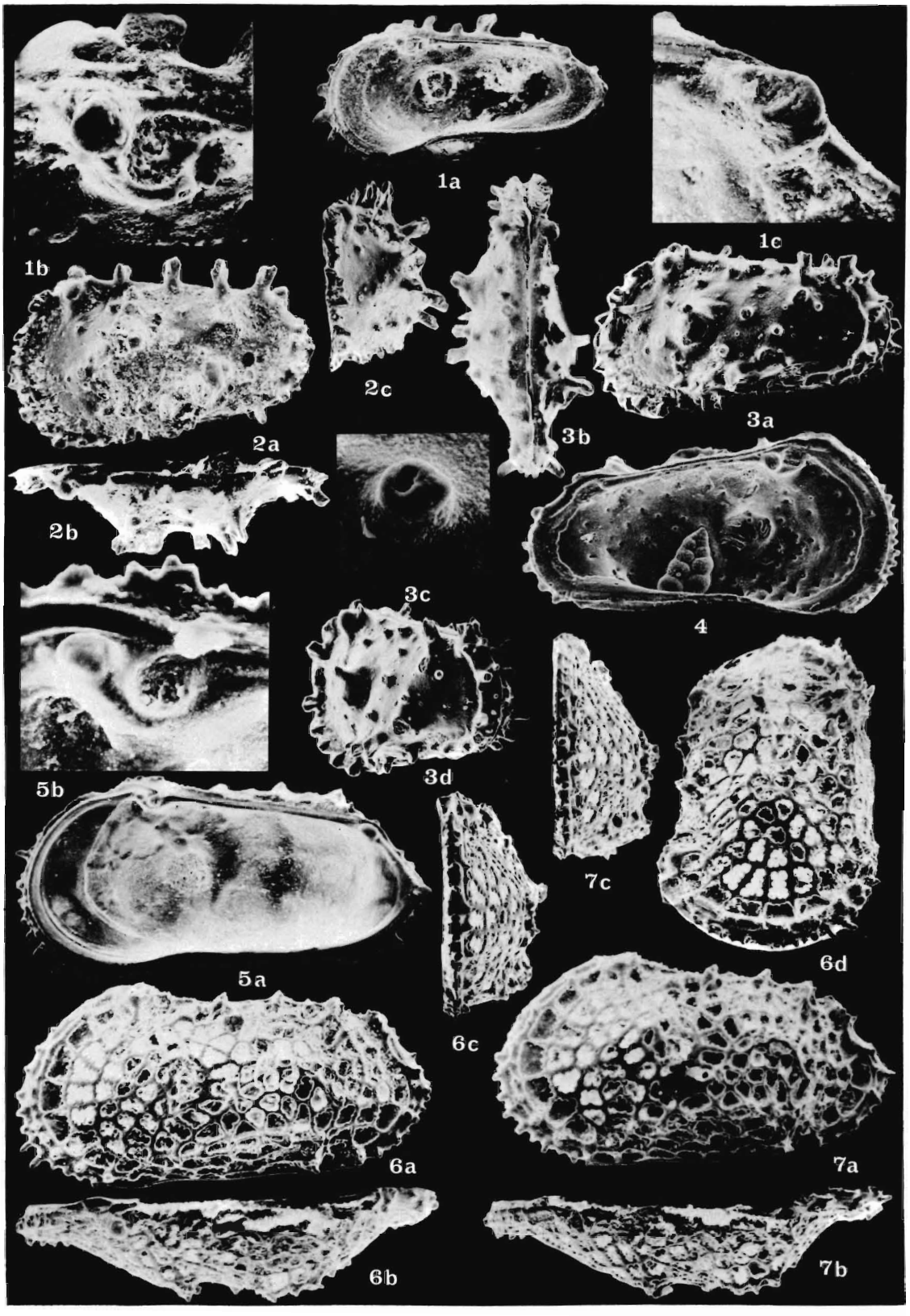
EXPLANATION OF PLATE 11

All figures $\times 75 \pm 2$ except where stated.

Figs. 1–3. *Trachyleberis pennyi* sp. nov. 1, paratype, male right valve, HU.63.C.18. *a*, internal lateral view. *b*, anterior tooth, $\times c.$ 370. *c*, posterior tooth, $\times c.$ 370. 2, paratype, female left valve, HU.63.C.19. *a*, external lateral view. *b*, dorsal view. *c*, anterior view. 3, holotype, male carapace, HU.63.C.17. *a*, external lateral view. *b*, dorsal view. *c*, detail of spine, $\times c.$ 400. *d*, oblique posterior view.

Fig. 4. *Hermanites volans* sp. nov. Paratype, male left valve, HU.64.C.15. Internal lateral view.

Figs. 5–7. *Limburgina aurora* sp. nov. 5, paratype, male right valve, HU.63.C.29. *a*, internal lateral view. *b*, anterior tooth and postjacent socket, $\times c.$ 375. 6, holotype, male left valve, HU.63.C.27. *a*, external lateral view. *b*, dorsal view. *c*, anterior view, $\times 81$. *d*, oblique anterior view, $\times 81$. 7, paratype, female left valve, HU.63.C.28. *a*, external lateral view. *b*, dorsal view. *c*, anterior view.



