

CARBONIFEROUS CHONETACEAN AND PRODUCTACEAN BRACHIOPODS FROM EASTERN AUSTRALIA

by JOHN ROBERTS

ABSTRACT. Chonetacean and productacean brachiopods are amongst the most useful groups in defining the nine Carboniferous brachiopod zones of Eastern Australia. The current revision of the zones has led to the recognition of many new taxa and the clarification of a number of previously described species. Three new chonetaceans and fourteen new productaceans, nearly half the known productacean fauna, are described. Chonetaceans include *Trichoconetes perpendicularis* gen. et sp. nov., *Leioconetes salisburyensis* gen. et sp. nov., and *Megachonetes alatus* sp. nov.; and productaceans include *Pharcidodiscus boulderensis* gen. et sp. nov., *Spinorugifera chichesterensis* gen. et sp. nov., and the new species *Productina striata*, *P. macdonaldi*, *P. morrisoni*, *Krotovia prociua*, *Stegacanthia leviatha*, *Rugauris? brookeri*, *Eomarginifera megalotis*, *Inflatia engeli*, *Scolococoncha geniculata*, *Marginicinctus reticulatus*, *Antiquatonia spinulicosta*, and *Reticulatia cinctifera*. The morphological relationships between *Retichonetes kennedyensis*, *Rugosochonetes magnus*, *R. careyi*, and *R. gloucesterensis* are clarified, and *Spinocarinfiera kennedyensis* and *Marginatia patersonensis* are revised. The affinities of the species provide new evidence for the ages of some zones: the *Tulcumbella tenuistriata* Zone is confirmed as early Tournaisian; the *Delepinea aspinosa* Zone is, mainly from ammonoid evidence, late Viséan; and the *Levipustula levis* Zone is shown to be Namurian to Westphalian in age.

THE sequence of eastern Australian Carboniferous brachiopod faunas, which ranges in age from Tournaisian to possibly Stephanian, has been divided into nine zones (text-fig. 3; Campbell and Roberts 1969; Jones *et al.* 1973; and Roberts 1975). Recent biostratigraphical studies by Roberts (1975) have linked the Early Carboniferous zones to reference sections within well-known stratigraphical sequences. This has clarified both the faunal composition of each zone and the relationships between zones. Work is currently in progress to revise the zonal sequence in the Upper Carboniferous. During the course of these revisions new taxa have been recognized, and it has also been necessary to revise the concept of a number of existing taxa.

This paper provides a large part of the systematic basis for the revision of early Carboniferous zones, and includes the description or revision of a large proportion of the Early Carboniferous chonetacean fauna and half the known Carboniferous productacean fauna. The seven chonetaceans include two new genera, *Trichoconetes* and *Leioconetes*, and the sixteen productaceans the new genera *Pharcidodiscus* and *Spinorugifera*.

Material from both New South Wales and Queensland is housed in three museums: the Australian Museum, Sydney; the Geological Survey of Queensland, Brisbane; and the Department of Geology, University of Queensland, St. Lucia. Details of localities, including locality number, grid reference, and the name of the topographic sheet, of material used in the systematic descriptions are listed at the end of the paper. Most of the locality numbers cited in the occurrences of species refer to collections held in the School of Applied Geology, University of New South Wales (for example, 88-3); other locality numbers refer to collections in the Geology Departments at the University of Newcastle (L402 U Newcastle), the University of New England (L35 UNE), the Australian National University, Canberra (L10024 ANU), and the University of Queensland (L1288 UQ), and to collections at the Geological Survey of Queensland. Precise locality data can be obtained from each of these institutions.

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BIOSTRATIGRAPHY AND AGES OF THE ZONES

The stratigraphical ranges of all known Early Carboniferous chonetaceans and Carboniferous productaceans described from eastern Australia are shown in text-figs. 2 and 3 respectively. The

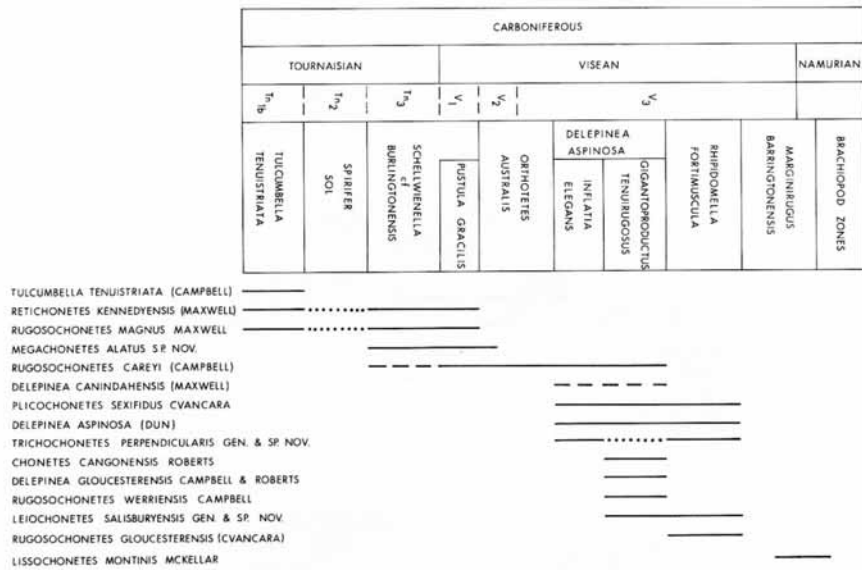


TEXT-FIG. 1. Locality map showing main areas of outcrop of Carboniferous rocks in eastern Australia.

ranges are plotted against the eastern Australian brachiopod zones, which in turn are correlated with the standard European stages. Correlations with Europe are based mainly on evidence from ammonoids and to a smaller extent on conodonts and brachiopods (Jones *et al.* 1973). Jenkins (1974), from work on conodonts, suggested alternative ages for some of the zones, particularly the *Orthotetes australis* and *Delepineia aspinosa* Zones. His proposals are examined, and rejected, in the following discussion on the ages of some of the zones. Brachiopod faunas do not appear to be as precise as ammonoids or conodonts in determining correlations between Australia and northern hemisphere continents, possibly because of the geographic separation of the two areas (Smith *et al.* 1973, fig. 11). A number of the productaceans described in this paper, however, are sufficiently close morphologically to overseas species to give 'indications' of age.

The early Tournaisian age of the *Tulcumbella tenuistriata* Zone, previously derived indirectly (Jones *et al.* 1973), is confirmed by the close morphological relationship between *Spinocarinfiera kennedyensis* (Maxwell) and *S. adumata* Roberts. *S. adumata* comes from rocks in the Bonaparte Gulf Basin, north-western Australia, dated by conodonts and brachiopods as early Tournaisian (Roberts 1971).

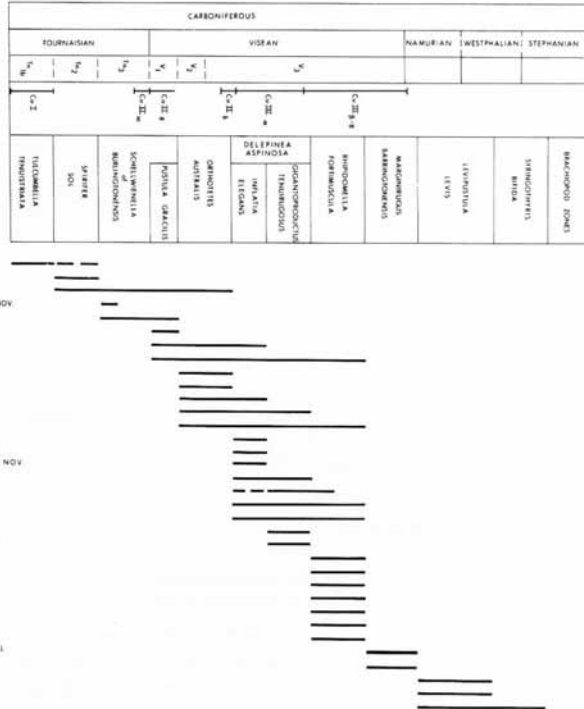
The *Delepineia aspinosa* Zone has long been considered to be late Viséan in age (Roberts 1965a; Campbell and McKellar 1969; Jones *et al.* 1973). Brachiopods from the zone do not give precise indications of age because species with which they are compared have long stratigraphical ranges, but ammonoids from immediately adjacent zones determine the maximum and minimum ages of the zone. The lower limit is provided by an ammonoid fauna from the *Orthotetes australis* Zone at Trevallyn (Roberts 1965a, b; Brown *et al.* 1965), and the upper limit by ammonoid faunas in the *Rhipidomella fortimuscula* Zone in both New South Wales and Queensland (Jones *et al.* 1973; Campbell and Brown, unpublished). Conodonts from the *Gigantoproductus tenuirugosus* Subzone of the *Delepineia aspinosa* Zone in the Flagstaff Sandstone at Brownmore led Jenkins (1974) to suggest younger ages for both the *Orthotetes australis* and *D. aspinosa* Zones. Jenkins's *Patrognathus?* cf. *capricornis* Zone at Brownmore was dated as early Viséan because of the associa-



TEXT-FIG. 2. Ranges of Early Carboniferous chonetaceans plotted against eastern Australian Brachiopod Zones. Specimens have not been collected from dotted portions of the stratigraphical ranges.

tion of *Gnathodus bulbosus* with *Taphrognathus varians*. The latter species ranges into the late Viséan *Apertognathus scalenus*-*Cavusgnathus* Zone in the Mississippi Valley (Collinson *et al.* 1971) and hence the age is based essentially on *G. bulbosus*, which was considered to be short-ranging and to be confined to the early Viséan. More recent sampling of limestones in eastern Australia by Jenkins (pers. comm.) indicates that *G. bulbosus* has a longer range than previously recognized. The species has so far been recorded from the *Pustula gracilis* Subzone in the Waverley Formation at Rouchel, New South Wales; from both the *O. australis* and *D. aspinosa* Zones in the Woolooma Formation at Rouchel; and fragments have been recovered from the *Marginirugus barringtonensis* Zone in the Killala Creek Formation, Queensland. In Australia, therefore, the range of *G. bulbosus* is so large that the species cannot indicate a precise correlation. It is perhaps noteworthy that Collinson *et al.* (1971, pp. 380-381) suggested that the *G. bulbosus* Zone in Missouri 'may be the result of a local biologic phenomenon of little biostratigraphic significance'.

Jenkins (1974) also questioned the identifications of *Prolecanites* sp. (Roberts 1965b) and the generic assignment of *Beyrichoceras trevallynense* (Brown *et al.* 1965) which provide the basis of the CuII_δ or CuIII_α age for the *O. australis* Zone and hence the maximum possible age for the *D. aspinosa* Zone. Additional specimens of *Prolecanites* sp., identical with those from Trevallyn, have been collected from the lowermost part of the *Inflatia elegans* Subzone of the *D. aspinosa* Zone at Rouchel, New South Wales (Roberts and Oversby 1974). These possess a ventral lobe intermediate between those of *Prolecanites* and an informal taxon termed Genus B by



TEXT-FIG. 3. Ranges of Carboniferous productaceans plotted against eastern Australian Brachiopod Zones.

Weyer (1972*b*, fig. 2). According to Weyer, *Prolecanites* ranges throughout the late Viséan and into the E₂ Zone of the Namurian, and Genus B first appears in the latest part of the late Viséan and also ranges into the E₂. The authors of *Beyrichoceras trevallynense* cannot see any valid reason for changing the generic assignment of the species. They still consider it closest to *B. submicronotum* Bisat, and, where it is associated with *Prolecanites* sp., to indicate an equivalence with subzones 3 and 4 of the *Beyrichoceras* Zone. This level is unaffected by the hiatus in the German ammonoid succession (Weyer 1972*a*), implied by Jenkins (1974) to be relevant to the age of the Trevallyn fauna, and the ammonoids still provide the soundest basis for the age of the *O. australis* Zone and hence the lower limit of the *D. aspinosa* Zone. The conflict with the early Viséan age indicated by *G. bulbosus* is resolved by its extended range in Australia compared with that in North America or Europe.

The affinities of the brachiopods in the *D. aspinosa* Zone are given by Roberts (1965*a*) and Jones *et al.* (1973). Two species described in this paper provide additional information: *Scoloconcha geniculata* sp. nov., which is relatively long-ranging (text-fig. 3), is morphologically close to *S. indianensis* (Hall) from the Salem Limestone,

U.S.A., and is younger than early Viséan; and *Marginicinctus reticulatus* sp. nov. resembles *M. projectus* (Muir-Wood), which ranges from the C₂ to the D₂ in Britain, and is also younger than early Viséan in age.

The *Rhipidomella fortimuscula* Zone is characterized by many short-ranging brachiopods (Roberts 1975), a number of which indicate a late Viséan age. *Inflatia engeli* sp. nov. is morphologically close to *I. inflata* (McChesney) from the Chesterian Fayetteville Formation, Oklahoma. *Krotovia procidua* sp. nov. is closest to *K. spinulosa* (J. Sowerby) which occurs mainly in the D₂ and D₃ of Great Britain (Thomas 1914), although Brunton (1966) records it from low in the D Zone in Ireland. Two species are morphologically related to forms in the Upper Kohlenkalk of Germany: *Eomarginifera megalotis* sp. nov. to *E. frechi* Paeckelmann; and *Productina morrisi* to specimens incorrectly referred by Paeckelmann (1931) to *P. pectinoides* (Phillips). Ammonoids from the *Rhipidomella fortimuscula* Zone indicate correlation with the CuIII_β of Germany (Jones *et al.* 1973). Additional ammonoids of late Viséan aspect from the *R. fortimuscula* Zone in Queensland are being studied by K. S. W. Campbell and D. A. Brown at the Australian National University.

Jones *et al.* (1973) suggest that the *Marginirugus barringtonensis* Zone spans the interval CuIII_γ to early Namurian. *Stegacanthia leviatha* sp. nov. is closest to *S. strigis* Roberts from the late Viséan to early Namurian *Anthracospirifer milliganensis* Zone in the Burvill Beds in the Bonaparte Gulf Basin, north-western Australia (Roberts 1971).

The *Levipustula levis* Zone was considered by most workers (Campbell 1961; McKellar 1965; Jones *et al.* 1973) to be Westphalian in age because of the close morphological relationship between *L. levis* Maxwell, *L. piscariae* (Waterlot), and *L. rimberti* (Waterlot); the latter species are from the Westphalian B and basal Westphalian C respectively of Europe (McKellar 1965). *L. levis* is also found in Argentina where it is associated with ammonoids and trilobites. The ammonoids indicate a Pennsylvanian (Desmoinesian) age, but they may not have been *in situ* (Amos *et al.* 1960). *L. levis*, however, has a long stratigraphic range, and in New South Wales first appears in the Namurian. At Kempsey *L. levis* is found on two horizons (Lindsay 1969), approximately 2000 m stratigraphically apart, in the Kullatine and Taits Creek Formations. These horizons bracket beds containing *Cravenoceras kullatinensis* Campbell, indicative of a Namurian, probably E₁, age (Campbell 1962). Lindsay's (1969) initial report of *L. levis* from below *C. kullatinensis* has been confirmed by recent field work. The Namurian age for the base of the zone is supported by field evidence from Yagon Gibber near Forster, New South Wales, where in a conformable sequence exposed along the coastline the *L. levis* Zone first appears only about 50 m above the *M. barringtonensis* Zone. The large productacean, *Reticulatia cinctifera* sp. nov., which occurs with *L. levis* in the Branch Creek Formation, Queensland (Maxwell 1964; McKellar 1967), and at Yagon Gibber in New South Wales, supports a Westphalian age for the *levis* Zone. *R. cinctifera* is closely related morphologically to specimens identified by Demanet (1943) as *Productus* (*Dictyoclostus*) aff. *americanus*, which are from the same horizon as *L. rimberti* in the Westphalian C of Belgium; and to specimens identified as *Tolmatchoffia demaneti* by Böger and Fiebig (1963) from the Westphalian C of Germany. Because of the ammonoid evidence, the range of the *levis* Zone on the correlation chart of Jones

et al. (1973) should be lowered to almost meet the *M. barringtonensis* Zone. Apart from brachiopod evidence there is no information available to reliably date the top of the *levis* Zone, and in text-fig. 3 the zone is shown to extend into the Westphalian. *L. levis* has also been collected by the author from the *Syringothyris bifida* Zone near Booral, New South Wales, and that unit is shown to be also partly Westphalian; there is no evidence of age for the top of the *S. bifida* Zone.

SYSTEMATIC DESCRIPTIONS

Superfamily CHONETACEA Bronn, 1862

Family CHONETIDAE Bronn, 1862

Subfamily ?STROPHOCHONETINAE Muir-Wood, 1962

Genus TRICHOCHONETES nov.

Type species. *Trichoconetes perpendicularis* gen. et sp. nov. from the Flagstaff Sandstone near Brownmore, New South Wales.

Diagnosis. Shell gently concavo-convex, and ornamented by fine capillae; pedicle valve with spines at 90° to the hinge, and a short median septum; brachial valve having twin divergent septa, and a cardinal process with a posterior face bearing three concave lobes; lateral septa and brachial markings absent.