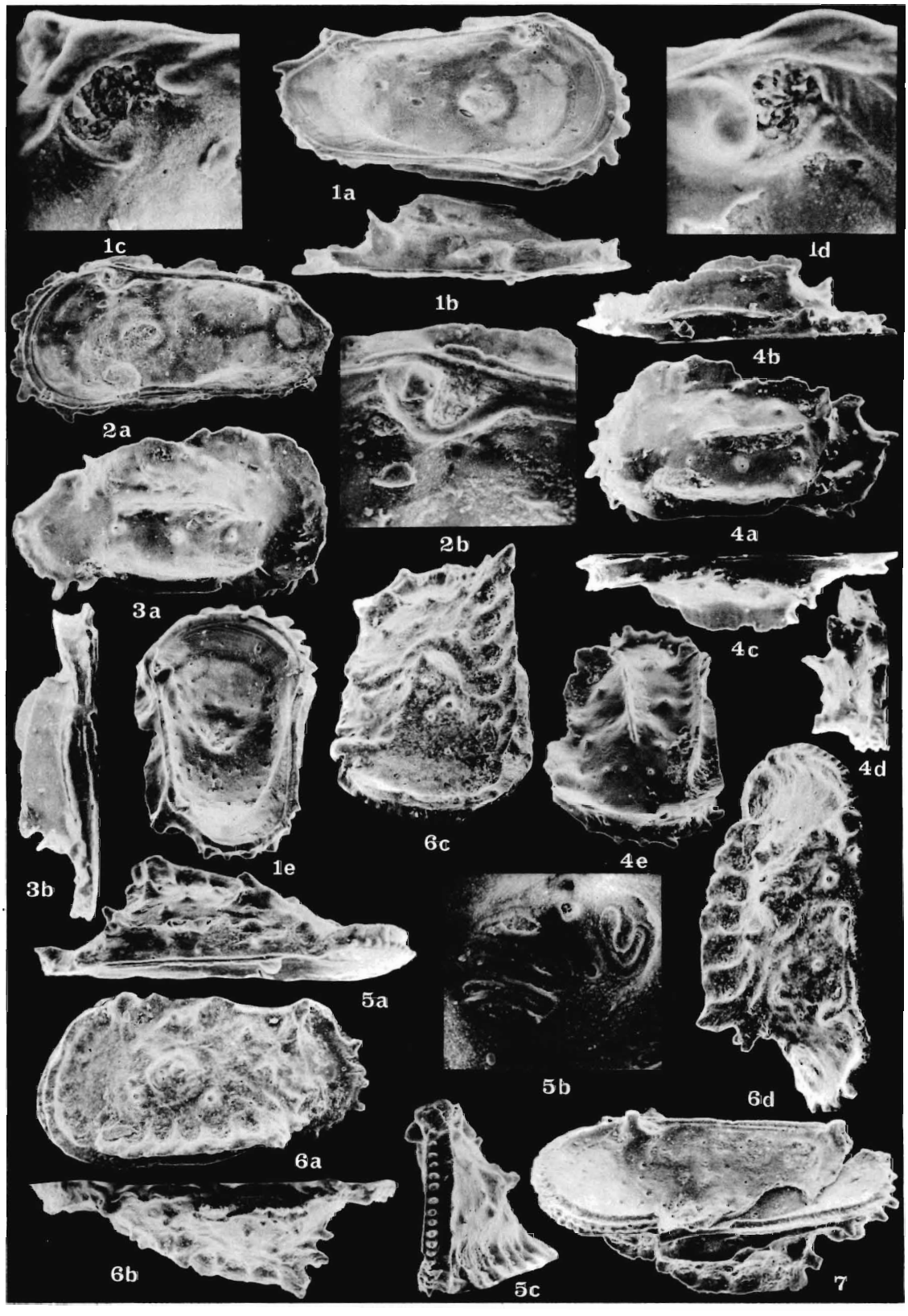
NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 12

All figures $\times 76 \pm 5$ except where stated.

Figs. 1–4. *Rayneria ginginensis* gen. et sp. nov. 1, holotype, female left valve, HU.64.C.9. *a*, internal lateral view. *b*, dorsal view. *c*, posterior part of hinge, $\times 400$. *d*, anterior part of hinge, $\times 400$. *e*, oblique internal view from posterior. 2, paratype, male right valve, HU.64.C.10. *a*, internal lateral view. *b*, anterior part of hinge, $\times c.$ 230. 3, paratype, female right valve, HU.64.C.11. *a*, external lateral view. *b*, ventral view. 4, paratype, female left valve, HU.64.C.12. *a*, external lateral view. *b*, ventral view. *c*, dorsal view. *d*, posterior view. *e*, oblique external view from anterior.

Figs. 5–7. *Hermanites volans* sp. nov. 5, paratype, male left valve, HU.64.C.15. *a*, dorsal view. *b*, muscle-scar pattern, $\times c.$ 250. *c*, anterior view. 6, holotype, female left valve, HU.64.C.14. *a*, external lateral view. *b*, dorsal view. *c*, oblique external view from anterior. *d*, oblique dorsal view. 7, paratype, female right valve, HU.64.C.16. Oblique internal view from ventral side.



NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 13

Fig. 1. *Pedicythere australis* sp. nov. Paratype, female right valve, HU.64.C.19. *a*, external lateral view. *b*, dorsal view. *c*, anterior view. *a*, *b*, ×155; *c*, ×195.

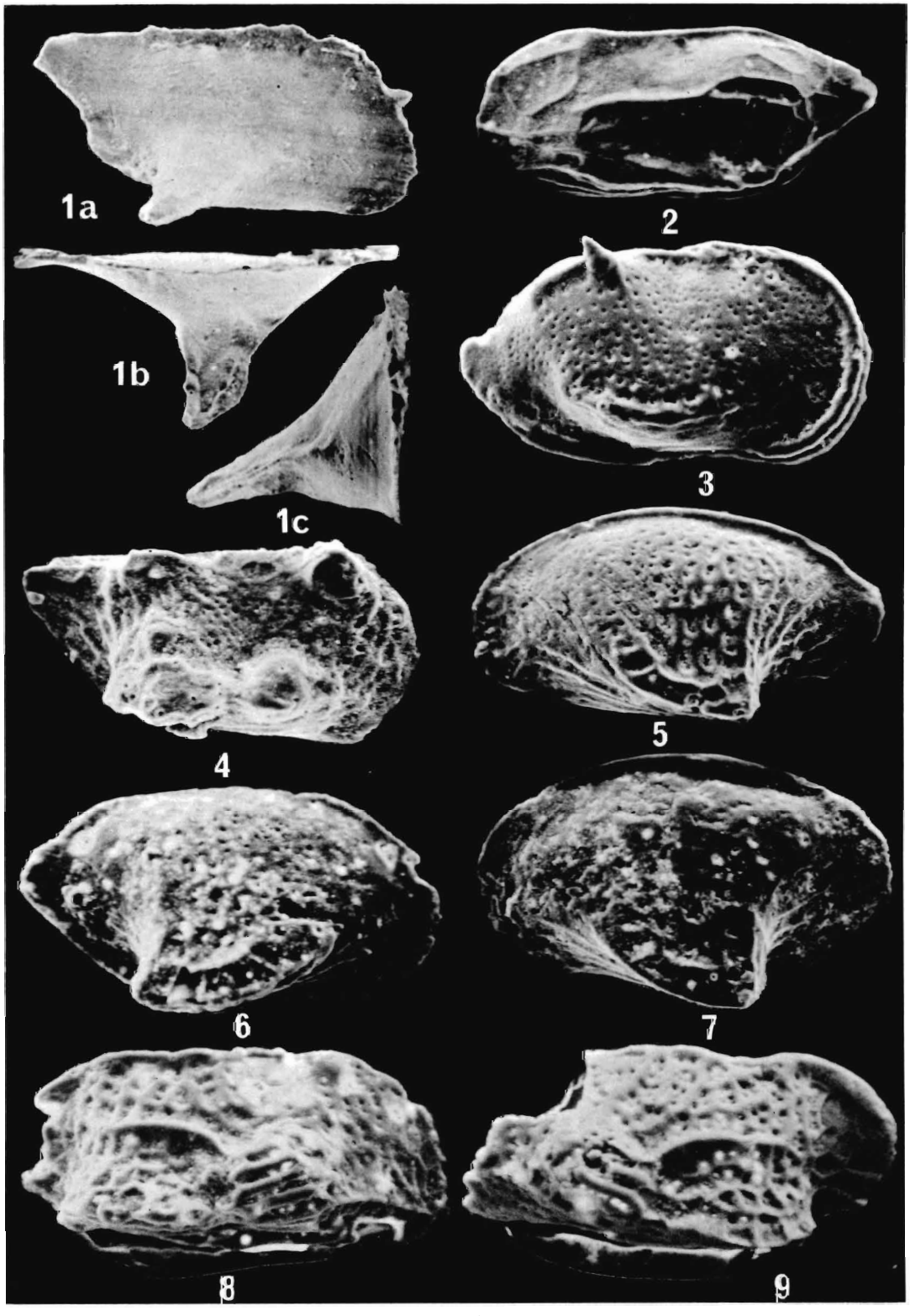
Fig. 2. *Semicytherura cretae* sp. nov. Paratype, left valve, HU.66.C.6. External lateral view, ×170.