Remarks. The assignment of *Trichoconetes* to the subfamily Strophochonetinae is based on the presence of twin septa in the brachial valve and long spines projecting at 90° to the hinge of the pedicle valve. However, because strophochonetoid genera have not previously been recorded outside the time range of ?Late Ordovician, Early Silurian–Early Devonian (Muir-Wood 1962) the ancestry of *Trichoconetes* is doubtful, and the genus is therefore tentatively placed in the Strophochonetinae. The only other group of chonetaceans in which some genera possess twin dorsal septa is the Anopliidae Muir-Wood, 1962. *Trichoconetes* cannot be assigned to the Anopliidae because of its large size, transverse outline, and low concavo-convex profile.

The name of the genus is derived from the Greek *trichos*, hair, and refers to the fine hair-like capillae ornamenting the shell.

Trichoconetes perpendicularis gen. et sp. nov.

Plate 3, figs. 10–21

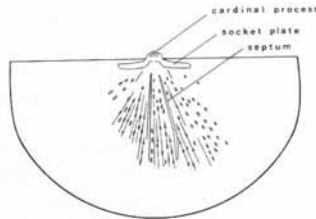
1975 Chonetoid gen. et sp. A, Roberts, Table 1.

Diagnosis. Shell wider than long, semi-elliptical in outline, and bearing 24–28 capillae per 3 mm at 5 mm from the umbo; pedicle valve with up to two hinge spines on either side of the umbo; ventral umbo low; internal surface ribbed in the pedicle valve, and finely spinose in the brachial valve.

Description. External. Shell moderately concavo-convex, and widest just behind the mid-length; hinge line usually slightly less than the greatest width; capillae occasionally irregular over the mid-part of the shell, and increasing by bifurcation or intercalation; micro-ornament not observed; specimens ranging in size up to 15 mm wide and 0.5 mm long. Pedicle valve highest around the middle of the valve; umbo low, projecting a short distance behind the hinge, and barely rising above the level of the lateral slopes; lateral slopes usually evenly convex, but in some cases becoming flat at the postero-lateral extremities; hinge line straight, and bearing up to two long spines on either side of the umbo; delthyrium wide, triangular, and

apparently open; cardinal area low and apsacline. Brachial valve deepest around the mid-point; lateral slopes becoming flat on the postero-lateral extremities.

Internal. Pedicle valve. Median septum extending one-quarter the length of the valve; ventral muscle scars poorly differentiated, but forming a smooth impressed muscle field; adductor muscle scars possibly subovate and bordering the median septum; diductor muscle scars triangular, and in some specimens bounded postero-laterally by ridges; teeth not observed; inner surface of valve finely ribbed except for a patch of small endospines immediately in front of the median septum. Brachial valve (text-fig. 4). Socket ridges mainly parallel with the hinge, but medially curving abruptly posteriorly and supporting the cardinal process; cardinal process with three concave lobes on the posterior face; the floor of the valve immediately in front of the cardinal process is depressed, but does not actually form an alveolus; dorsal septa comprise two thin delicate divergent blades which extend from in front of the depression to about two-thirds the length of the valve; lateral septa and brachial markings not observed; internal surface of the valve, particularly the medial portion, bearing radial rows of fine endospines.



TEXT-FIG. 4. Dorsal interior of *Trichochoonetes perpendicularis* gen. et sp. nov. showing twin septa. Drawn from the holotype F56943 AM. Approximately $\times 3$.

Remarks. Other than the type species, only one species is tentatively referred to *Trichochoonetes*. The finely ribbed *Rugosochonetes delicatus* Brunton (1968, pp. 62-66, pl. 9, figs. 3-15) from the D Zone at Bunnahone Lough, Northern Ireland, resembles *T. perpendicularis* in having a comparable over-all shape and profile, a short, slender, ventral median septum, and in lacking a dorsal median septum; because of these similarities, *delicatus* is tentatively referred to *Trichochoonetes*. *T. ? delicatus* differs from *T. perpendicularis* in having an indistinct capillate ornament at the umbo, up to four pairs of spines on either side of the umbo, divergent socket ridges, and lateral septa in the brachial valve.

The specific name *perpendicularis*, Latin for upright or at right angles, refers to the spines at right angles to the ventral hinge.

T. perpendicularis ranges from the *Inflatia elegans* Subzone of the *Delepinea aspinosa* Zone to the *Rhipidomella fortimuscula* Zone, but has not been recorded from the *Gigantoproductus tenuirugosus* Subzone of the former zone; it is late Viséan in age.

Occurrence. Locality 86-2 (the type locality) in a quarry alongside the Dungog-Salisbury road; locality 100-5, Native Dog Creek; locality 100-13, Byron's Quarry on the Dungog-Chichester road; locality 106-15, Chichester River; all in the Flagstaff Sandstone. Locality 88-3, Quartpot Creek, in an unnamed formation. Localities L404, Nooroo, and L437, North Coast Railway Line east of Dungog, in the Wootton Beds; and L402, north of Clarencetown in unidentified sediments; all University of Newcastle localities.

Material. F56938-F56945, Australian Museum. Holotype F56943; paratypes F56938, F56939, F56941, and F56942.

Subfamily RETICHONETINAE Muir-Wood, 1962
Genus RETICHONETES Muir-Wood, 1962

Type species. *Chonetes amatus* Bouchard-Chantreaux in de Verneuil 1845.

Remarks. Maxwell (1954) previously referred this material to *Rugosochonetes*. The small semicircular and concavo-convex nature of the shell, and prominent concentric

growth lines crossing costellae are typical of *Retichonetes*. Internally, this material has a ventral median septum which extends to the apex of the umbo, whereas in the type species the septum is reported to be 'not continuous to the umbo' (Muir-Wood 1962, p. 63); fig. 13B of Muir-Wood (1962), however, suggests that the septum in *R. amatus* extends well into the umbonal region. The brachial valve of this material is known only from poorly preserved material, but it is clear that there is a median septum. The presence of a dorsal median septum indicates a lack of affinity with *Caenanoplia* Carter (1968), another small Early Carboniferous genus. *Caenanoplia* is characterized by weaker ribs, a lamellose ornament, larger ears, and a typically anopliinid dorsal interior.

Retichonetes kennedyensis (Maxwell)

Plate 4, figs. 12-20

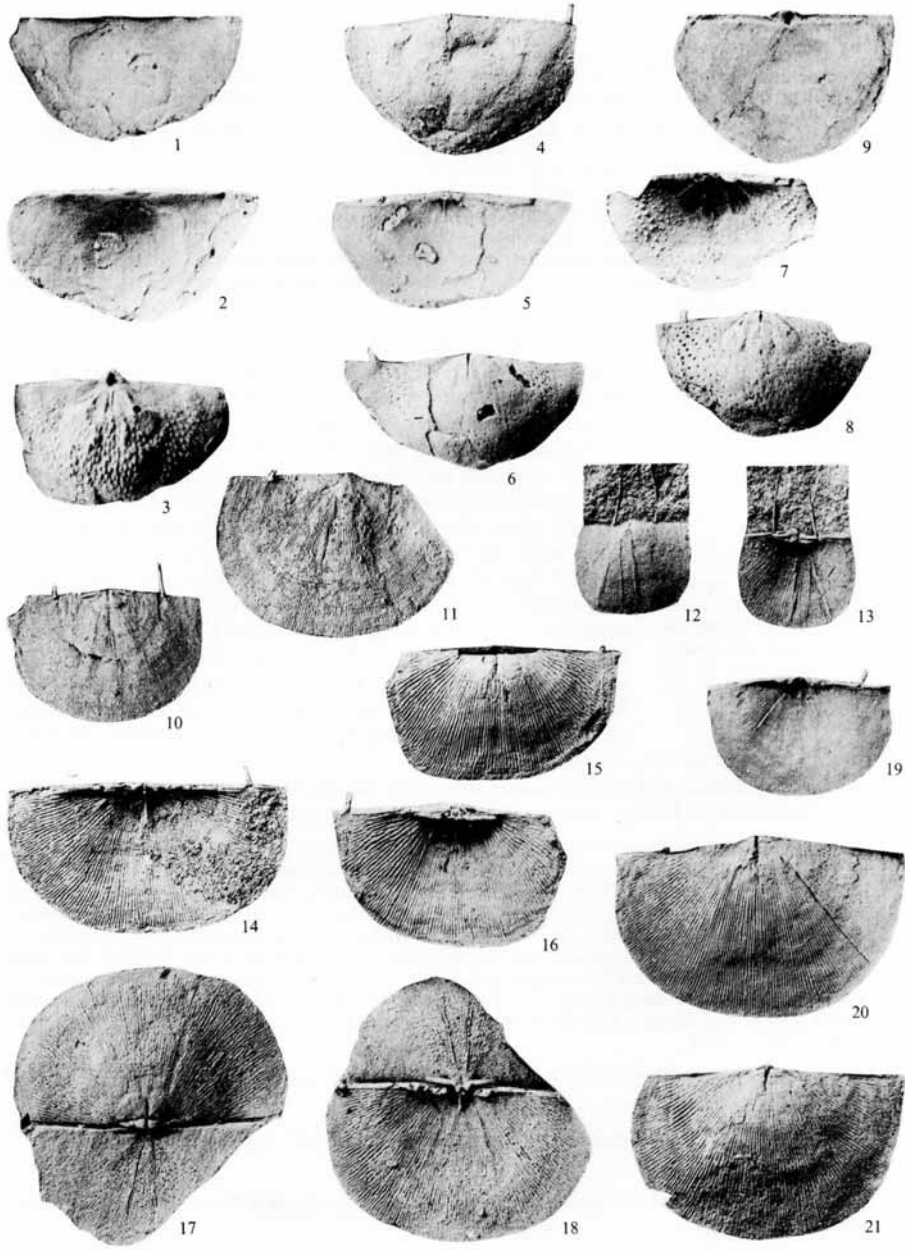
- 1892 *Chonetes cracowensis* Etheridge Snr. in Jack and Etheridge, pl. 13, fig. 9.
 1954 *Rugosochonetes kennedyensis* Maxwell, pp. 20-21, pl. 2, figs. 8-12.
 non 1964b *Rugosochonetes kennedyensis* Maxwell; Roberts, pp. 181-182, pl. 2, figs. 1-7.
 non 1971 *Rugosochonetes kennedyensis* Maxwell; Roberts, pp. 67-69, pl. 8, figs. 11-22.
 1974 *Rugosochonetes kennedyensis* Maxwell; Roberts and Oversby, Table 1.
 1975 *Rugosochonetes kennedyensis* Maxwell; Roberts, Table 1.

Diagnosis. Shell small, strongly concavo-convex, semicircular in outline, and wide at the hinge; costellae with a density of 18 per 5 mm at 5 mm from the umbo; pedicle valve having up to eight hinge spines, a small umbo, steep lateral and anterior margins, and small auriculate postero-lateral extremities; ventral median septum short and separating triangular adductor muscle scars; brachial valve with a deep alveolus, a median septum extending to the mid-length of the valve, and short divergent lateral septa.

Description. External. Shell globular and widest at the hinge; costellae strongly developed, increasing by both bifurcation and intercalation, and crossed by closely spaced concentric striae having a density of about 10 per 1 mm; postero-lateral margins lacking costellae and ornamented only by concentric growth lines; specimens ranging in size up to 9 mm wide and 6.5 mm long. Pedicle valve strongly convex, particularly at the umbo, and highest at about one-third the length of the valve; umbo small, barely projecting beyond the hinge line, and poorly differentiated from the body of the valve because of inflated umbonal shoulders; postero-lateral margins gently convex to flat, auriculate, and forming the widest part of the valve; ventral interarea short, apsacline to orthocline, and having a small delthyrium filled by a convex

EXPLANATION OF PLATE 3

- Figs. 1-9. *Leiochonetes salisburyensis* gen. et sp. nov. 1, 2, a mould and rubber cast of the dorsal exterior. F56933a, $\times 4$. 3, rubber cast of the brachial valve interior, a counterpart of the specimen figured in 1 and 2. F56933b, holotype, $\times 4$. 4, rubber cast of the exterior of the pedicle valve. F56934, paratype, $\times 4$. 5, 6, rubber cast and a mould of the ventral interior. F56935, paratype, $\times 4$. 7, 8, rubber cast and a mould of the ventral interior. F56936, paratype, $\times 4$. Figs. 1-8 from locality 85-10. 9, rubber cast of a partly decorticated brachial valve exterior. F56937, $\times 4$, from locality 90-2.
- Figs. 10-21. *Trichoconetes perpendicularis* gen. et sp. nov. 10, 11, rubber casts of two pedicle valve exteriors. F56938 and F56939 respectively, paratypes, $\times 3$. 12, 13, rubber casts of the ventral and dorsal exterior of F56940a and F56940b respectively, $\times 3$. 14, rubber cast of the ventral interior of F56941, paratype, $\times 3$. 15, 16, external mould and rubber cast of a brachial valve exterior. F56942, paratype, $\times 3$. 17, 18, mould and rubber cast of the interior of F56943, holotype, $\times 3$. Figs. 10-18 from locality 86-2. 19, 20, rubber cast and internal mould of the pedicle valve. F56944, $\times 2$ and $\times 3$ respectively. 21, internal mould of a pedicle valve. F56945, $\times 3$. Figs. 19-21 from locality L437 U Newcastle.

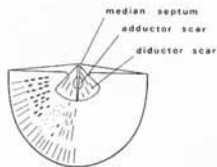


ROBERTS, Australian chonetaceans

plug-like deltidial plate; up to eight hinge spines projecting at 90° to the hinge. Brachial valve strongly concave, and deepest at about one-third the length of the valve; lateral slopes steep, and passing on to flat or gently concave postero-lateral extremities; interarea shorter than on the pedicle valve.

Internal. Pedicle valve (text-fig. 5). Median septum extending between one-quarter and one-sixth the length of the valve; adductor muscle scars moderately large, impressed, pointed posteriorly, and broader anteriorly; diductor muscle scars faint, and flabellate in outline; teeth not observed; internal surface ribbed and bearing radially arranged endospines.

Brachial valve. Median septum extending from in front of a large alveolus to the mid-point of the valve; lateral septa short, diverging from the median septum at about 30° , and separating poorly defined adductor muscle scars; cardinal process not observed; socket ridges elongate, subparallel with the hinge, and bordering narrow elongate sockets; internal surface of valve bearing radially arranged endospines; brachial markings not observed.



TEXT-FIG. 5. Ventral interior of *Retichonetes kennedyensis* (Maxwell) drawn from a topotype specimen from locality 121-2, Pond Formation, Queensland. The median septum extends to the apex of the valve. Approximately $\times 2.5$.

Remarks. *Retichonetes kennedyensis* (Maxwell) was first compared with *R. amatus* by Maxwell (1954). Some of the similarities and differences between the two species have been discussed in the remarks on the genus. In addition, *R. amatus* is characterized by a more subcircular outline, and the possession of dorsal accessory septa and divergent hinge spines.

Several small chonetaceans from the United States are externally close to *R. kennedyensis*. Specimens identified as *Chonetes logani* Norwood and Pratten by Weller (1914, pp. 84-86, pl. 8, figs. 43-46) from the Kinderhook of Iowa are close in size, shape, and, according to the description, in the density of costellae. *C. logani* is assigned by Carter (1968) to *Caenanoplia*. Specimens referred to *Chonetes glenparkensis* Weller (Weller 1914, pl. 8, figs. 47-49) from the Chouteau Limestone of Missouri, and believed by Carter (1967, p. 280) to be conspecific with *C. logani*, differ from *kennedyensis* in the auriculate nature of their postero-lateral extremities.

R. kennedyensis (Maxwell) ranges from the *Tulcumbella tenuistriata* Zone to the *Schellwienella cf. burlingtonensis* Zone, and is Tournaisian to early Viséan in age.

Occurrence. Specimens figured in this paper are from the type locality, L1288 UQ in the Pond Formation, Mount Morgan, Queensland, and from locality L10024 ANU in the Namoi Formation at Rangari Station, Boggabri district, New South Wales. Specimens in collections at the University of New South Wales are from localities 15-3, 24-7, 8 and 15, 31-1, 38-7 and 39-13, and 16 in the Waverley Formation in the Rouchel district, New South Wales; localities 94-2 and 98-2 in the Ararat Formation at Gresford, New South Wales; localities L23 UNE, 112-1 and possibly 112-4 in the Namoi Formation in the Werrie Syncline, New South Wales; localities F3 and F12 of Yeates (unpublished B.Sc. thesis 1970) in the Namoi and Luton Formations respectively in the Gravesend district, New South Wales; locality L1312 UNE in the Luton Formation, Luton Station near Bingara, New South Wales; and at locality 121-2 in the Pond Formation, Mount Morgan, Queensland.

Material. F56954-F56958 Australian Museum, F15155 (the holotype), F15156 and F15165 University of Queensland.

Subfamily RUGOSCHONETINAE Muir-Wood, 1962
Genus LEIOCHONETES nov.

Type species. *Leiochonetes salisburyensis* gen. et sp. nov. from the Flagstaff Sandstone near Brownmore, New South Wales.

Diagnosis. Shell small and moderately to strongly concavo-convex; external surface smooth except for growth lines; hinge spines few in number, and diverging from the hinge at between 90° and 60° ; ventral median septum short and separating deeply impressed muscle scars; dorsal interior with a short ridge-like median septum, lateral septa, an alveolus, and well-defined brachial markings; cardinal process with two concave posterior lobes.

Remarks. Smooth chonetaceans are rare in Early Carboniferous rocks, and few of those so far described are closely comparable with *Leiochonetes*. The nearest Australian form, an indeterminate species from the Tournaisian Enga Sandstone in the Bonaparte Gulf Basin, Western Australia (Roberts 1971, pl. 10, figs. 1-10), has a smooth exterior, but is more gently arched and has two spines on either side of the umbo; its interior is unknown. *Tornquistia? transversalis* Carter (1967) from the Chappel Limestone of Texas may also belong to the genus.

The Pennsylvanian genus *Eolissochonetes* Hoare (1960) has an external ornament similar to that of *Leiochonetes*. Externally it differs from *Leiochonetes* in having a moderately to weakly developed ventral median sinus, and a larger number of hinge spines. Internally *Eolissochonetes* is characterized by the possession of a longer dorsal median septum, weaker brachial ridges, and a flatter dorsal visceral disc. According to Hoare (1960), *Eolissochonetes* was derived from *Mesolobus* Dunbar and Condra, 1932 and is transitional between that genus and *Lissochonetes* Dunbar and Condra, 1932. The evidence presented by Hoare makes it unlikely that *Eolissochonetes* is genetically related to *Leiochonetes*.

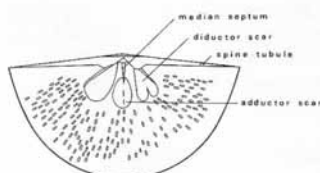
The generic name is derived from the Greek *leios*, smooth, referring to the smooth exterior.

Leiochonetes salisburyensis gen. et sp. nov.

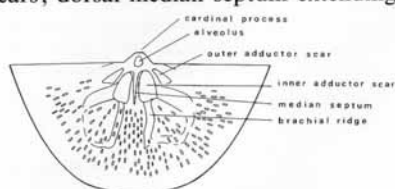
Plate 3, figs. 1-9

1975 Chonetoid gen. et sp. B, Roberts, Table 1.

Diagnosis. Shell transverse and trigonal in outline; a single hinge spine near the postero-lateral extremities projects at between 90° and 60° to the hinge; ventral median septum extending one-fifth the length of the valve, and separating ovoid adductor and lachrymose diductor muscle scars; dorsal median septum extending



TEXT-FIG. 6. Ventral interior of *Leiochonetes salisburyensis* gen. et sp. nov. drawn from a paratype F56936 AM. The anterior margin of the right diductor scar is apparently deformed. Approximately $\times 4$.



TEXT-FIG. 7. Dorsal interior of *Leiochonetes salisburyensis* gen. et sp. nov. drawn from the holotype F56933b AM. Approximately $\times 4$.

one-third the length of the valve; socket ridges almost obsolete; internal surface of the shell bearing fine endospines.

Description. External. Shell moderately to strongly concavo-convex and with alate postero-lateral extremities; greatest width at or immediately in front of the hinge; external surface essentially smooth, lacking radial ornament, but having fine concentric growth lines; faint radial markings on some valves apparently originate within the shell rather than being on the exterior; specimens ranging in size up to 10.5 mm wide and 6 mm long. Pedicle valve highest and most strongly convex at the mid-point; umbo moderately high and projecting a short distance behind the hinge; lateral slopes steep nearest the umbo, but becoming flatter towards the postero-lateral margins. Brachial valve strongly concave, deepest at the mid-point, and then sloping upwards to flat postero-lateral margins.

Internal. Pedicle valve (text-fig. 6). Median septum high and blade-like at the apex, but becoming abruptly lower and ridge-like anteriorly; muscle field deeply impressed, particularly posteriorly; adductor muscle scars ovoid, diductor muscle scars having pointed posterior extremities which curve medially around the posterior of the adductor muscle scars, and expanding anterior portions which extend beyond the front of the adductor muscle scars; postero-lateral margins of the diductor muscle scars bordered by ridges extending laterally from the apex of the valve; teeth not observed; internal surface of the valve bearing small radially arranged endospines. Brachial valve (text-fig. 7). Cardinal process highest medially and with two concave lobes on the posterior face; alveolus deep and circular; median septum low, narrow and ridge-like posteriorly, and broader and higher anteriorly; lateral septa short, divergent and dividing the adductor muscle scars into two pairs; inner adductor scars narrow posteriorly, broader anteriorly, and situated on small platforms; outer adductor muscle scars less well defined and forming triangular depressions on the outer margins of the lateral septa; brachial ridges commencing on the anterior margins of the outer adductor muscle scars, enclosing brachial discs which are high posteriorly, and distally curving towards the front of the inner adductor muscle scars.

Remarks. *Leiochonetes salisburyensis* gen. et sp. nov. is comparable with two forms: an unnamed species from the Tournaisian Enga Sandstone in the Bonaparte Gulf Basin (p. 27), and *Tornquistia? transversalis* Carter (1967, pp. 274-276, pl. 14, figs. 15-20) from the Chappel Limestone of Texas. The relationship with the unnamed form is discussed in the remarks on the genus. *T.? transversalis* is distinguished from *L. salisburyensis* by the possession of a high ventral interarea, and a wide delthyrium closed apically by a pseudodeltidium. Although the brachial valve of *transversalis* is unknown, other morphological features, particularly those of the ventral interior, suggest that it should be assigned to *Leiochonetes* rather than *Tornquistia*. The species ranges from the *Gigantoproductus tenuirugosus* Subzone of the *Delepinea aspinosa* Zone into the *Rhipidomella fortimuscula* Zone, and is known only in New South Wales; it is late Viséan in age.

Occurrence. Locality 85-10 (the type locality), Quartpot Creek near Brownmore; locality 90-2, Big Creek, Salisbury; possibly at locality 100-3, Native Dog Creek, west of Bendolba; all in the Flagstaff Sandstone. Locality 114-1 in sediments mapped as Wootton Beds by Mayer (1972), 2 km north of Rawdon Vale.

Material. F56933-F56937, Australian Museum. Holotype F56933b; paratypes F56934, F56935, and F56936.

Genus RUGOSOCHONETES Sokolskaya, 1950

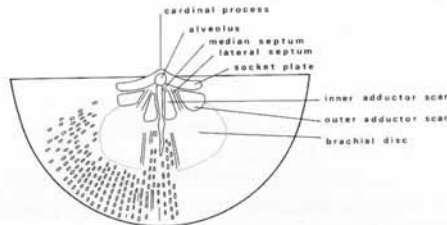
Type species. *Orthis hardrensis* Phillips, 1841.

Rugosochonetes magnus Maxwell emend.

Plate 4, figs. 21-29

- 1954 *Rugosochonetes kennedyensis* var. *magnus* Maxwell, pp. 44-45, pl. 5, figs. 9-10.
 ?1961 *Rugosochonetes kennedyensis* var. *magnus* Maxwell, pl. 19, fig. 1.

Diagnosis. Shell strongly concavo-convex, transverse, with slightly pointed postero-lateral extremities; costellae having a density of 19–20 per 5 mm at 5 mm from the umbo; pedicle valve with a prominent umbo, convex venter, steep lateral and anterior slopes, and one or two erect hinge spines on either side of the umbo; ventral adductor muscle scars ovoid; brachial valve with subparallel socket ridges located anteriorly from the hinge, a deep alveolus, a wide median septum extending to the mid-length of the valve, and robust lateral septa; brachial ridges high distally.



TEXT-FIG. 8. Dorsal interior of *Rugosochonetes magnus* Maxwell drawn from F15288 UQ, a topotype specimen figured by Maxwell (1954, pl. 5, fig. 13). Approximately $\times 3$.

Description. External. Shell approximately 1.5 times wider than long, with the greatest width at or immediately in front of the hinge; costellae increasing by bifurcation and intercalation; micro-ornament of concentric growth lines; specimens range in size up to 12.5 mm wide and 7.5 mm long. Pedicle valve highest at the mid-point; umbo extending behind the hinge but not strongly incurved; postero-lateral extremities convex, slightly auriculate, and lacking radial ornament near the hinge; anterior margin steep and almost trail-like; one or two hinge spines on either side of the umbo emerging at between 70° and 90° to the hinge; ventral interarea low, apsacline laterally to orthocline medially. Brachial valve deepest around the middle or immediately in front of the mid-point of the valve; anterior margin steep and trail-like; postero-lateral margins small, flat, and with weak radial ornament.

Internal. Pedicle valve. Visceral disc deep; median septum extending to approximately the mid-point of the valve; muscle field moderately well impressed; adductor muscle scars giving rise anteriorly to vascular trunks; diductor muscle scars flabellate, narrow posteriorly, wider anteriorly, and deeply impressed along the postero-lateral margins; teeth are robust; internal surface bearing radially arranged rows of fine endospines; the spines are finest near the centre of the valve and become coarser towards the margin. Brachial valve (text-fig. 8). Alveolus very large and deep or infilled with callus; median septum strongest posteriorly, and extending from the front of the alveolus or platform to the middle part of the valve; lateral septa extending up to two-thirds the length of the median septum; inner adductor muscle scars narrow, triangular, and located on low platforms; outer adductor muscle scars lachrymose, pointed postero-laterally, rounded antero-laterally, and deeply impressed; posterior face of cardinal process with two long lobes, the lateral portions being obscured by chilidial plates; brachial markings originate from the anterior margins of the outer adductor muscle scars, and enclose round brachial discs; proximally the markings comprise a smooth shallow depression, but distally, where they have recurved posteriorly, form distinct ridges; endospines coarsest on the trail but also present on the lateral margins of the brachial discs.

Remarks. *Rugosochonetes magnus* Maxwell was previously recognized as a variety of *R. kennedyensis* (Maxwell, 1954); the latter species is now referred to *Retichonetes*, and *magnus* is interpreted as a species of *Rugosochonetes*. *R. magnus* and *Retichonetes kennedyensis* are both recorded from eastern Australia in the *Tulcumbella tenuistriata* and *Schellwienella* cf. *burlingtonensis* Zones. *R. kennedyensis* is readily distinguished

by its smaller size, semicircular outline, coarse costellae which bear a well-defined concentric ornament, and by the possession of a pedicle valve which is especially convex over the venter, and which has up to eight hinge spines.

Larger rugosochonetoids, mainly from the *Orthotetes australis* and *Delepineia aspinosa* Zones, which were previously identified as *R. kennedyensis* by Roberts (1964*b*, 1965*b*) are now referred to *Rugosochonetes careyi* (Campbell). *R. magnus* is distinguished from *R. careyi* by its smaller size, more prominent ventral umbo, greater curvature of the valves, and the possession of pointed postero-lateral extremities. The pedicle valve of *magnus* is more strongly convex, has a steep trail-like anterior margin, steeper lateral slopes, possesses fewer but more erect hinge spines, and has ovoid rather than linear adductor muscle scars. In the brachial valve the visceral disc is more convex, the socket ridges are more robust and are located further anteriorly than those in *R. careyi*, the alveolus is deeper, the median septum wider and longer, and the lateral septa stronger.

R. gloucesterensis (Cvancara) (Cvancara 1958, pp. 866-868, pl. 111, figs. 1-7), from the *Rhipidomella fortimuscula* Zone, was erroneously placed in synonymy with *Rugosochonetes magnus* by Maxwell (1961, p. 87). *R. gloucesterensis* is larger, more quadrate, has relatively smaller postero-lateral extremities, a flange-like inner margin on the pedicle valve, and a finer external ornament.

McKellar (in Kirkegaard *et al.* 1970, p. 148) suggested that the type specimens of *magnus* appeared to lack a dorsal median septum. An examination of a rubber cast of specimen F15288 UQ, the figured topotype in Maxwell (1954, pl. 5, fig. 13), and which is illustrated in text-fig. 8, confirms the existence of a dorsal median septum. *R. magnus* is recorded from the *T. tenuistriata* and *Schellwienella cf. burlingtonensis* Zones; it is Tournaisian to early Viséan in age.

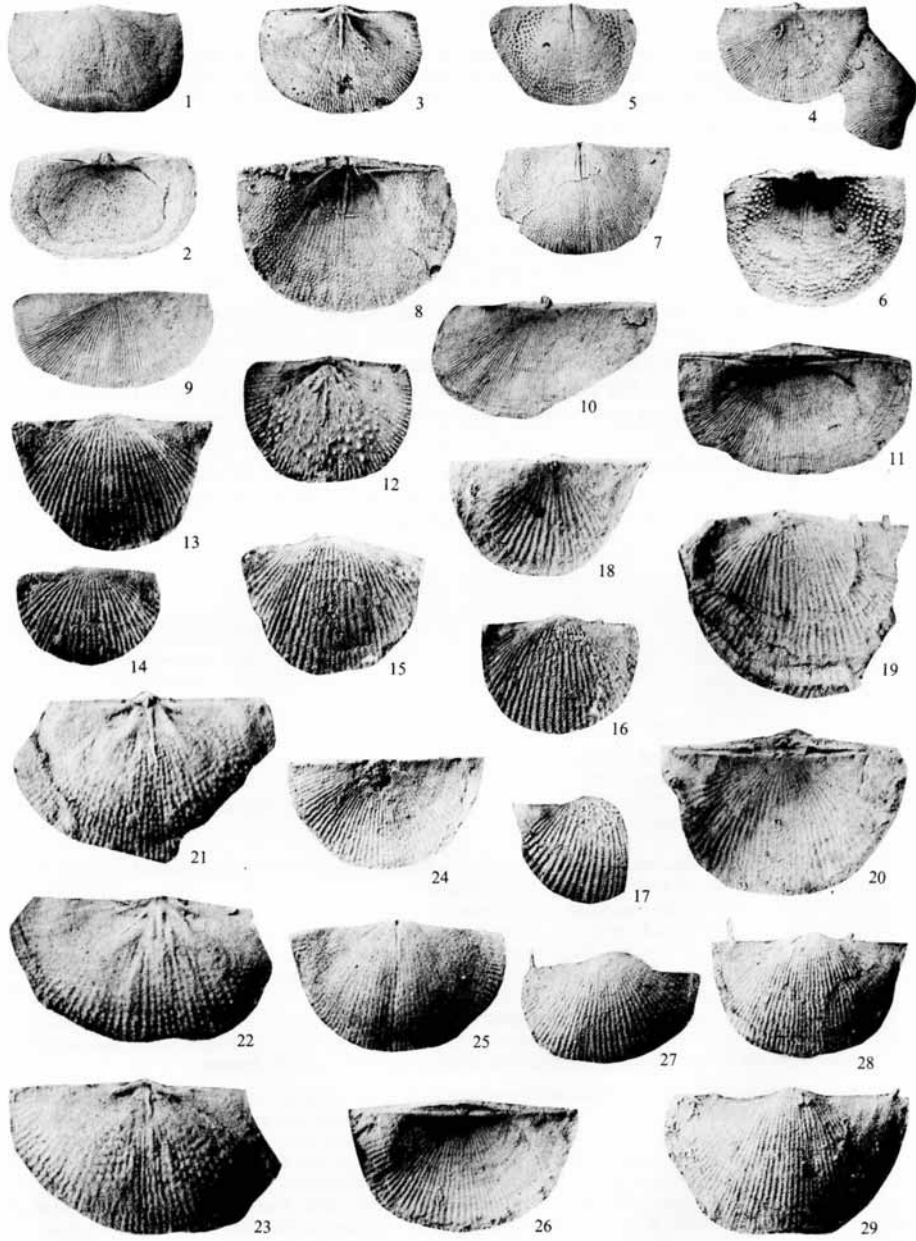
Occurrence. Collections at the University of New South Wales contain specimens of *R. magnus* from the following areas in New South Wales: in the Rouchel district from locality 4-1 in the Dangarfield Formation, and localities 15-3, 24-8, 38-7, 39-18, 41-3, 58-3 and 12, 63-5, and 107-1 in the Waverley Formation; at Gresford from locality 72-3 in the Bingleburra Formation; in the Werrie Syncline at localities 112-1, 2, 4,

EXPLANATION OF PLATE 4

Figs. 1-11. *Rugosochonetes careyi* (Campbell). 1, 2, rubber casts of the exterior of F56946a and F56946b respectively, $\times 1.5$. Locality 88-2. 3, rubber cast of the dorsal interior of F56947, $\times 2$. Locality 88-2. 4, exteriors of two specimens from locality 85-10. F56948, $\times 1.5$. 5, 6, internal mould and rubber cast of the ventral interior of F56949, $\times 1.5$ and $\times 2$ respectively. Locality 17-5. 7, 8, internal mould and rubber cast of the ventral interior of F56950, $\times 1.5$ and $\times 2$ respectively. Locality 17-7. 9-11, rubber cast of three dorsal exteriors from locality 106-15. Note the width of the specimens. F56951, F56952, and F56953 respectively. All $\times 1.5$.

Figs. 12-20. *Retichonetes kennedyensis* (Maxwell). 12, rubber cast of a brachial valve interior. F56954, $\times 4$. 13-15, exteriors of three pedicle valves. F56955, F56956, and F56957 respectively, $\times 4$. 16, 17, exterior and rubber cast of the exterior of F56958a and F56958b respectively, $\times 4$. Figs. 13-17 from locality 10024 ANU. 18, rubber cast of a dorsal valve. F15165 UQ, $\times 4$. 19, rubber cast of the holotype. F15155 UQ, $\times 4$. 20, rubber cast of a dorsal valve. F15156 UQ, $\times 4$. Figs. 18-20 from locality L1288 UQ.

Figs. 21-29. *Rugosochonetes magnus* Maxwell. 21-23, rubber casts of three dorsal interiors. F56959, F56960, and F56961. All $\times 4$. 24, exterior of a dorsal valve. F56962, $\times 3$. 25, internal mould of a pedicle valve. F56963, $\times 3$. 26, rubber cast of a dorsal exterior. F56964, $\times 3$. 27-29, rubber casts of three pedicle valves. F56965, F56966, and F56967 respectively. All $\times 3$. Figs. 21-29 from locality 107-1.