Fig. 3. *Hermanites volans* sp. nov. Juvenile right valve, HU.67.C.11. External lateral view, ×166.

Fig. 4. *Hemiparacytheridea hemingwayi* sp. nov. Paratype, female right valve, HU.66.C.2. External lateral view, ×226.

Figs. 5–7. *Cytheropteron* (*Aversovalva*) *westaustraliense* sp. nov. 5, paratype, left valve, HU.62.C.15. External lateral view, ×204. 6, paratype, right valve, HU.62.C.14. External lateral view, ×186. 7, holotype, left valve, HU.62.C.13. External lateral view, ×195.

Figs. 8–9. *Hemingwayella ornata* gen. et sp. nov. 8, paratype, right valve, HU.62.C.4. External lateral view, ×218. 9, paratype, left valve, HU.62.C.2. External lateral view, ×230.



NEALE, Gingin Ostracoda

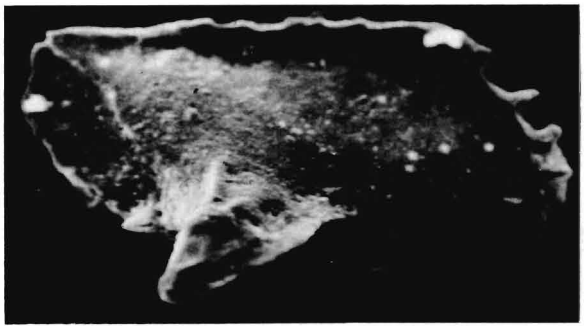
EXPLANATION OF PLATE 14

Stereoscopic paired photographs.

Figs. 1–2. *Pedicythere australis* sp. nov. 1, paratype, female right valve, HU.66.C.12. External lateral view, ×201. 2, paratype, female left valve, HU.66.C.13. External lateral view, ×186.

Fig. 3. *Majungaella verseyi* sp. nov. Holotype, right valve, HU.66.C.11. External lateral view, ×98.

Fig. 4. *Saida rhomboidea* sp. nov. Holotype, right valve, HU.63.C.1. External lateral view, ×241.



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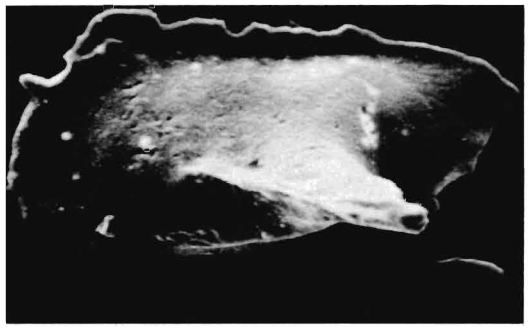

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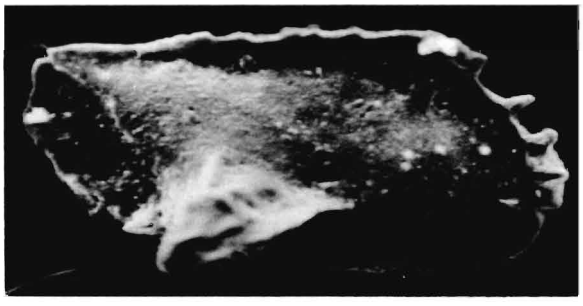

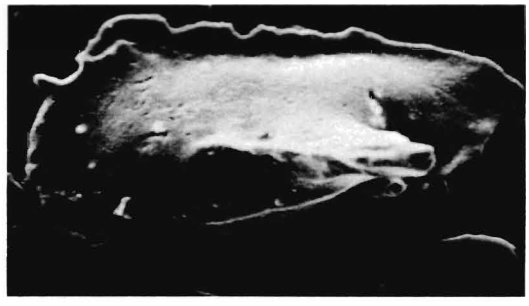

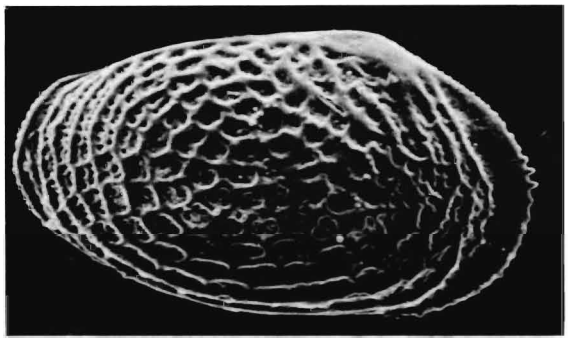

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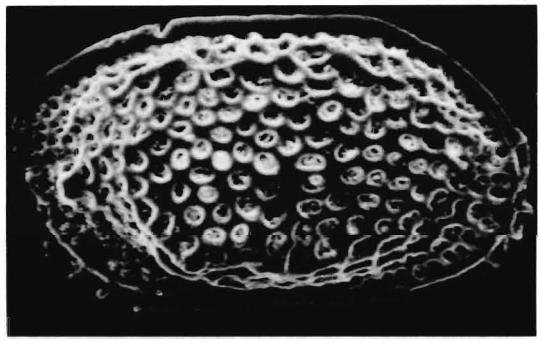

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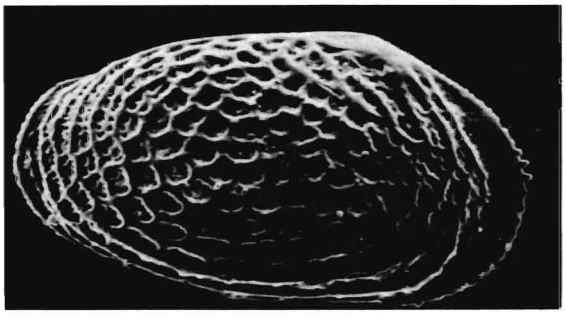
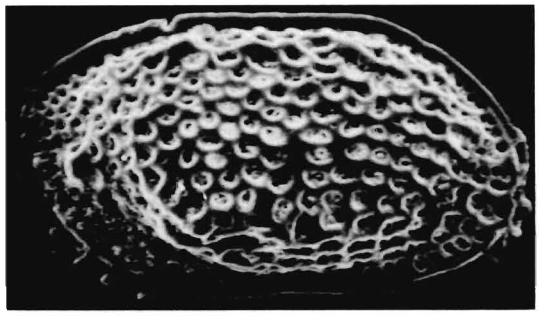




NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 15

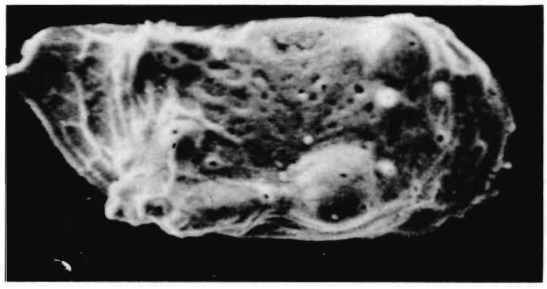
Stereoscopic paired photographs.