ROBERTS, Australian chonetaceans

6, 7, 9, and 10 in the Namoi Formation; and from near Gravesend at localities F13 and F14 of Yeates (1970, unpublished B.Sc. thesis) in the Luton Formation. Occurrences of the species in Queensland are documented by Maxwell (1954, 1961), Dear (1968), and McKellar (in Kirkegaard *et al.* 1970).

Material. F56959-F56967, Australian Museum.

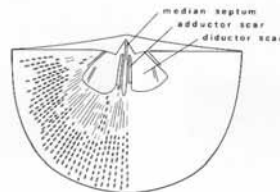
Rugosochonetes careyi (Campbell)

Plate 4, figs. 1-11

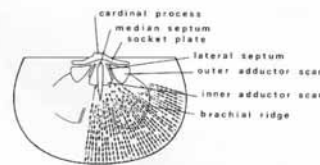
1957 *Chonetes careyi* Campbell, pp. 63-65, pl. 12, figs. 21-26.

1964b *Rugosochonetes kennedyensis* Maxwell; Roberts, pp. 181-182, pl. 2, figs. 1-7.

Diagnosis. Shell semicircular to rectangular in outline, and gently to moderately concavo-convex; the brachial valve has relatively less curvature than the pedicle valve; density of costellae at 20-22 per 5 mm at 20 mm from the umbo; ventral umbo low, resulting in the pedicle valve having a nearly even curvature from the venter to the lateral margins; ventral median septum extending one-quarter to one-third the length of the valve; ventral adductor muscle scars narrow and linear; cardinal process bilobate posteriorly; alveolus absent, but median septum originating from in front of the cardinal process and extending one-third to one-half the length of the valve; lateral septa short, slender, and divergent.



TEXT-FIG. 9. Ventral interior of *Rugosochonetes careyi* (Campbell) drawn from F56950 AM. Approximately $\times 2$.



TEXT-FIG. 10. Dorsal interior of *Rugosochonetes careyi* (Campbell) drawn from F56947 AM. Approximately $\times 2$.

Description. External. Postero-lateral extremities flat and either pointed or rounded; greatest width at, or a short distance in front of, the hinge; costellae bearing minute spinule and apertures increasing by bifurcation and intercalation; micro-ornament of faint concentric growth lines; the majority of specimens range in size to 18.5 mm wide and 10.5 mm long; some from Chichester are larger, particularly in width, and are up to 24 mm wide and 13.5 mm long. Pedicle valve gently to moderately convex over the venter, and having a low umbo which barely projects behind the hinge; three to six hinge spines on either side of the umbo project at 45° to the hinge; interarea low, varying from apsacline near the lateral margins to orthocline adjacent to the delthyrium; delthyrium triangular and open; anterior margin of some specimens bearing faint median sinus. Brachial valve gently concave, deepest a short distance in front of the umbo, and flat on the postero-lateral margins; some specimens bear a faint fold at the anterior margin.

Internal. Pedicle valve (text-fig. 9). Diductor muscle scars large, flabellate in outline, with moderately well-impressed pointed posterior margins, and shallow subrounded anterior margins; mantle canals originate from the anterior margins of both the adductor and diductor muscle scars, and in some specimens form a ridge extending anteriorly from the median septum; teeth are large, and situated on the inner margins of the delthyrium; endospines arranged in radial rows, finest medially and near the visceral disc, and coarsest on the postero-lateral shoulders. Brachial valve (text-fig. 10). Socket ridges parallel with the hinge; cardinal process bilobate posteriorly, the concave lobes being highest medially and flanked by small chilidial plates;

lateral septa extending half the length of the median septum; inner adductor scars triangular, and situated on low muscle platforms; outer adductor scars larger, lachrymose and slightly impressed; brachial markings extremely faint, originating from the antero-lateral margins of the outer adductor scars, forming an arcuate curve, and at their distal ridge-like extremities abruptly changing direction posteriorly; inner surface of the valve, including the brachial discs, bearing radial rows of endospines.

Variation. Specimens from locality 106-15 (Pl. 4, figs. 9-11) from the Flagstaff Sandstone near Chichester are larger and more transverse than individuals from other localities. Because their remaining characters are consistent with those of *careyi* they are referred to this species and are interpreted as gerontic variants.

Remarks. The description of *Rugosochonetes careyi* was made from relatively poorly preserved topotype specimens from Babbinboon, and from material from the Dungog and Rouchel districts of New South Wales. The type specimens figured by Campbell (1957) were destroyed by fire in 1958. Figured specimens (Pl. 4) are all from the Dungog and Rouchel districts.

R. careyi (Campbell) is morphologically close to *R. gloucesterensis* (Cvancara) (Cvancara 1958, pp. 866-868, pl. 111, figs. 1-7) from the *Rhipidomella fortimuscula* Zone at Barrington, New South Wales. An examination of topotype specimens shows that *gloucesterensis* is more quadrate in outline. The pedicle valve of *gloucesterensis* is characterized by the possession of a wider and deeper visceral disc which restricts the size of the postero-lateral extremities, a flange-like inner margin, more deeply impressed muscle scars, and ovoid rather than linear ventral adductor muscle scars. The external ornament has approximately the same density as that on *Rugosochonetes careyi*, and cannot be used as a distinguishing character (Cvancara 1958, p. 867). A detailed comparison with *R. magnus* Maxwell is given on page 30.

R. careyi is morphologically close to the finely ribbed group of *R. celticus* Muir-Wood, from the Viséan and Namurian of Great Britain. *R. celticus*, as originally defined by Muir-Wood (1962, pp. 68-70, pl. 6, figs. 8-9; pl. 7, figs. 3-14), encompassed a wide range of forms. Brunton (1968, p. 54, pl. 8, figs. 1-9) demonstrated that *celticus* could be divided into three informal groups: a finely ribbed group typified by the holotype; a coarsely ribbed group; and a third group with poorly defined ribs. The fine-ribbed group of *R. celticus* resemble *careyi* in having a small ventral umbo and gentle umbonal shoulders; it differs from most of the specimens referred to *careyi* in being less transverse, particularly posteriorly, and in having a slightly finer costellate ornament, possibly a greater convexity, and a longer dorsal median septum. In addition to having coarser ribs than those of *careyi*, the coarse-ribbed form of *celticus* is typified by ovoid rather than strap-like ventral adductor muscle scars. Brunton (1968, pp. 54-55) regards *R. celticus* as a possible junior synonym of *R. hardrensis* (Phillips), and hence the same distinctions may apply to that species. The characters of *hardrensis* are still poorly understood because of the loss of some of Phillips's specimens, doubt about the type locality, and difficulties in relating specimens still in existence with the original illustrations (Muir-Wood 1962, pp. 66-68). Specimens referred to *R. hardrensis* (Phillips) by Sokolskaya (1950, pl. 3, figs. 1-16) and compared with specimens from Greenhills by Roberts (1964b, p. 182) are smaller and more quadrate than *R. careyi*. The transverse specimens of *R. careyi* from locality 106-15 (Pl. 4, figs. 9-11) are close in shape to a Scottish specimen of *Rugosochonetes* sp. compared by Brand (1970, p. 107) with *R. hardrensis*. The Scottish form (Brand 1970,

pl. 9, fig. 24) from the Penton Limestone in the Archerbeck Bore has six spines on either side of the umbo.

The species ranges from the *Schellwienella* cf. *burlingtonensis* to the *Gigantoproductus tenuirugosus* Subzone, and is late Tournaisian to late Viséan in age.

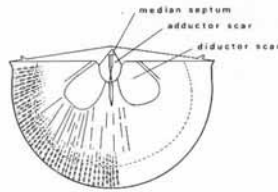
Occurrence. The type locality is L35 UNE (equals 112-14) at Babbinboon in the Werrie Syncline, New South Wales. Stratigraphically the type locality is in a mudstone member of the Merlewood Formation (Roberts 1975), not near the top of the Namoi Formation as indicated by Campbell (1957). In the Rouchel district, New South Wales, the species is present in locality 4-2, Dangarfield Formation, possibly in localities 24-7 and 8, Waverley Formation, and in localities 6-10, 17-5, 7 and 11, 29-1, 2 and 7, 30-13, and 41-1 and 2 in the Woolooma Formation. At Gresford and Dungog the species is present in localities 72-3 and 100-8 in the Bingleburra Formation, localities 16-3, 72-18, and 74-7A in the Bonnington Siltstone, localities 73-8, 90-1 and 2, 100-4 and 13, 104-1 and 106-2, 9 and 15 in the Flagstaff Sandstone, at L404 U Newcastle in the Wootton Beds, and at L359 U Newcastle in the Ararat Formation. A form closely comparable with *R. careyi* is present in the Namoi Formation at localities 112-1, 4, 7 and 10 in the Werrie Syncline, New South Wales.

Rugosochonetes gloucesterensis (Cvancara)

Plate 5, figs. 1-2

1958 *Chonetes gloucesterensis* Cvancara, pp. 866-868, pl. 111, figs. 1-7.

Rugosochonetes gloucesterensis has been fully described by Cvancara (1958). An emended diagnosis is provided to illustrate the distinction between *gloucesterensis* and the morphologically close forms *R. magnus* Maxwell and *R. careyi* (Campbell). Comparisons with *R. magnus* Maxwell and *R. careyi* (Campbell) are given above.



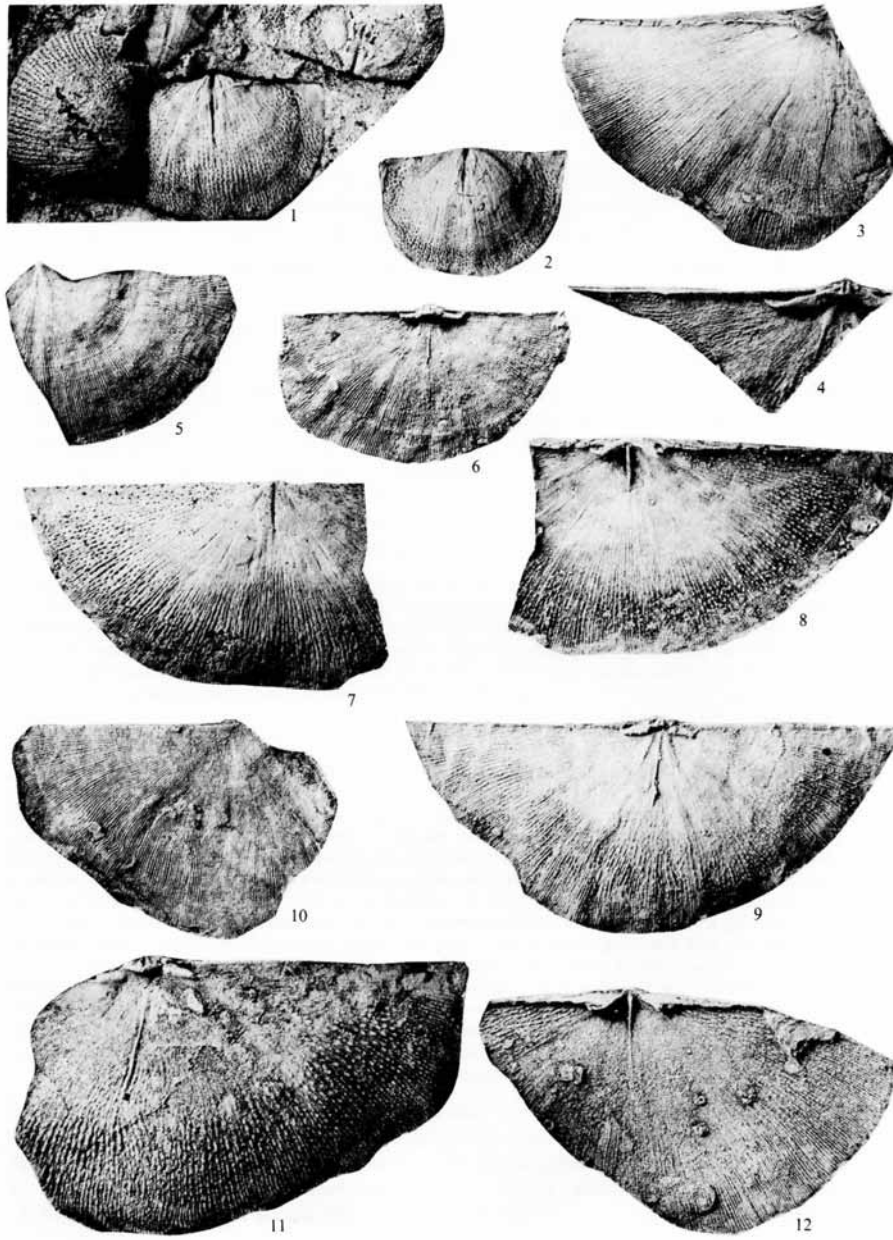
TEXT-FIG. 11. Ventral interior of *Rugosochonetes gloucesterensis* (Cvancara) drawn from F56968b AM. Approximately $\times 2$.

Diagnosis (emend.). Shell quadrate to rectangular in outline, strongly concavo-convex, and with the greatest width anterior to the hinge; postero-lateral margins slightly constricted immediately in front of the hinge; costellae with a density of 19-23 per 5 mm at 5 mm from the umbo; pedicle valve having a broad deep visceral disc, flange-like inner margins, and small postero-lateral extremities; ventral muscle field deeply impressed, and with ovoid adductor muscle scars (text-fig. 11).

EXPLANATION OF PLATE 5

Figs. 1-2. *Rugosochonetes gloucesterensis* (Cvancara). Internal moulds of pedicle valves showing flange-like lateral and anterior margins. F56968a and b respectively, $\times 2$. Figs. 1-2 from locality L422 U Newcastle.

Figs. 3-12. *Megachonetes alatus* sp. nov. 3, rubber cast of pedicle valve interior. Note the tubules through the hinge. F56969, $\times 2$. 4, rubber cast of portion of a brachial valve showing the cardinal process. F56970, $\times 2$. Figs. 3-4 from locality 31-1. 5, rubber cast of pedicle valve exterior. F56971, a paratype, $\times 1.5$. 6, rubber cast of ventral interior. F56972, a paratype, $\times 1.5$. 7-8, internal mould and rubber cast of a pedicle valve. F56973, a paratype, $\times 1.5$. 9, rubber cast of a dorsal interior. F56974, the holotype, $\times 1.5$. Figs. 5-9 from locality 15-3. 10, rubber cast of a dorsal exterior. F56975, $\times 1$. 11, rubber cast of a dorsal interior. F56976, $\times 2$. 12, rubber cast of a ventral interior. F56977, $\times 1.5$. Figs. 10-12 from locality 39-16.



ROBERTS, Australian chonetaceans

Occurrence. In New South Wales *R. gloucesterensis* is restricted to the *Rhipidomella fortimuscula* Zone. It is recorded from locality L422 U Newcastle in the Copeland Road Formation at Barrington, and from localities 85-15, 88-3, and 90-6 in an unnamed formation at Salisbury and Brownmore.

Material. F56968, Australian Museum.

Family DAVIESIELLIDAE Sokolskaya, 1960
Subfamily DELEPINEINAE Muir-Wood, 1962
Genus MEGACHONETES Sokolskaya, 1950

Type species. *Chonetes compressa* Sibly, 1908, equals *C. siblyi* I. Thomas, 1919.

Megachonetes alatus sp. nov.

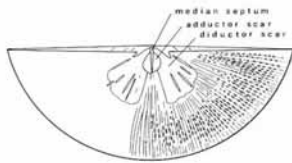
Plate 5, figs. 3-12

Diagnosis. Shell large for the genus, semi-elliptical in outline, approximately twice as wide as long, gently concavo-convex posteriorly, but more strongly incurved anteriorly; costellae with a density of 18-20 per 5 mm at 20 mm from the umbo; ventral median septum extending one-quarter to one-third the length of the valve; ventral adductor muscle scars subovate; socket ridges nearly parallel with the hinge; dorsal median septum extending from the alveolus to between one-third and one-half the length of the valve; lateral septa diverging at 20° from the median septum.

Description. External. Shell transverse, with the lateral margins meeting the hinge at nearly right angles; costellae frequently irregular and wavy, increasing mainly by intercalation and to a lesser extent by bifurcation; specimens range in size to an estimated 85 mm wide and 38 mm long. Pedicle valve gently and evenly convex; umbo low and barely rising above the level of the lateral slopes; ventral interarea apsacline, and bearing a wide delthyrium closed apically by a small arched pseudodeltidium; hinge bearing a row of spine bases spaced approximately 3 mm apart. Brachial valve gently concave to nearly flat on the posterior half of the valve, but becoming increasingly concave anteriorly; dorsal interarea short, catacline, and bearing a convex notothyrial plate over the dorsal exterior of the cardinal process.

Internal. Pedicle valve (text-fig. 12). Adductor muscle scars slightly impressed, subovate, pointed posteriorly, and bluntly rounded anteriorly; diductor muscle scars less well impressed, bounded postero-laterally by ridges, and flabellate in outline; teeth slender, laterally elongate, and supported by thickened dental plates on the margins of the delthyrium; internal surface of valve ornamented by spinose radially arranged ribs. Brachial valve (text-fig. 13). Socket ridges robust, and enclosing narrow sockets; cardinal process high and bilobed, the posterior face (text-fig. 14) having two elongate concave lobes separated ventrally by a narrow groove; median septum commencing in front of a shallow but almost cavernous depression or alveolus located anteriorly from or beneath the cardinal process; lateral septa slender, commencing in front of the cardinal process, and extending approximately half the length of the median septum; inner adductor muscle scars elongate, pointed posteriorly, expanding anteriorly, and extending two-thirds the length of the median septum; outer adductor muscle scars impressed postero-medially on the margins of the lateral septa and in front of the cardinal process, striated, but obscure anteriorly; internal surface of the valve ornamented by radial ridges which are particularly spinose on the margins of the visceral disc; brachial markings comprising relatively smooth subquadrate discs bordered laterally by low brachial ridges (text-fig. 13); ridges absent along the anterior margins of the brachial discs.

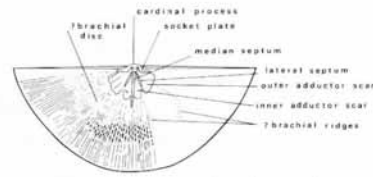
Remarks. *Megachonetes alatus* may belong to the *papilionaceus* (Phillips) group of species, a group of transverse gently concavo-convex forms. None of the *papilionaceus* group has previously been adequately described, presumably because of poor preservation of the thin shells. From a brief description of the type specimen of *M. papilionaceus* given by Muir-Wood (1962, p. 106) and a figure in Phillips (1836,



TEXT-FIG. 12. Ventral interior of *Megachonetes alatus* sp. nov. drawn from paratype F56973 AM. Approximately $\times 0.75$.



TEXT-FIG. 14. External face of the cardinal process of *Megachonetes alatus* sp. nov.



TEXT-FIG. 13. Dorsal interior of *Megachonetes alatus* sp. nov. drawn from the holotype F56974 AM. Approximately $\times 0.75$. The brachial markings are apparently the first described in a species of *Megachonetes*.

pl. 11, fig. 6) it appears that *M. alatus* is shorter, and has a coarser costellate ornament. Davidson's (1861, pl. 46, figs. 3-6) figures of *M. papilionaceus*, including Phillips's original specimen from Bolland, show that species to be larger, particularly in width, than *M. alatus*. Specimens of the *papilionaceus* group from Scotland figured by Brand (1970, pl. 11, figs. 15-18; pl. 12, fig. 3), resemble this species in the morphology of the dorsal and ventral musculature and septa. *M. alatus* differs from the Scottish form in having a brachial valve which is strongly concave anteriorly, and socket plates which are nearly parallel with the hinge. *M. papilio* (Paeckelmann) from the Viséan of Germany (Paeckelmann 1930, pp. 295-299, pl. 22, figs. 1-3; pl. 23, fig. 5) resembles *M. alatus* in the over-all outline and convexity of the shell, but differs in its larger size and coarser costellate ornament; adult shells of *alatus* have eighteen costellae per 5 mm, and those of *papilio* approximately ten costellae per 5 mm at the anterior margin. One other species of *Megachonetes* has been described from Australia. *M. zimmermanni* (Paeckelmann), described by Roberts (1971, pl. 10, figs. 11-22) from the Burvill Beds in the Bonaparte Gulf Basin, is less transverse, has a stronger ventral umbo, sloping ventral cardinal margins, and is smaller in size. These same distinctions apply to specimens of *M. zimmermanni* described by Paeckelmann (1930, pl. 17, fig. 23; pl. 18, fig. 1) from the Viséan of Germany, and by Sokolskaya (1950, pl. 6, figs. 7-13) from the Viséan of the Moscow Basin. *M. alatus* ranges from the *Schellwienella* cf. *burlingtonensis* Zone into the base of the *Orthotetes australis* Zone, and is late Tournaisian to possibly middle Viséan in age.

Occurrence. *M. alatus* sp. nov. is present at localities 15-3, 31-1, 39-16, 39-18, and 24-7 in the Waverley Formation, and locality 17-5 and possibly 29-7 in the Woolooma Formation in the Rouchel district; at locality 94-2 in the Ararat Formation near Gresford; at localities 112-4 and 12 in the Namoi Formation in the Werrie Syncline; at locality 113-4 in the Namoi Formation near Boggabri; and at locality F3 of Yeates (1970, unpublished B.Sc. thesis) in the Namoi Formation near Gravesend.

Material. F56969-F56977, Australian Museum. Holotype F56974; paratypes F56971, F56972, and F56973.

Superfamily PRODUCTACEA Gray, 1840
 Family LEIOPRODUCTIDAE Muir-Wood and Cooper, 1960
 Subfamily PRODUCTININAE Muir-Wood and Cooper, 1960
 Genus PRODUCTINA Sutton, 1938

Type species. Productus sampsoni Weller, 1909, by original designation of Sutton 1938.

Productina striata sp. nov.

Plate 6, figs. 10-20

1975 *Productina* sp. A., Roberts, Table 1.

Diagnosis. Shell strongly to moderately concavo-convex, subround in small forms, but elongate and spreading anteriorly in large individuals; ornament of fine to sometimes obsolete costae having a density of 25 per 10 mm at 10 mm from the umbo; pedicle valve rugose to slightly lamellose, with one or two erect spines on the postero-lateral margins, and usually one median spine; ventral diductor muscle scars wide; dorsal median septum extending to about the mid-length of the valve.

Description. External. Pedicle valve with greatest width near the mid-length in small forms, but at about two-thirds the length in large individuals; valve with steep umbonal shoulders, but becoming flatter on the spreading anterior of gerontic specimens; postero-lateral margins ear-like, and flat to slightly convex; hinge slightly shorter than the greatest width; spines large and halteroid, one or two erect spines arising from the umbonal slopes near each ear, and usually one or sometimes two spines arising at a low angle from wide costae on the median part of the valve; costae strap-like, and increasing by bifurcation and intercalation. Brachial valve deepest at about one-third the length of the valve, and with extremely steep umbonal shoulders rising to flat or slightly concave postero-lateral extremities; concentric lamellae frequently irregular, crowded anteriorly and in some cases crossed by rugae; specimens range in size up to 28 mm wide and 26 mm long.

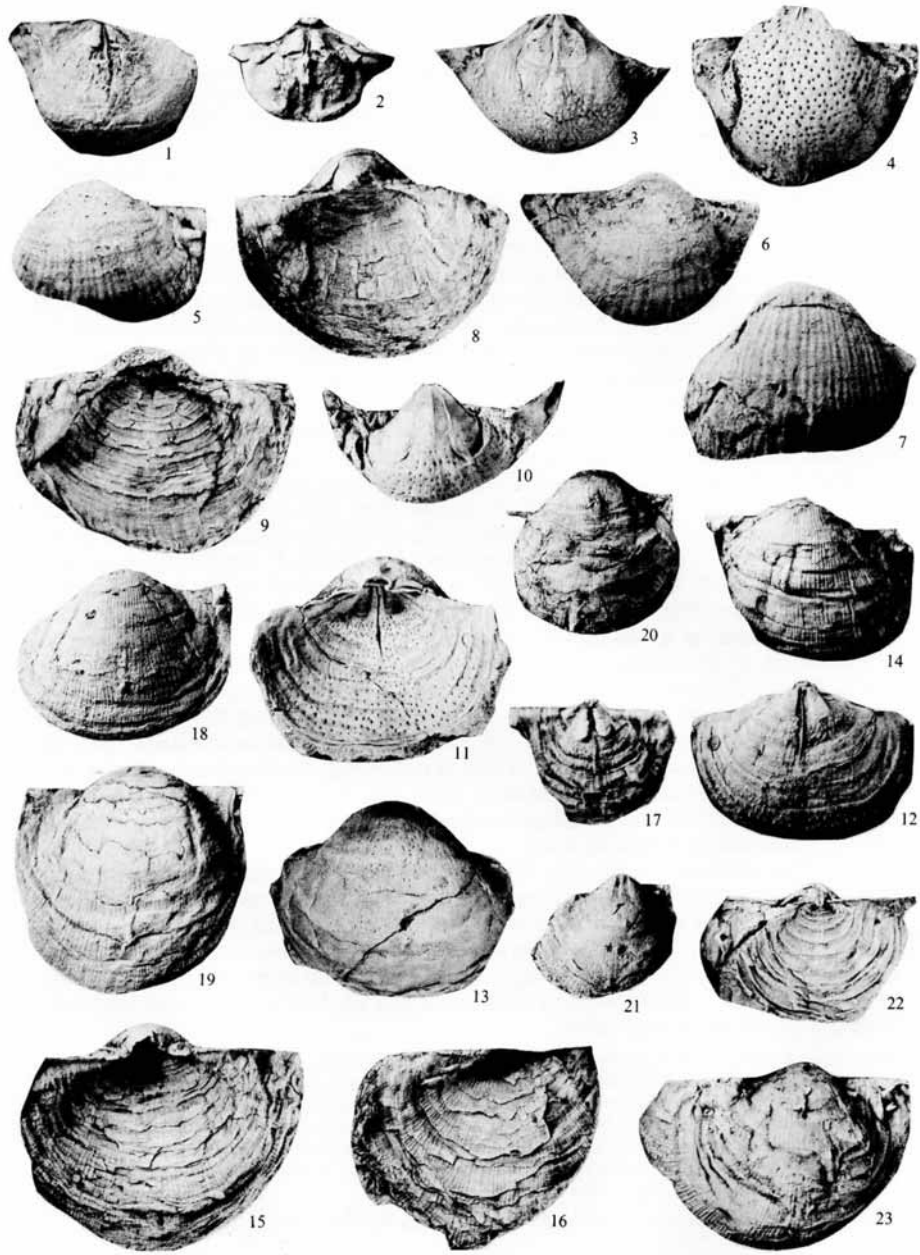
Internal. Pedicle valve. Adductor muscle scars subrectangular, pointed posteriorly, wider and with slightly rounded extremities anteriorly, and bearing faint radial striae; adductor scars on low platforms divided by a narrow furrow containing a median ridge; diductor muscle scars slightly impressed, extending well in front of the adductor muscle scars, broad and rounded anteriorly, tapering posteriorly, and marked by faint radial mantle canals; internal surface bearing fine endospines. Brachial valve. Median septum low; inner adductor scars situated on platforms between the median septum, elongate and pointed posteriorly,

EXPLANATION OF PLATE 6

Figs. 1-9. *Productina macdonaldi* sp. nov. 1-2, rubber casts of two brachial valve interiors. F57000a and F57001a the holotype, $\times 3$. 3-4, internal moulds of the pedicle valve. F57002 and F57001b, both paratypes, $\times 3$. 5-7, rubber casts of pedicle valve exteriors. F57003 a paratype, F57004, and F57000b a paratype, $\times 3$. 8-9, rubber casts of two brachial valve exteriors. F57005 and F57006, a paratype, $\times 3$. All from locality 92-1.

Figs. 10-20. *Productina striata* sp. nov. 10, internal mould of the apical portion of pedicle valve. F57007, $\times 1.5$. 11-13, internal mould and a rubber cast of the brachial valve interior of the holotype. F57008, $\times 1.5$. 14, rubber cast of a pedicle valve exterior. F57009, a paratype, $\times 1.5$. 15-16, rubber casts of two brachial valve exteriors. F57010 and F57011, paratypes, $\times 1.5$. Figs. 10-16 from locality 6-10. 17, rubber cast of a brachial valve interior from locality 6-13. F57012, $\times 3$. 18-19, a rubber cast of a pedicle valve exterior and an internal mould of a pedicle valve. F57013 and F57014 respectively. Both $\times 1.5$ and from locality 89-1. 20, rubber cast of the pedicle valve exterior of F57015, $\times 1.5$, from locality 41-1.

Figs. 21-23. *Productina* cf. *striata* sp. nov. 21, internal mould of a pedicle valve showing narrow diductor muscle scars. F57016, $\times 1.5$. 22, rubber cast of a brachial valve exterior. F57017, $\times 1.5$. 23, rubber cast of a deformed pedicle valve showing an additional spine on the postero-lateral extremities. F57018, $\times 1.5$. Figs. 21-23 from locality L386 U Newcastle.



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and expanding anteriorly; outer adductor scars shallowly impressed, and narrowly triangular in outline; cardinal process bilobed, each lobe bearing a deep median furrow on the postero-dorsal surface; lateral ridges short and obsolete; brachial markings faint, comprising low ridges extending in a sinuous curve anteriorly from the front of the inner adductor scars, and curving laterally near the front of the valve; internal surface bearing fine endospines.

Remarks. Morphologically *Productina striata* is close to the cosmopolitan species *P. margaritacea* (Phillips). This species is distinguished from *margaritacea* by its generally more round outline, and by the possession of much finer costae (25 per 10 mm at 10 mm from the umbo compared with 12–16 in the same dimensions on *margaritacea*), and a more rugose pedicle valve. The dorsal median septum of *striata* is more robust than that of specimens of *margaritacea* from Northern Ireland figured by Brunton (1966, pl. 8, fig. 9), but may be weaker than that on a specimen from the Utting Calcarene in the Bonaparte Gulf Basin (Roberts 1971, pl. 17, figs. 22 and 25). In addition, the ventral diductor muscle scars are wider in *striata* than in *margaritacea*, and *striata* may have one less spine on each umbonal shoulder. Material from the Carboniferous Limestone of Great Britain figured by Davidson (1861, pl. 44, figs. 6–8), including Phillips's type specimen, show *P. margaritacea* to be more lamellose on the pedicle valve and to have much stronger costae and a greater number of postero-lateral spines when compared with *P. striata*. The specimen of *P. margaritacea* illustrated by Sarycheva and Sokolskaya (1952, pl. 15, fig. 106) from the C₁ of the Moscow Basin is less rugose and has coarser costae than *P. striata*. *P. pectinoides* (Phillips) figured by Davidson (1861, pl. 44, fig. 8) resembles *striata* in outline, but has coarser costae and, according to Dr. C. H. C. Brunton (pers. comm.), may lack median and flanking spines on the pedicle valve.

Specimens of *Productina* cf. *striata* from locality L386 at Alison near Dungog (Pl. 4, figs. 21–23) are externally very close to *striata*. They are similar in size, have a comparable density of costae (22–28 per 10 mm at 10 mm from the ventral umbo), and are rugose to lamellose on the pedicle valve. There may be an additional spine on each umbonal shoulder, and a group of five or more spines on the posterior portion of the visceral disc behind the large median spine; the major difference with *striata* is the smaller size of the ventral diductor muscle scars, and the more narrow elongate outline of the diductor muscle scars.

P. globosa Roberts (1963, pp. 12–13, pl. 3, figs. 1–3) which ranges from the *Schellwienella* cf. *burlingtonensis* Zone into the lower part of the *Orthotetes australis* Zone in New South Wales, and is also recorded from Queensland (McKellar 1967), is much smaller than *striata*. *P. globosa* is more strongly concavo-convex, has a coarser costate ornament, a band of six to eight spines around the front of the pedicle valve, obsolete diductor muscle scars, a delicate dorsal median septum, and divergent lateral ridges in the dorsal valve.

Occurrence. *P. striata* is restricted to the Viséan *Inflatia elegans* Subzone. It is recorded from locality 6-10, the type locality, and localities 6-11 and 13, 35-3, and 41-1 and 2 in the Woolooma Formation in the Rouchel district; locality 89-1 in the Flagstaff Sandstone at Mirannie; localities 100-2, 10 and 12, 106-2 and 16 in the Flagstaff Sandstone in the Salisbury-Brownmore district; and at localities 98-1 and 129-1 in the Flagstaff Sandstone in the Gresford district, New South Wales. In Queensland the species is present at locality K21 GSQ in the Caswell Creek Group at Cannindah. *Productina* cf. *striata* is present at locality L368 U Newcastle at Alison, near Dungog, New South Wales.

Material. F57007–F57015 AM. Holotype F57008; paratypes F57009, F57010, F57011.

Productina macdonaldi sp. nov.

Plate 6, figs. 1-9

1975 *Productina* sp. B., Roberts, Table 1.

Diagnosis. Shell small, globose, and strongly concavo-convex; pedicle valve with 6-7 costae per 3 mm at the anterior margin, and two or three spine bases on each umbonal shoulder, but lacking median spines or a concentric row of spines near the anterior of the valve; ventral adductor muscle scars in two pairs separated by a furrow bearing a median ridge; dorsal costae obsolete to absent; brachial valve having a median septum extending beyond the mid-length of the valve, triangular inner adductor muscle platforms, prominent hook-shaped brachial ridges, and lateral ridges parallel with the hinge.

Description. External. Pedicle valve semicircular to rounded-rectangular in outline, narrow at the umbo, and flaring anteriorly; umbo prominent, with steep umbonal shoulders passing on to flat moderately wide postero-lateral extremities; costae poorly defined on the umbo, stronger anteriorly, increasing by bifurcation, and crossed by several lamellose growth halts. Brachial valve deepest at about one-third of its length, with steep lateral slopes and flat postero-lateral extremities; concentric lamellae closely spaced and short posteriorly, and longer and more widely spaced anteriorly; specimens range in size up to 14 mm long and 10.5 mm wide.