Fig. 1. *Hemiparacytheridea hemingwayi* sp. nov. Holotype, male right valve, HU.66.C.1. External lateral view, ×250.

Fig. 2. *Verseya pulchra* gen. et sp. nov. Paratype, right valve, HU.66.C.29. External lateral view, ×174. Note that part of the valve is missing postero-ventrally.

Fig. 3. *Semicytherura cretae* sp. nov. Holotype, right valve, HU.66.C.5. External lateral view, ×186.

Fig. 4. *Semicytherura augusta* sp. nov. Holotype, left valve, HU.66.C.8. External lateral view, ×223.



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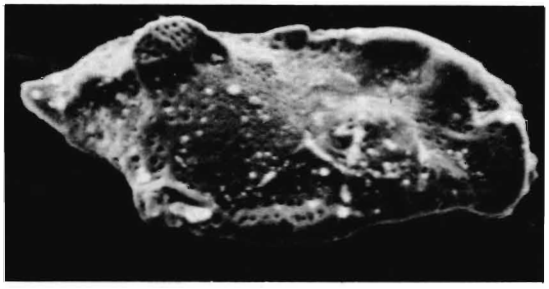

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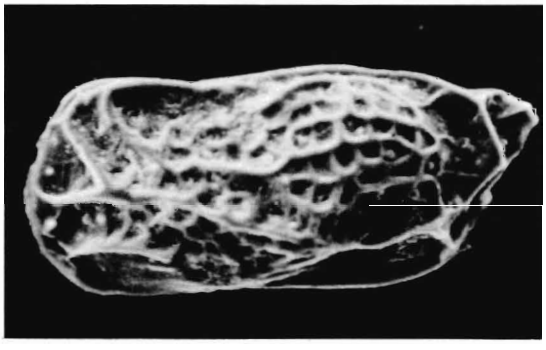

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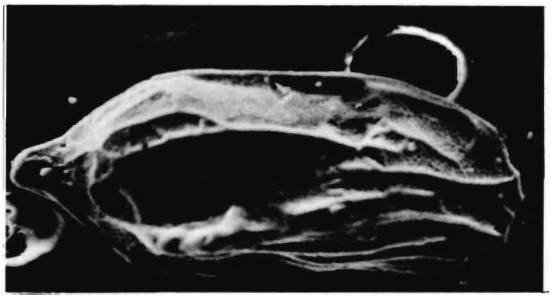
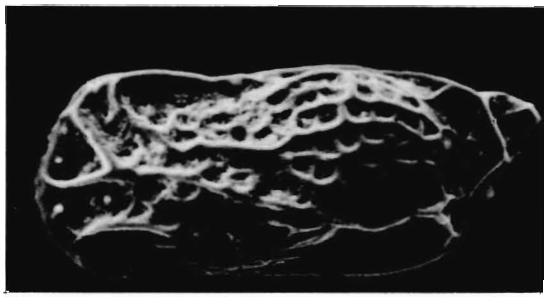




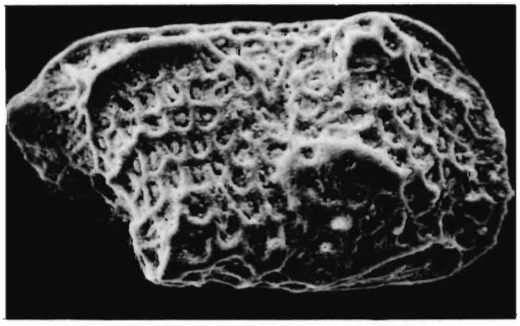
NEALE, Gingin Ostracode

EXPLANATION OF PLATE 16

Stereoscopic paired photographs.

Fig. 1. *Eucytherura* (*Eucytherura*) *antipodum* sp. nov. Paratype, juvenile right valve, HU.66.C.16. External lateral view, ×270.

Figs. 2–4. *Eucytherura* (*Eucytherura*) *fissipunctata* sp. nov. 2, paratype, right valve, HU.66.C.22. Internal lateral view, ×201. 3, paratype, right valve, HU.66.C.23. External lateral view, ×180. 4, holotype, left valve, HU.66.C.20. External lateral view, ×208.



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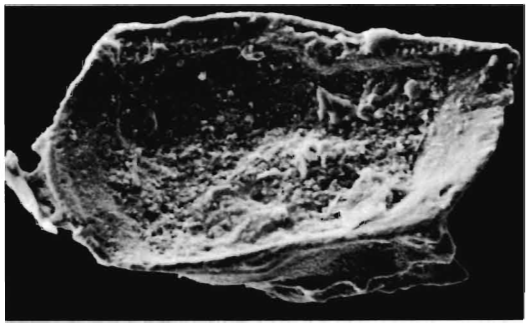

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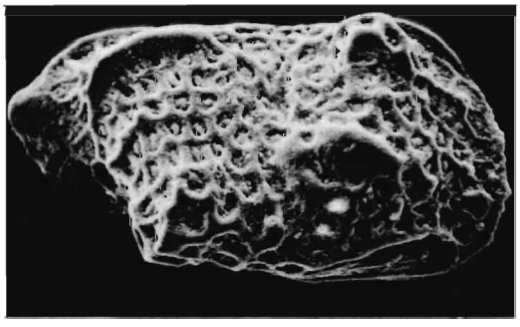

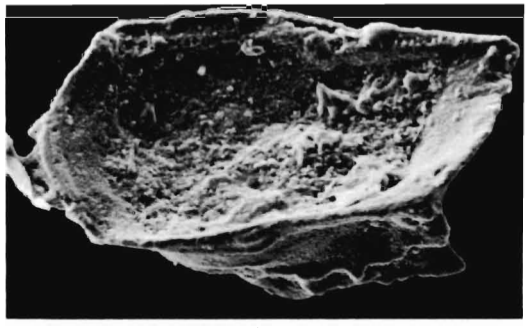

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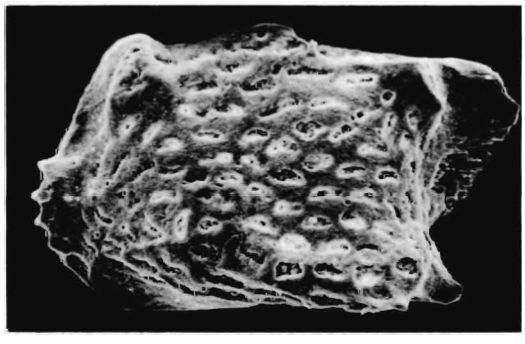

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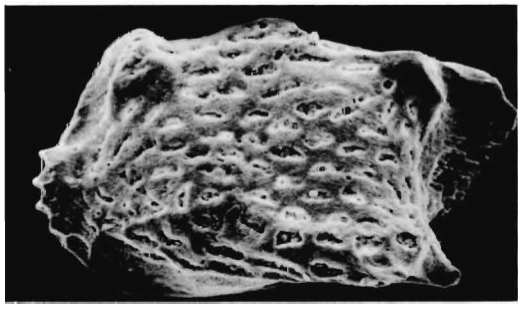
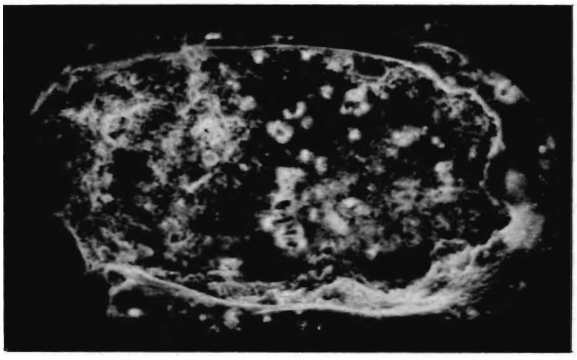


NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 17

Stereoscopic paired photographs.

Figs. 1–5. *Verseya pulchra* gen. et sp. nov. 1, paratype, left valve, HU.66.C.31. Internal lateral view, × 186. 2, holotype, left valve, HU.66.C.28. External lateral view, × 183. 3, holotype, left valve, HU.66.C.28. Detail of postero-dorsal tubercle, × 550. 4, holotype, left valve, HU.66.C.28. Oblique anterior view, × 140. 5, paratype, left valve, HU.66.C.32. Oblique internal ventral view, × 136.



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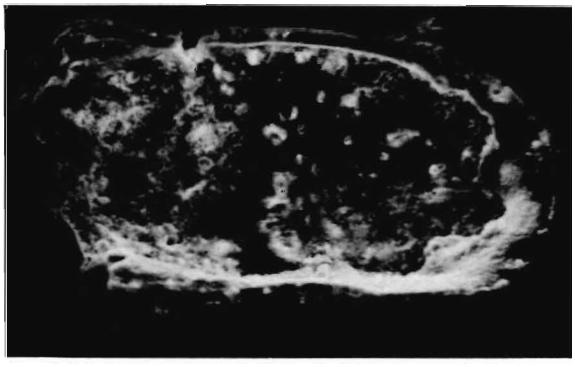

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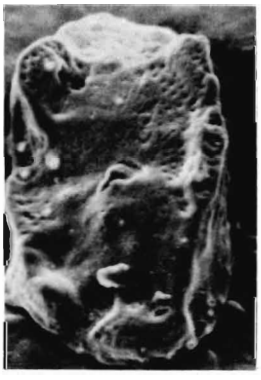

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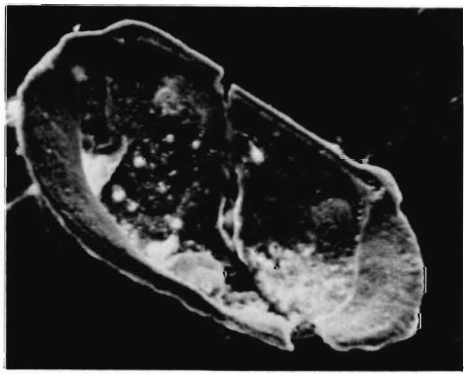

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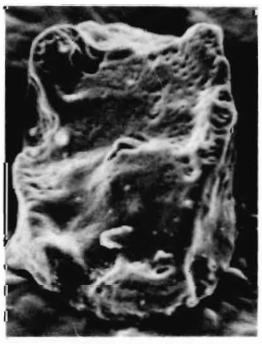
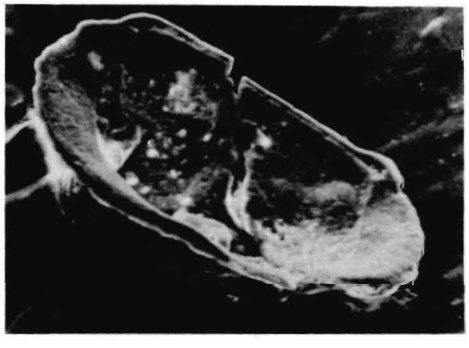