Internal. Pedicle valve. Adductor muscle scars comprising a larger club-shaped inner pair, and a smaller impressed ovoid outer pair inset into the postero-lateral extremities of the inner adductor scars; median ridge arising at the umbo and extending through a median furrow to the anterior margin of the adductor scars; diductor muscle scars less well defined, extending in front of the adductor scars, broad and rounded posteriorly, and tapering posteriorly; internal surface ornamented with small endospines. Brachial valve. Inner adductor muscle scars situated on high muscle platforms; outer adductor muscle scars poorly defined, subquadrate, and slightly impressed; median septum commencing at a position level with the posterior of the inner adductor platforms, narrow between the muscle platforms, and becoming wider and higher anteriorly; cardinal process bilobed and supported by slender lateral ridges; posterior of cardinal process not observed; brachial ridges high, extending from the front of the outer adductor muscle scars and enclosing nearly square pustulose brachial discs (Pl. 6, fig. 2); internal surface of valve bearing small endospines, particularly in front of the muscle field.

Remarks. *P. macdonaldi* sp. nov. is known only from the upper part of the *Rhipidomella fortimuscula* Zone at Salisbury and Brownmore. Morphologically, it is remarkably close to *P. globosa* Roberts (1963, pp. 12-13, pl. 3, figs. 1-3) which in New South Wales ranges from the *Schellwienella* cf. *burlingtonensis* Zone into the lower part of the *O. australis* Zone. There are no small globose species of *Productina* recorded in either New South Wales or Queensland from the intervening upper part of the *australis* and *Delepinea aspinosa* Zones, and hence *macdonaldi* is considered to be a homeomorph of *globosa*. The differences between the species are slight. *P. globosa* is a little less transverse, does not possess a low ventral median ridge, lacks brachial ridges, which, however, are not invariably present in *macdonaldi*, possesses a row of 6-8 spines around the front of the pedicle valve, and has divergent lateral ridges in the brachial valve. In *macdonaldi* the inner adductor muscle platforms are triangular in shape and higher than those in *globosa*, the dorsal median septum is slightly longer, and the postero-lateral extremities may be a little wider.

P. sampsoni (Weller) from the Lower Mississippian of U.S.A. (Muir-Wood and Cooper 1960, pl. 123, figs. 1-10; Carter 1967, pl. 10, fig. 1) is morphologically close

to both *globosa* and *macdonaldi*. When compared with *macdonaldi* the main distinguishing features of *P. sampsoni* are the geniculation at the front of the brachial valve, and a shorter hinge line. Another species from the Lower Mississippian of the U.S.A., *P. lodgepoleensis* Rodriguez and Gutschick (1968, pl. 128, figs. 1-9), is characterized by a hinge line of comparable width to that in *macdonaldi*. *P. lodgepoleensis* is distinguished by the smaller convexity of the pedicle valve, the possession of coarser dorsal endospines, and the lack of brachial ridges.

Occurrence. Locality 92-1, the type locality, and locality 103-4 in an unnamed formation in the Salisbury-Brownmore district. Late Viséan *R. fortimuscula* Zone.

Material. F57000-F57006 AM. Holotype F57001a; paratypes F57000b, F57001b, F57002, F57003, F57006.

Productina morrissi sp. nov.

Plate 7, figs. 26-31

?1931 *Productus* (*Thomasina*) *pectinoides* Phillips; Paeckelmann, pp. 188-191, pl. 17, figs. 13-16.

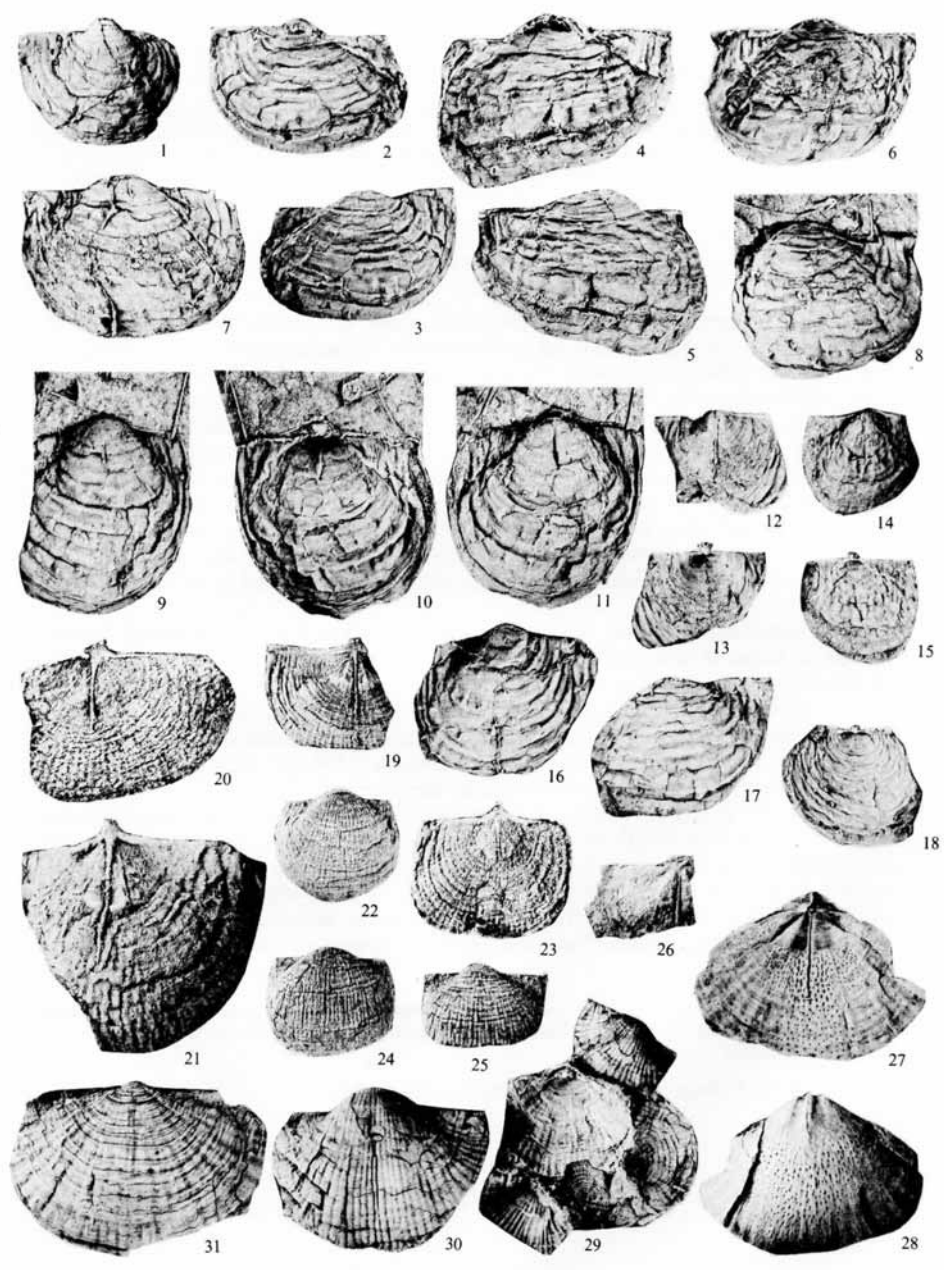
1975 *Productina pectinoides* (Phillips); Roberts, Table 1.

Diagnosis. Shell large, transverse, moderately concavo-convex, and with coarse costae; pedicle valve with wide postero-lateral extremities, each bearing a row of three large spines; ventral median spines absent; dorsal median septum extending two-thirds the length of the valve.

Description. External. Shell pentagonal in outline, and widest behind the mid-length; specimens range in size up to 36 mm wide and 26.5 mm long. Pedicle valve most strongly convex at the umbo, and with broad evenly convex lateral slopes; umbo wide, and extending well behind the hinge; hinge slightly less than the greatest width of the valve; costae wide, increasing in number by rare bifurcations, having a density of 10-13 per 10 mm at 10 mm, and 8-10 per 10 mm at 20 mm from the umbo, and crossed by occasional lamellose growth halts. Brachial valve rounded-rectangular in outline, and with flat postero-lateral extremities; gerontic individuals having an elongate trail; concentric lamellae regularly spaced over the

EXPLANATION OF PLATE 7

- Figs. 1-18. *Spinorugifera chichesterensis* gen. et sp. nov. 1, internal mould of a pedicle valve. F57019, $\times 2$. 2-3, rubber cast and mould of the interior of a pedicle valve. F57020, $\times 2$. 4-5, rubber cast and mould of the interior of a pedicle valve. F57021, $\times 2$. 6, rubber cast of a pedicle valve interior. F57022, $\times 2$. 7, rubber cast of a pedicle valve exterior. F57023, $\times 2$. 8, rubber cast of a pedicle valve exterior. F57024, $\times 2$. 9-11, rubber casts of the ventral and dorsal exterior and an internal mould of the pedicle valve of F57025a, b, and c, the holotype, $\times 2$. 12-13, rubber casts of the dorsal interior and exterior of F57026, paratype, $\times 2$. 14-15, rubber casts of the dorsal interior and exterior of F57027, paratype, $\times 2$. 16-17, rubber casts of two pedicle valve exteriors. F57028 and F57029 respectively, $\times 2$. 18, rubber cast of a brachial valve exterior. F57030, $\times 2$. Figs. 1-18 from locality 106-15.
- Figs. 19-25. *Antiquatonia spinulicosta* sp. nov. 19, rubber cast of a brachial valve interior from locality 24-7. F57031, $\times 1.5$. 20-21, rubber casts of two brachial valves. F57032 and F57036, the holotype, $\times 1.5$ and $\times 3$ respectively. 22, internal mould of pedicle valve. F57033, paratype, $\times 1$. 23, rubber cast of a brachial valve interior. F57034a, paratype, $\times 1.5$. 24-25, internal mould and rubber cast of the exterior of pedicle valve. F57035, $\times 1$. Figs. 20-25 from locality 10026 ANU.
- Figs. 26-31. *Productina morrissi* sp. nov. 26, interior of brachial valve. F57037, $\times 1.5$. 27-28, internal mould of the dorsal and ventral interior. F57038a, holotype, $\times 1.5$. 29, rubber cast of a group of shells. F57039, $\times 1$. 30, exterior of pedicle valve. F57040, paratype, $\times 1$. 31, external mould of brachial valve. F57038b, $\times 1.5$. Figs. 26-31 from locality L498 U Newcastle.



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visceral disc, having a density of 5-9 per 10 mm on the mid-region of the disc; lamellae longer towards the front of the valve, and up to 8 mm in length on the trail of a gerontic specimen.

Internal. Pedicle valve. Adductor muscle scars elongate, tapering posteriorly, wider anteriorly, situated on low muscle platforms, and separated by a deep median furrow; diductor muscle scars immediately adjacent to and extending further anteriorly than the adductor scars, wide and rounded anteriorly, and tapering posteriorly; internal surface of the valve bearing numerous small endospines. Brachial valve. Inner adductor muscle scars triangular, pointed posteriorly and wide anteriorly, and located on high muscle platforms separated by the posterior portion of the median septum; outer adductor muscle scars poorly defined; cardinal process bilobed, but unknown posteriorly; lateral ridges short and divergent; brachial ridges not observed; endospines small, covering most of the internal surface of the valve, but concentrated particularly in the middle of the valve in front of the muscle field.

Remarks. The present material is extremely close to specimens from the Upper Kohlenkalk of Germany identified as *Productus (Thomasina) pectinoides* Phillips by Paeckelmann (1931); the shells are large, have a similar profile, coarsely costate ornament, large umbo, and configuration of spines on the postero-lateral extremities. *Productina pectinoides* (Phillips) is presently poorly understood, and was placed in synonymy with *P. margaritacea* by Davidson (1861). The type specimen (Phillips 1836, pl. 7, fig. 11; Davidson 1861, pl. 44, fig. 8), however, appears to be circular in outline, and according to Dr. C. H. C. Brunton (pers. comm.) may lack median and flanking spines; it is therefore doubtful whether Paeckelmann's specimens are correctly assigned. Spanish material identified as *P. pectinoides* by Winkler Prins (1968) is small, subcircular in outline, and strongly concavo-convex and is not closely comparable with *P. morrisoni*.

P. margaritacea (Phillips), which has a transverse outline and internal features similar to those of this species, differs in having a median spine or spines on the venter, a larger number of spines on the shoulders, and slightly finer costae. Specimens used in this comparison were described by Brunton (1966) from Ireland, and Roberts (1971) from the Bonaparte Gulf Basin, north-western Australia. Phillips's type specimen of *P. margaritacea*, figured by Davidson (1861, pl. 44, fig. 6), appears to have finer costae than specimens figured by Brunton and Roberts.

P. morrisoni is the largest of four species of *Productina* recorded from Lower Carboniferous rocks in New South Wales. It is distinguished from *P. striata* sp. nov., the other relatively large species, by its greater size, more rectangular outline, and much coarser costae. In the pedicle valve *morrisoni* has wider postero-lateral extremities, each of which bears a row of three spines, has fewer lamellae or rugae, and lacks median spines on the venter. The dorsal median septum of *morrisoni* is longer than in *striata*.

Occurrence. *P. morrisoni* is recorded from localities L498 U Newcastle, the type locality, 90-7 and probably 90-9 in an unnamed formation in the Salisbury-Brownmore district, New South Wales. Late Viséan *R. fortimuscula* Zone.

Material. F57037-F57040 AM. Holotype F57038a; paratype F57040.

Family OVERTONIIDAE Muir-Wood and Cooper, 1960
Subfamily OVERTONIINAE Muir-Wood and Cooper, 1960
Genus KROTOVIA Fredericks, 1928 emend. Brunton, 1966

Type species. Productus spinulosus J. Sowerby, 1814.

Krotovia prociua sp. nov.

Plate 9, figs. 24-33

1975 *Krotovia* sp. nov., Roberts, Table 1.

Diagnosis. Shell transverse, and semicircular in outline; ventral ornament of unevenly spaced lamellae with irregular rows of elongate spine bases bearing mainly prostrate spines; dorsal spines in irregular concentric rows, small, erect, and arising immediately from the surface of the valve; dorsal median septum extending one-third the length of the valve; lateral ridges apparently absent.

Description. External. Shell widest in front of the hinge, moderately concavo-convex, and with a thin body cavity; specimens range in size up to 33.5 mm wide and 31.0 mm long. Pedicle valve evenly convex over the venter, with a narrow tapering umbo, steep concave umbonal shoulders, and small, flat postero-lateral extremities; spine bases quincuncially arranged on the anterior of the valve. Brachial valve deepest at the posterior of the visceral disc, and having flat postero-lateral extremities; exterior of valve ornamented by dimples in positions equivalent to spines on the interior of the valve, and irregular spinose lamellae and rugae; rugae forming closely spaced lumpy ridges, strongest on the umbonal shoulders, and in some cases extending across the visceral disc; spines without node-like bases, but arising directly from the surface of the rugae or the lamellae.

Internal. Pedicle valve interior poorly known; diductor muscle scars apparently ovoid in outline, rounded anteriorly, and separated by a low median ridge; adductor muscle scars not observed; internal surface finely spinose. Brachial valve. Median septum low and slender; adductor muscle scars in one pair, lachrymose in outline, pointed posteriorly and rounded anteriorly, and forming elevated muscle platforms; cardinal process bilobed, but unobserved posteriorly; brachial markings absent; internal surface of valve bearing large endospines on concentric ribs, and fine endospines.

Remarks. Specimens from Barrington, New South Wales (Pl. 9, figs. 32-33), are less transverse than those from the type locality at Salisbury. Their spine bases are shorter, but the spines are still arranged in rough concentric rows.

The type species, *Krotovia spinulosa* (Sowerby) from the Lower Carboniferous of Great Britain (Muir-Wood and Cooper 1960, pl. 50, figs. 1-5), differs from *K. prociua* sp. nov. in its smaller size and in details of the external ornament. *K. spinulosa* has quincuncially rather than mainly concentrically arranged spines, lacks lamellose growth halts, and has weaker dorsal rugae. Silicified specimens of *K. spinulosa* described by Brunton (1966, pp. 224-225, pl. 12, figs. 1-18; pl. 13, figs. 1-7) from the D₁ of Northern Ireland have a subcircular outline, are more strongly concavo-convex, and have shorter spine bases on the pedicle valve and weaker rugae on the brachial valve. Internally they have smaller dorsal adductor muscle scars, divergent lateral ridges, and a weaker dorsal median septum. A lamellose form, *K. lamellosa* Brunton (1966, pp. 225-228, pl. 13, figs. 8-16; pl. 14, figs. 1-19) also from the D₁ of Northern Ireland, is more regularly lamellose than *K. prociua*, lacks elongate spine bases, is more circular in outline, and has a smaller size.

The specific name is from the Latin *prociuus*, prostrate, and refers to the prostrate nature of spines on the pedicle valve.

Occurrence. Locality 92-1, the type locality, and locality 90-6 in an unnamed formation at Salisbury; locality L145 UNE in the Copeland Road Formation at Barrington, New South Wales, and locality 119-7 in the Mundubbera Sandstone at Mundubbera, Queensland. Late Viséan *R. fortimuscula* Zone.

Material. F57068–F57075 AM. Holotype F57069; paratypes F57068, F57072b.

Genus PHARCIDODISCUS nov.

Type species. *Pharcidodiscus boulderensis* gen. et sp. nov. from the Neils Creek Clastics, Mount Morgan, Queensland.

Diagnosis. Shell rounded-rectangular to subquadrate in outline, moderately concavo-convex, auriculate, and with a short dorsal anterior geniculation; ornament rugose posteriorly and costate anteriorly; on the pedicle valve, spines arising from spine ridges on the rugose portion of the valve, from crests of costae on the front of the visceral disc and trail, and also forming a single divergent row at the hinge; brachial valve aspinose; ventral adductor muscle scars divided by a low median ridge; dorsal adductor muscle scars smooth and in two pairs; median septum slender, arising in front of an alveolus in small specimens, but joined by a rod-like callus to the front of the cardinal process in large specimens; cardinal process bilobed internally and with medianly fused lobes posteriorly.