NEALE, Gingin Ostracoda

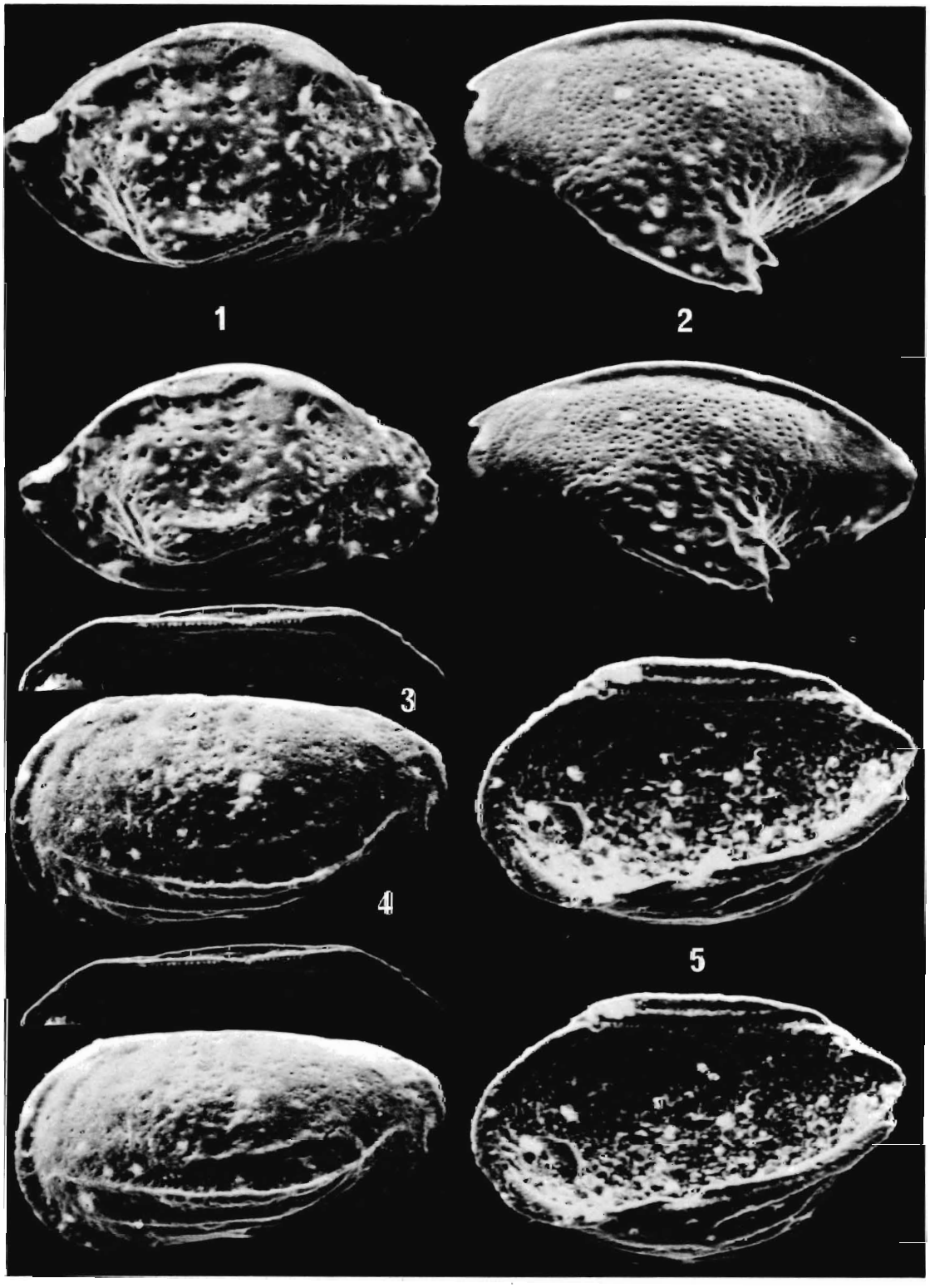
EXPLANATION OF PLATE 18

Stereoscopic paired photographs.

Fig. 1. *Oculocytheropteron praenuntatum* Bate, 1972. Right valve, HU.67.C.25. External lateral view, × 183.

Fig. 2. *Cytheropteron* (*Aversovalva*) *mccomborum* sp. nov. Holotype, left valve, HU.62.C.6. External lateral view, × 255.

Figs. 3–5. *Collisarboris cooki* gen. et sp. nov. 3, paratype, male left valve, HU.67.C.31. Internal view showing hinge structure, × 154. 4, paratype, male left valve, penultimate instar, HU.67.C.32. External lateral view, × 185. 5, paratype, female right valve, penultimate instar, HU.67.C.33. Internal view, × 185.



NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 19

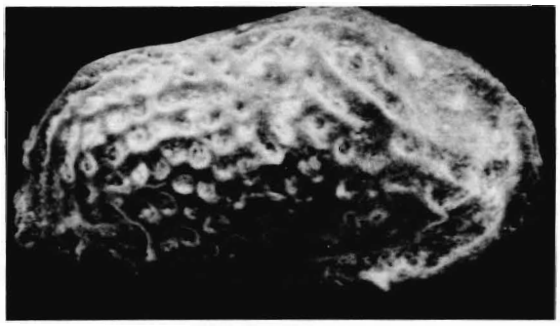
Stereoscopic paired photographs.

Fig. 1. *Paramunseyella austracretacea* Bate, 1972. Female(?) right valve, HU.67.C.21. External lateral view, × 142.

Fig. 2. *Premunseyella imperfecta* Bate, 1972. Male right valve, HU.67.C.12. External lateral view, × 151.

Fig. 3. *Paramunseyella prideri* sp. nov. Holotype, female right valve, HU.67.C.14. External lateral view, × 152.

Fig. 4. *Eorotundracythere compta* Bate, 1972. Female left valve, HU.67.C.35. External lateral view, × 186.



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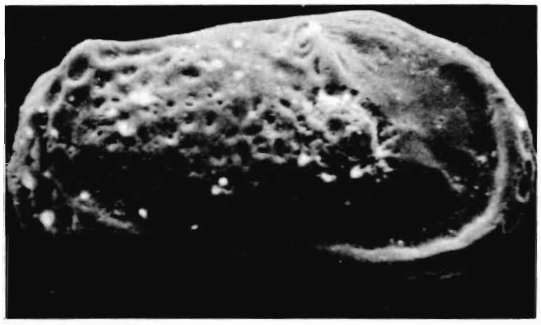

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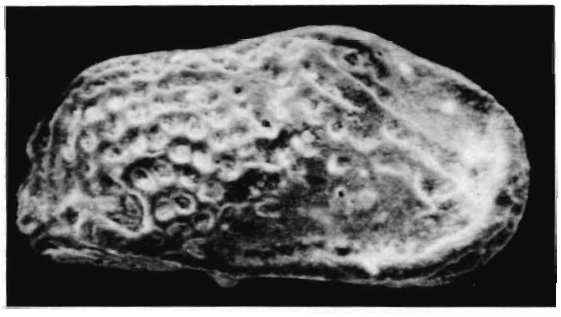

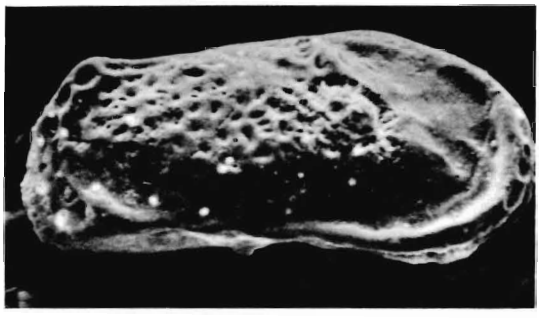

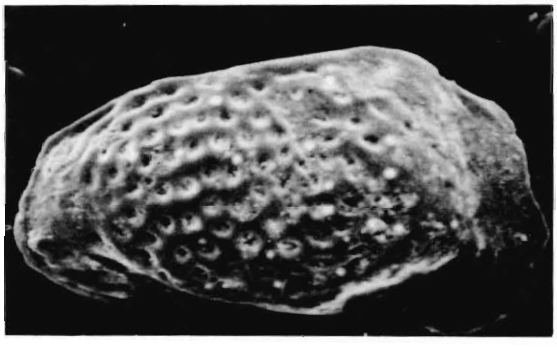

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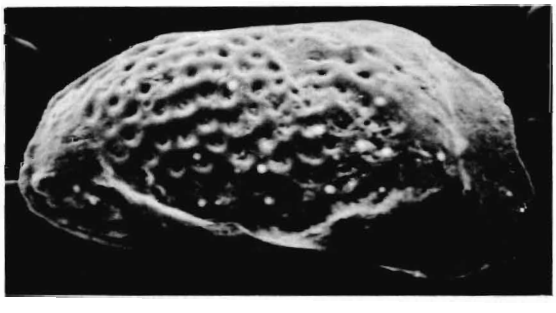


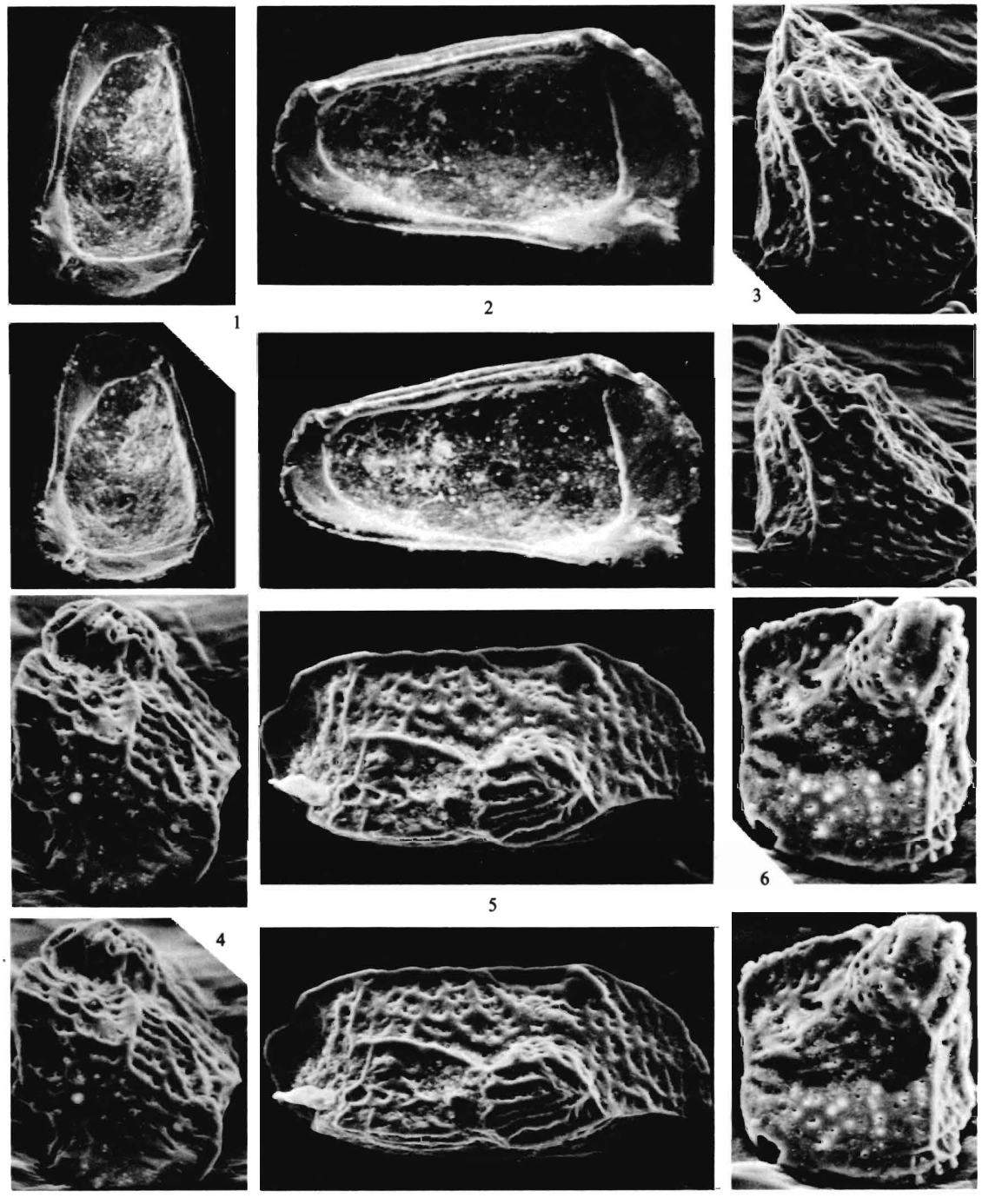
NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 20

Stereoscopic paired photographs.

Figs. 1–2. *Paramunseyella prideri* sp. nov. 1, paratype, female left valve, HU.67.C.15. Internal anterior oblique view, ×115. 2, paratype, female left valve, HU.67.C.15. Internal lateral view, ×161.

Figs. 3–6. *Hemingwayella ornata* gen. et sp. nov. 3, holotype, right valve, HU.62.C.1. External anterior oblique view, ×212. 4, paratype, left valve, HU.62.C.2. External posterior oblique view, ×236. 5, holotype, right valve, HU.62.C.1. External lateral view, ×210. 6, paratype, left valve, HU.62.C.3. External anterior oblique view, ×234.



NEALE, Gingin Ostracoda

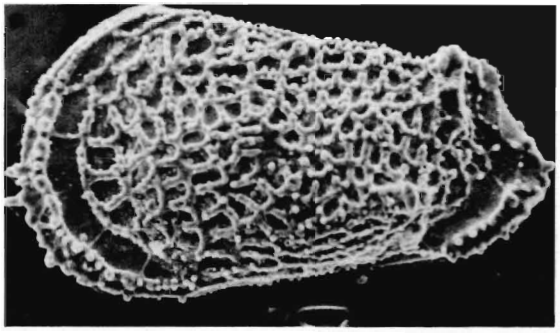
EXPLANATION OF PLATE 21

Stereoscopic paired photographs.

Figs. 1–2. *Pennyella pennyi* Neale, 1974. 1, holotype, female left valve, HU.67.C.1. External lateral view, ×140. 2, paratype, female left valve, HU.67.C.5. Internal lateral view, ×124.

Fig. 3. *Limburgina aurora* sp. nov. Paratype, female left valve, HU.63.C.30. External lateral view, ×70.

Fig. 4. *Scepticocythereis ornata* Bate, 1972. Female left valve, HU.63.C.33. External lateral view, ×70.



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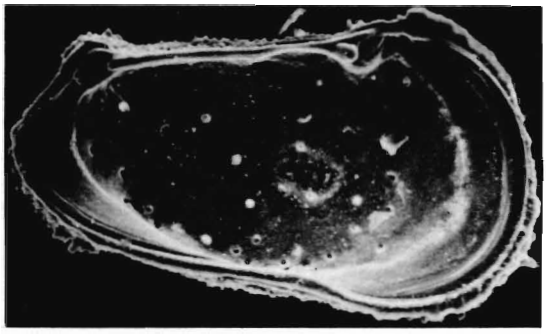
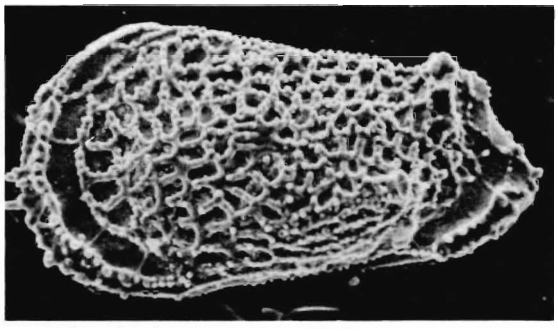
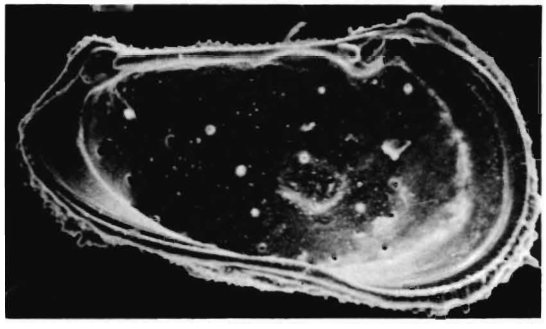
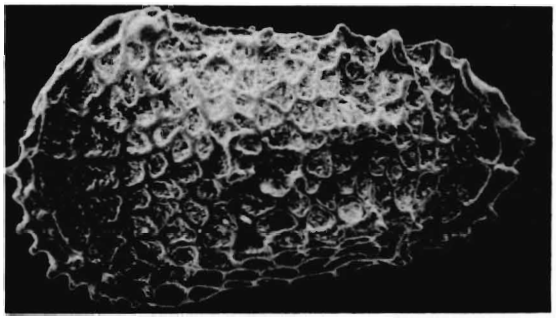