Remarks. Few productaceans are characterized by an ornament which is rugose posteriorly and costate anteriorly. *Semicostella* Muir-Wood and Cooper (1960), which has this type of ornament, resembles *Pharcidodiscus* in having smooth dorsal adductor muscle scars. *Semicostella*, however, has far fewer spines on the costae, less well-defined costae on the brachial valve, a more highly convex pedicle valve which possesses a short trail separated from the visceral disc by a cincture, lateral ridges which extend around the ears to the middle of the valve, a stronger dorsal median septum, prominent brachial markings, and a bilobate posterior face on the cardinal process. The spine ridges in some species of *Rhytiophora* Muir-Wood and Cooper (1960) tend to become elongate and form ridges resembling costae, but this is not a consistent feature of the genus. *Rhytiophora* is distinguished from *Pharcidodiscus* by the possession of long curving lateral ridges, dendritic outer adductor muscle scars in the brachial valve, and a rim-like extension to the trail. *Spinocariniifera* Roberts (1971), from the Tournaisian of the Bonaparte Gulf Basin in north-western Australia, has a spinose costate ornament on the anterior of the shell, but also lacks the strongly rugose posterior ornament.

The generic name is derived from the Greek *pharkidodes*—wrinkled, and *diskos*—disc, and refers to the rugose nature of the visceral disc.

Pharcidodiscus boulderensis gen. et sp. nov.

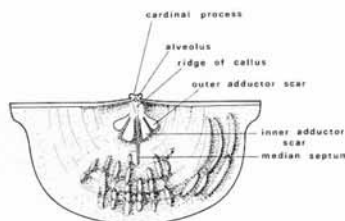
Plate 8, figs. 1–14

1970 *Semicostella*(?) sp., McKellar *et al.*, in Kirkegaard *et al.*, p. 149.

Diagnosis. Shell subrectangular to subquadrate, and strongly auriculate; ventral ornament comprising up to fourteen rugae on the posterior of the largest individuals, and irregular spinose costae with a density of 12–14 per 10 mm at 10 mm from the umbo; brachial valve with a similar number of rugae on the visceral disc, and with aspinose costae on the trail.

Description. External. Pedicle valve moderately convex on the visceral disc, evenly rounded across the venter, and with a steep elongate trail; valve highest around the mid-part and widest at the hinge; posterior portion ornamented by spine-bearing rugae, and the trail by irregular spinose costae; rugae high and well defined on the ears, extending as lower ridges across the visceral disc, and bearing erect spines; costae interfingering with the rugae at the posterior of the trail, irregular in width and height, bearing longitudinal rows of erect spines, and giving a strongly ribbed appearance to the trail; spines distributed in a row diverging from the hinge, in concentric rows on the crests of rugae, and in longitudinal rows on the trail; micro-ornament of concentric growth lines. Brachial valve having a moderately concave visceral disc, large flat auricles, and a short trail formed by an anterior geniculation; visceral disc with steep lateral margins, and slightly dimpled by depressions corresponding to spine bases on the pedicle valve; ears and visceral disc strongly rugose, large individuals having up to fourteen rugae; costae interrupting the rugae on the anterior of the visceral disc, and strongly developed on the trail; valve aspinose; specimens ranging in size up to 20 mm wide and 11 mm long.

Internal. Pedicle valve. Muscle field divided by a slender median ridge; muscle scars obscure; elongate radially arranged tubules, connected to the external spines, emerging from hollows in the floor at the posterior of the visceral disc. Brachial valve (text-fig. 15). Inner adductor muscle scars narrow posteriorly, usually widest anteriorly, and located on elevated muscle platforms; outer adductor muscle scars less well defined, and almost completely obscure in small specimens; median septum slender, highest at the anterior, and extending through a trough between the inner adductor muscle scars to the mid-length of the visceral disc; in small specimens the septum arises as a low narrow ridge in front of a circular alveolus; in large specimens a tapering rod-like callus extends from between the base of the cardinal process and the median septum; cardinal process with two convex lobes internally, and medianly fused lobes posteriorly; lateral ridges low, and extending along the hinge; brachial markings poorly defined; floor of valve surrounding the muscle field ornamented with fine radial granules; trail bearing small endospines.



TEXT-FIG. 15. Dorsal interior of *Pharcidodiscus boulderensis* gen. et sp. nov. drawn from F12143 GSQ. Approximately $\times 2$.

Remarks. No other species referable to *Pharcidodiscus* are known. A productacean from slightly lower in the sequence at Mount Morgan, *Spinocarinfera kennedyensis* (Maxwell), is distinguished from *P. boulderensis* by its subovate pedicle valve, more prominent and incurved ventral umbo, smaller ears, spinose brachial valve, fainter rugose ornament on the posterior of both valves, and more regularly developed and finer costae.

Occurrence. *P. boulderensis* is known only from locality L955 GSQ in the Neils Creek Clastics, west of Boulder Creek, Mount Morgan. Late Tournaisian part of the *Schellwienella* cf. *burlingtonensis* Zone.

Material. F10258, F10259, F10260a, F10262a, F10263, F10268, F10269, F10270, F10271b, F10273b, F12143-F12146 all GSQ. Holotype F10269; paratypes F10260a, F10262a, F10268, F10273b, F12145.

Genus SPINOCARINIFERA Roberts, 1971

Type species. *Spinocarinfera adunata* Roberts, 1971 from the Tournaisian Burt Range Formation, Bonaparte Gulf Basin, north-western Australia.

Diagnosis. See Roberts (1971, p. 100).

Spinocarinfera kennedyensis (Maxwell)

Plate 8, figs. 15-29

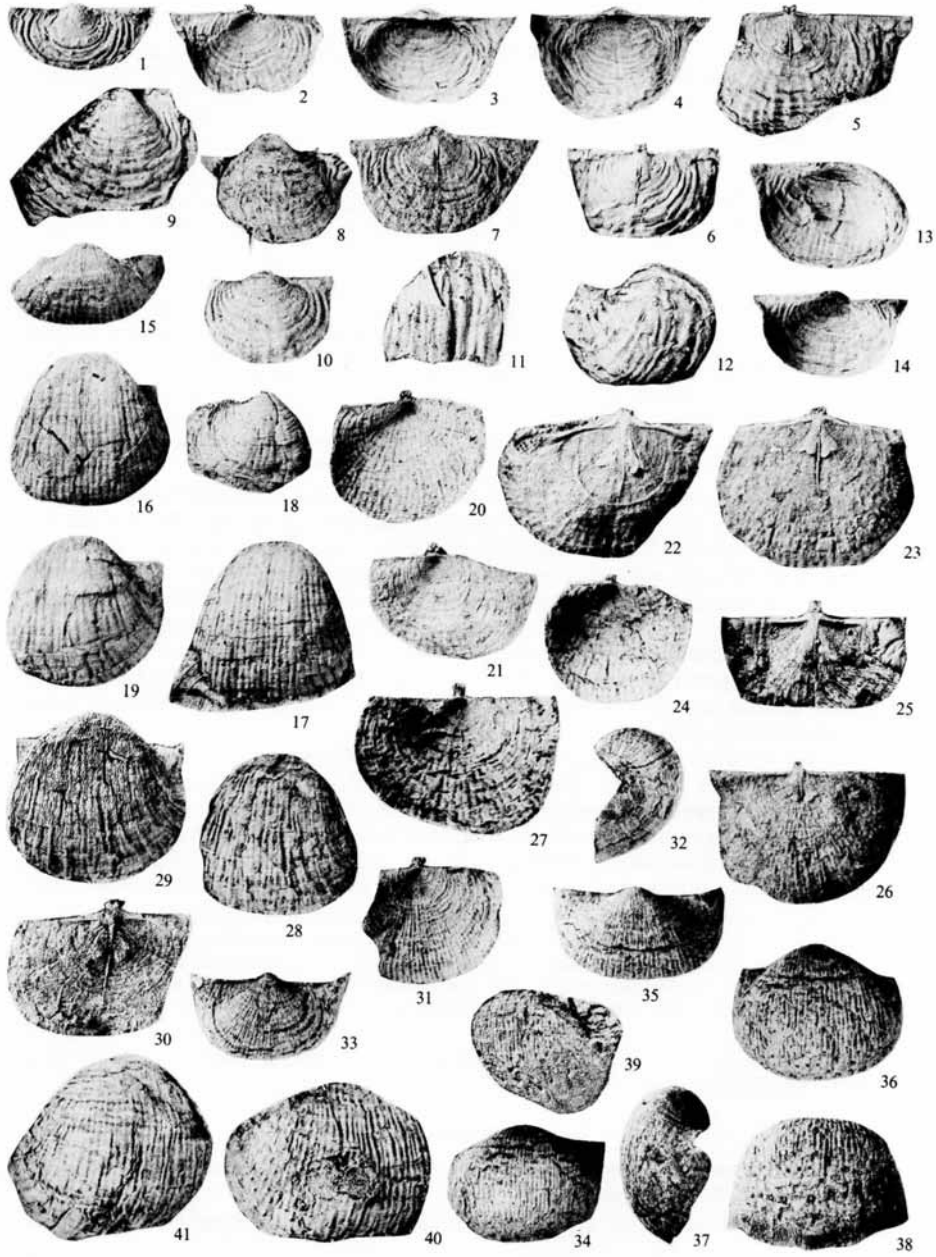
1954 *Avonia kennedyensis* Maxwell, p. 23, pl. 2, figs. 13-16.1964 *Avonia kennedyensis* Maxwell, in Hill and Woods, pl. 6, figs. 11-14.

Diagnosis. Shell longer than wide and moderately concavo-convex; pedicle valve with a slightly flattened venter and an elongate trail; spines subprostrate posteriorly but not forming a strong group at the ears; brachial valve with a short anterior geniculation, and spines arranged in poorly defined concentric rows; dorsal adductor muscle scars divided into two pairs.

Description. External. Pedicle valve subround to subovate in outline, slightly wider at the mid-length than at the hinge, and having a constriction immediately in front of the hinge; umbo prominent, and separated by steep concave umbonal shoulders from small, flat auricles; umbonal regions ornamented by weak rugae and spine ridges; rugae becoming obsolete at about one-quarter the length of the valve, but well defined on the umbonal shoulders; costae discontinuous and crossed by weak rugae on the anterior part of the visceral disc, but continuous and usually evenly spaced on the venter and trail; costae increasing by bifurcation and intercalation, and having a density of 14-16 per 10 mm at 10 mm from the umbo; subprostrate spines originating from spine ridges on the umbo, and erect spines arising from the crests of costae on the venter and on the trail. Brachial valve round to subquadrate in outline, with flat to slightly concave ears; rugae strongest on the ears and on the lateral shoulders but also extending across the posterior of the visceral disc; up to seventeen rugae on the visceral disc of a mature valve; anterior half of the visceral disc and the trail ornamented by well-defined rounded costae bearing ill-defined concentric rows of subcircular erect spines; specimens range in size up to 22 mm long and 18 mm wide.

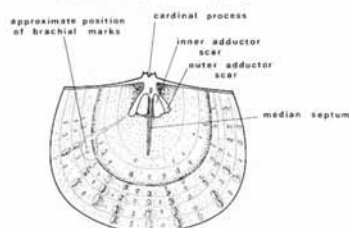
EXPLANATION OF PLATE 8

- Figs. 1-14. *Pharcidodiscus boulderensis* gen. et sp. nov. 1, rubber cast of apical portion of pedicle valve. F10268 GSQ, $\times 1.5$ paratype. 2-4, rubber casts of the exteriors of three brachial valves. F10260a GSQ, a paratype, F10259 GSQ, and F10263 GSQ respectively. All $\times 1.5$. 5-7, rubber casts of three brachial valve interiors. F12143 GSQ, F10270 GSQ, and F10269 GSQ, the holotype, $\times 2$, $\times 1.5$, and $\times 1.5$ respectively. 8-10, rubber casts of the exteriors of three pedicle valves. F10258 GSQ, F12144 GSQ, and F10262a GSQ a paratype. All $\times 1.5$. 11-12, rubber casts of the anterior and antero-lateral parts of two pedicle valves. F10271b GSQ and F12145 GSQ, paratype, $\times 1.5$. 13, rubber cast of a brachial valve exterior. F12146 GSQ, $\times 1.5$. 14, rubber cast of a pedicle valve interior. F10273b GSQ, $\times 1.5$, paratype. Figs. 1-14 from locality L955 GSQ.
- Figs. 15-29. *Spinocarinfera kennedyensis* (Maxwell). 15-17, posterior and anterior views of the ventral internal mould of F10217a GSQ, and rubber cast of the exterior of F10217b GSQ. All $\times 1.5$. 18, rubber cast of a pedicle valve exterior. F10220 GSQ, $\times 1.5$. 19, internal mould of a pedicle valve. F10226a GSQ, $\times 1.5$. 20-21, rubber casts of two brachial valve exteriors F10223 GSQ and F10219a GSQ, $\times 1.5$. 22-23, rubber casts of two brachial valve interiors. F10219b GSQ and F10235 GSQ, $\times 2$. Figs. 15-23 from locality K91 GSQ. 24, rubber cast of a brachial valve exterior from L244 GSQ. F12147, $\times 1.5$. 25, rubber cast of a brachial valve interior. F67154 UQ, $\times 1.5$. 26, rubber cast of a brachial valve interior. F15154 UQ, the holotype, $\times 1.5$. Figs. 25 and 26 from L1288 UQ. 27, rubber cast of a topotype brachial valve. F57041, $\times 1.5$. 28-29, rubber cast of the exterior, and an internal mould of a topotype pedicle valve. F57042, $\times 1.5$. Figs. 27-29 from locality 121-2 which equals L1288 UQ.
- Figs. 30-41. *Antiquatonia spinulicosta* sp. nov. 30, rubber cast of a brachial valve interior. F57043, $\times 1.5$. 31, rubber cast of a brachial valve exterior. F57044, $\times 1$. 32-34, lateral, posterior, and anterior views of the internal mould of a pedicle valve. Note the row of spines down the flanks. F57045, $\times 1$. 35-38, posterior, ventral, anterior, and lateral views of the internal mould of pedicle valve. F57046, $\times 1$. 39-40, rubber casts of the anterior and antero-lateral parts of two pedicle valve exteriors showing the spinose ornament. F57047, $\times 1$, and F57048, $\times 1.5$ respectively. Figs. 30-40 from locality L203 UNE. 41, rubber cast of a pedicle valve exterior. F57034b, $\times 1.5$ from locality 10026 ANU.



ROBERTS, Australian productaceans

Internal. Pedicle valve. Adductor muscle scars subrectangular, slightly wider anteriorly than posteriorly, bearing longitudinal striations, and separated by a low median ridge; diductor muscle scars flabellate, also radially striated, and slightly less well defined; internal surface of valve bearing fine granular micro-ornament. Brachial valve (text-fig. 16). Inner adductor muscle scars triangular in outline, low and pointed posteriorly, and having a high bulbous anterior extremity; outer adductor scars lower, and also triangular in outline; median septum originating from a broad callus or from in front of a small alveolus at the anterior margin of the cardinal process, and extending to the middle of the visceral disc; lateral ridges variable in strength and parallel with the hinge (one specimen from locality K91 (Pl. 6, fig. 22) has lateral ridges which diverge slightly from the hinge); cardinal process with two convex lobes internally and medianly fused lobes posteriorly; brachial ridges faint, diverging from the antero-lateral margins of the adductor muscle scars at about 40° and enclosing partly smooth subquadrate brachial discs; visceral disc bearing a granular ornament similar to that on the interior of the pedicle valve; anterior part of the visceral disc and the trail with radially arranged endospines.



TEXT-FIG. 16. Dorsal interior of *Spino-carinifera kennedyensis* (Maxwell) drawn from F10235 GSQ. Note the subdivision of the adductor muscle scars. Approximately $\times 2$.

Remarks. *S. kennedyensis* (Maxwell) has a number of morphological features which separate it from the type species, *S. adunata* Roberts (1971, pp. 101–104, pl. 19, figs. 1–18; pl. 20, figs. 9–16). Externally, *S. kennedyensis* is more elongate, has a less convex pedicle valve, possesses irregular rows of small spines on the brachial valve, and appears to lack a group of large halteroid spines on the postero-lateral extremities. Internally the two species are morphologically close, the only difference being the possession by *kennedyensis* of two pairs of dorsal adductor muscle scars; a specimen of *S. adunata* figured by Roberts (1971, pl. 20, fig. 16) may in fact show a very poorly defined second pair of adductor scars on the lateral margins of well-defined inner adductor muscle scars.

When compared with *S. niger* (Gosselet) from the Etroeungt and early Tournaisian of France (Dehee 1929, pp. 39–41, pl. 4, figs. 1–6), *S. kennedyensis* has the same external differences established in the comparison with the type species. The external ornament of *S. kennedyensis* is close to that of *S. ? arcuata* (Hall) from the Kinderhook of Missouri and Iowa (Weller 1914, pp. 107–108, pl. 13, figs. 1–12). *S. ? arcuata*, however, has a more convex pedicle valve, and a more strongly geniculate brachial valve.