2







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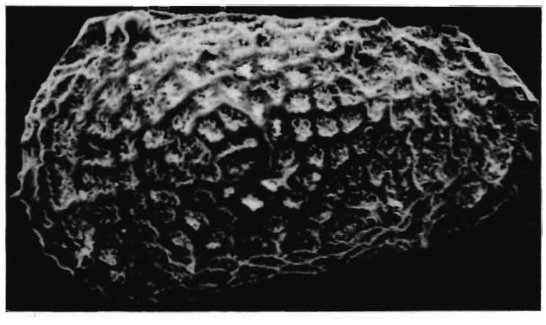

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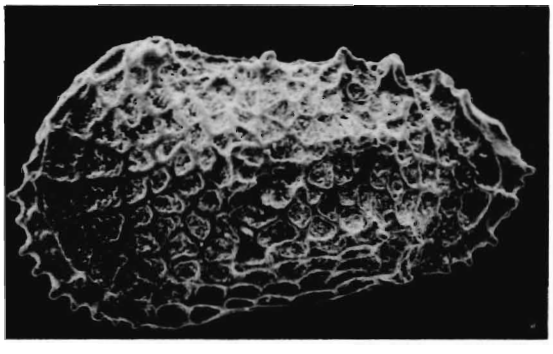
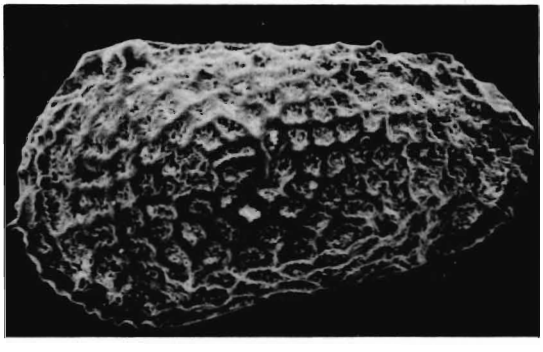


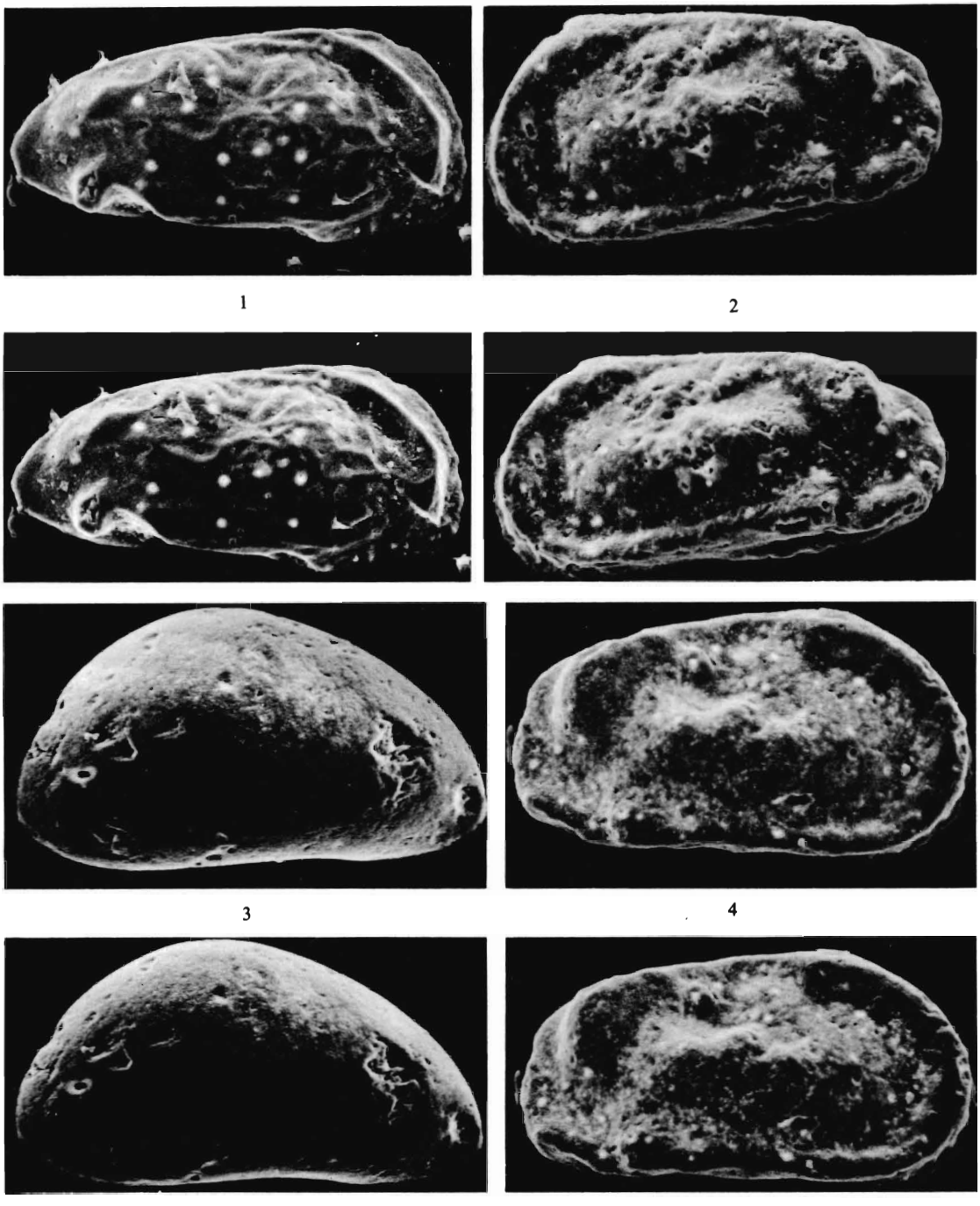


NEALE, Gingin Ostracoda

EXPLANATION OF PLATE 22

Stereoscopic paired photographs.

Fig. 1. Genus A sp. Right valve, HU.65.C.24. External lateral view, $\times 222$.
Fig. 2. *Munseyella tuberculata* sp. nov. Paratype, male left valve, HU.62.C.31. External lateral view, $\times 161$.
Fig. 3. *Uroleberis batei* sp. nov. Holotype, female right valve, HU.62.C.21. External lateral view, $\times 222$.
Fig. 4. *Munseyella tuberculata* sp. nov. Holotype, female right valve, HU.62.C.30. External lateral view, $\times 177$.



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