Occurrence. Locality 1288 UQ (equals 121–2), the type locality, in the Pond Formation at Mount Morgan, Queensland; locality 956 GSQ in the Pond Formation, Gelobera Range, Mount Morgan; locality K91 GSQ in the uppermost part of the Crana Beds west-north-west of Dakiel, Queensland; locality 244 GSQ from Mount St. Michael in the Star Basin, Queensland; and in locality L1312 UNE in the Luton Formation near Bingara, New South Wales. Tournaisian *Tulcumbella tenuistriata* Zone, and possibly equivalents of the *Spirifer sol* Zone.

Material. F57041–F57042 AM. F10217a and b, F10219a and b, F10220, F10223, F10226a, F10235, F12147 GSQ. F15154, F67154 UQ.

Genus SPINORUGIFERA NOV.

Type species. *Spinorugifera chichesterensis* gen. et sp. nov. from locality 106–1, in the Flagstaff Sandstone, Upper Chichester, New South Wales.

Diagnosis. Shell gently to moderately biconvex, having an evenly curved lateral

profile and lacking a well-defined trail; pedicle valve with a short tapering umbo, well-differentiated ears, a small number of posteriorly projecting spines near the hinge, and a triangular muscle field; ventral surface rugose to partly lamellose, the rugae bearing concentric rows of widely spaced erect to suberect spines; brachial valve rugose, usually aspinose and with flat postero-lateral extremities; cardinal process bilobate, supported by short divergent lateral ridges, and bordered anteriorly by an alveolus and a brevisseptum; dorsal adductor muscle scars smooth and in two pairs, an elevated inner pair and a slightly impressed outer pair; brachial ridges narrow and hook-shaped.

Remarks. *Spinorugifera* gen. nov. is similar in many respects to the early Carboniferous genus *Rugauris* Muir-Wood and Cooper (1960), having a rugose ornament which bears concentric rows of spines, and a row of spines on the posterior of the pedicle valve. *Rugauris* is distinguished from *Spinorugifera* by the possession of a geniculate brachial valve, a trilobed cardinal process which is supported anteriorly by the thickened base of the median septum, dendritic dorsal adductor muscle scars, and in the detailed configuration of the external ornament: on the pedicle valve spines are prostrate rather than erect, and they are rare on the visceral disc; and on the brachial valve rugae are narrower and more numerous than those on the pedicle valve, and are replaced by growth lines on the trail.

The Russian genus *Jakutoproductus* Kaschirtsev, 1959 (Abramov 1970, pl. 7, figs. 1-10) also has a spine-bearing rugose ornament, but is distinguished from *Spinorugifera* by the possession of larger spine bases, a narrow but prominent ventral median sinus and corresponding dorsal fold, different musculature in both valves, a dorsal marginal rim in the brachial valve, and brachial ridges which appear to originate nearly horizontally from the dorsal adductor muscle scars.

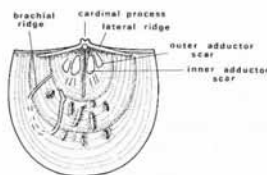
Spinorugifera chichesterensis gen. et sp. nov.

Plate 7, figs. 1-18

1975 Productoid n. gen., Roberts, Table 1.

Diagnosis. Pedicle valve rounded-rectangular to subquadrate in outline, with a low umbo, well-defined umbonal shoulders, and four long curving spines near the hinge; brachial valve moderately to strongly concave, with a brevisseptum which extends one-third the length of the valve, and short divergent lateral ridges.

Description. External. Pedicle valve gently to moderately convex, evenly convex in profile and without a well-defined trail; valve constricted immediately in front of the hinge, the greatest width being either at the hinge or at the mid-length; umbo narrow, and extending a short distance behind the hinge line; postero-lateral margins flat to slightly convex, and slightly auriculate; surface of valve with irregular partly lamellose rugae bearing scattered spines, and concentric growth lines; spines on the body of the valve situated mainly on the rugae, arranged in a roughly concentric pattern, widely spaced, erect to suberect, and having slightly elongate bases with diameters of up to approximately 0.2 mm; two long spines on either side of the umbo are slightly larger in diameter than the body spines, and originate normal to the hinge. Brachial valve with an evenly concave visceral disc and broad flat to concave postero-lateral extremities; valve strongly rugose and to a lesser extent lamellose, the rugae extending irregularly across the venter, but being more pronounced and regular on the postero-lateral margins; most specimens aspinose, but one small individual bearing minute suberect spinules arranged in irregular concentric rows; specimens ranging in size up to 17 mm wide and 14 mm long.



TEXT-FIG. 17. Dorsal interior of *Spinorugifera chichesterensis* gen. et sp. nov. drawn from F57027 AM, a paratype. Approximately $\times 2.5$.

Internal. Pedicle valve. Muscle field triangular in outline, but not clearly differentiated into adductor and diductor muscle scars; spine bases opening into the interior of the valve. Brachial valve (text-fig. 17). Cardinal process bilobate, each of the lobes being subdivided by a deep sulcus; median septum narrow, low, and arising from in front of an alveolus; adductor muscle scars smooth; inner adductor muscle scars forming low subovate platforms, and outer adductor muscle scars slightly impressed, tapered posteriorly and expanding anteriorly; brachial ridges arising at a high angle (approximately 40°) from the front of the outer adductor scars, and having high distal extremities in front of the inner adductor scars; internal surface bearing fine radially arranged endospines.

Remarks. *S. chichesterensis* gen. et sp. nov. is the only known species of the genus. A morphologically similar form referred to *Rugauris? brookeri* sp. nov. from the Woolooma Formation at Malumla in the Rouchel district of New South Wales is compared with this species on p. 57.

Occurrence. Locality 106-16, the type locality, in the Flagstaff Sandstone, Upper Chichester, New South Wales. Viséan *Inflatia elegans* Subzone.

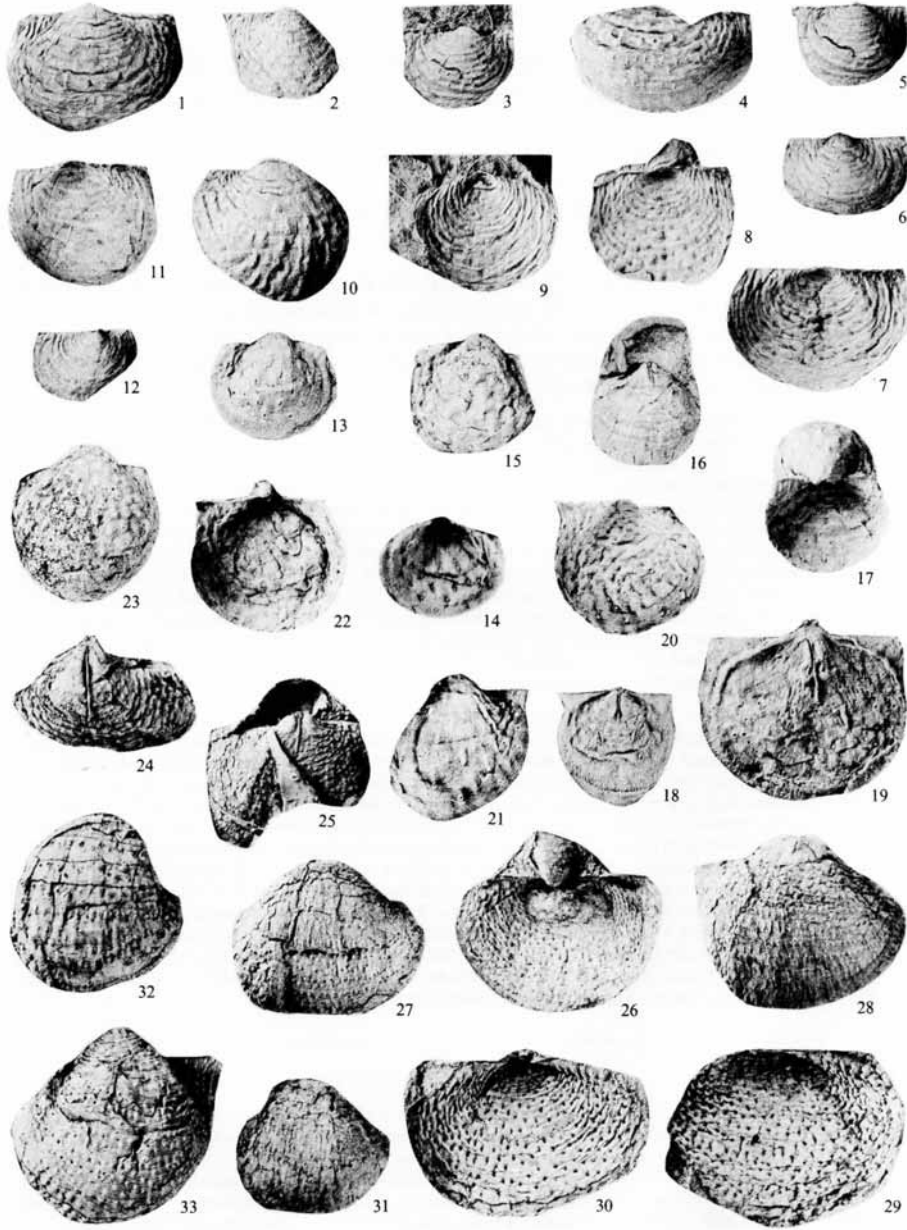
Material. F57019-F57030 AM. Holotype F57025a-c; paratypes F57026, F57027.

EXPLANATION OF PLATE 9

Figs. 1-12. *Rugauris? brookeri* sp. nov. 1-2, internal moulds of two pedicle valves. F57049, the holotype, and F57050, $\times 1.5$. 3-4, rubber casts of the exterior of two pedicle valves. F57051a, a paratype, and F57052, $\times 1.5$. 5, internal mould of F57051b, the counterpart of fig. 3, $\times 1.5$. 6, rubber cast of a pedicle valve exterior. F57051c, $\times 1.5$. 7-9, rubber casts of three brachial valve exteriors. F57053, a paratype, F57054, and F57055 a paratype, $\times 1.5$. The spines on fig. 9 come from the pedicle valve. 10, internal mould of a distorted pedicle valve. F57056, $\times 1.5$. 11, rubber cast of a pedicle valve interior. F57057, $\times 1.5$. Note the tubules on the interior of the valve. 12, rubber cast of a brachial valve interior. F57058, $\times 1.5$. Figs. 1-12 from locality 29-1.

Figs. 13-23. *Scoloconcha geniculata* sp. nov. 13-14, rubber casts of the exterior and interior of a pedicle valve. Note the spine apertures on the interior of the valve. F57059, $\times 3$. 15, rubber cast of a pedicle valve exterior. F57060, $\times 3$. 16-17, rubber casts of a specimen showing the apical parts of the pedicle valve and the brachial valve interior and exterior. F57061a and b, $\times 3$. 18, rubber cast of a brachial valve interior. F57062, $\times 3$. Figs. 13-18 from locality 85-10. 19, rubber cast of a brachial valve interior. F57063, the holotype. 20, rubber cast of a brachial valve exterior. F57064, a paratype, $\times 3$. Figs. 19-20 from locality 17-8. 21, rubber cast of a pedicle valve exterior from locality 16-3. F57065, $\times 3$. 22, rubber cast of a brachial valve exterior from locality 17-7. F57066, $\times 3$. 23, rubber cast of a pedicle valve exterior from locality 74-7A. F57067, $\times 3$.

Figs. 24-33. *Krotovia prociidua* sp. nov. 24, rubber cast of a distorted brachial valve interior. F57068, a paratype, $\times 1.5$. 25-26, rubber casts of the dorsal interior and exterior of the holotype. F57069, $\times 1$. 27, internal mould showing the apical portion of the pedicle valve and the anterior of the brachial valve. F57070, $\times 1$. 28, distorted internal mould of the pedicle valve. F57071, $\times 1$. 29-30, rubber casts of the exterior of two brachial valves. F57072a and F57073, $\times 1.5$. 31, rubber cast of the exterior of a pedicle valve. F57072b, a paratype, $\times 1$. Figs. 24-31 from locality 92-1. 32, rubber cast of a pedicle valve exterior showing slightly more erect spines. F57074, $\times 1.5$. 33, internal mould of a pedicle valve. F57075, $\times 1.5$. Figs. 32 and 33 from locality L145 UNE.



ROBERTS, Australian productaceans

Genus *STEGACANTHIA* Muir-Wood and Cooper, 1960

Type species. *Stegacanthia bowsheri* Muir-Wood and Cooper, 1960 from the Lake Valley Formation, New Mexico.

Diagnosis. See Muir-Wood and Cooper (1960, p. 198).

Stegacanthia leviatha sp. nov.

Plate 10, figs. 1-8

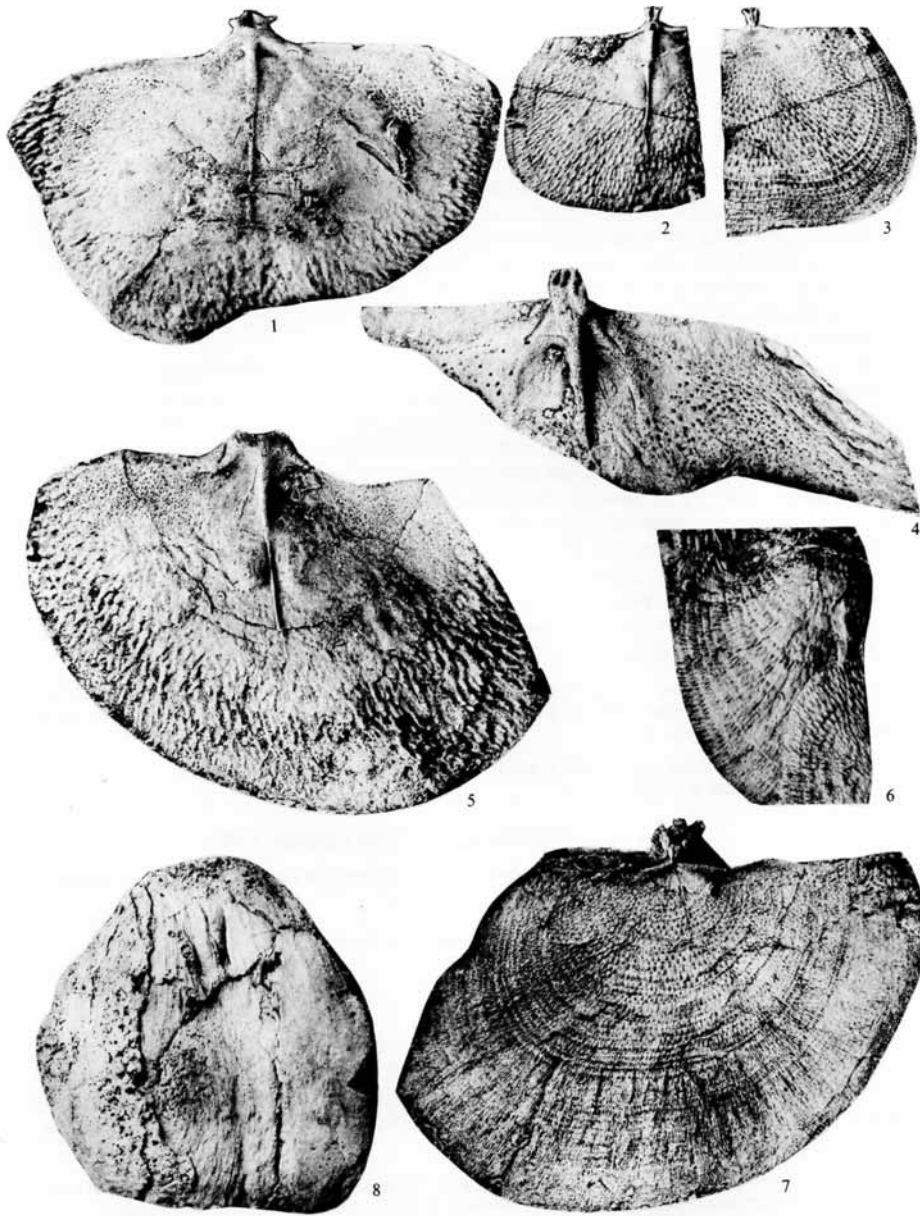
Diagnosis. Shell extremely large, semi-ovate in outline, and with a finely spinose external ornament; pedicle valve having a narrow median sinus; brachial valve with a low median fold and a short trail; lateral ridges thickened at the cardinal process; median septum extending two-thirds the length of the valve; front of visceral disc and trail bearing coarse endospines.

Description. External. Pedicle valve strongly convex posteriorly, having a swollen umbo, steep umbonal shoulders, and convex ears; median sinus commencing on the umbo and forming a narrow furrow along the length of the valve; concentric lamellae usually bearing single rows of prostrate spines, but on some, spine bases emerging from the posterior of a lamella alternating with bases arising from near the front of the lamella; spines near the hinge erect and divergent; approximately fifteen spine bases present along 10 mm of a lamella near the anterior margin. Brachial valve. Large specimens having a short rim-like trail produced by a small anterior geniculation; fold narrow, commencing in front of a small umbonal concavity, and extending on to the trail; concentric ornament of low rugae on posteromedian parts of the valve, but elsewhere lamellose; concentric lamellae crowded on the trail, more widely spaced on the visceral disc, ornamented by closely spaced growth lines, and bearing single rows of long prostrate spines; spines much denser on the trail than on the visceral disc with up to 40 spines per 10 mm on the trail of a large specimen compared with 12-15 per 10 mm at 20 mm from the umbo; small erect spines forming one or possibly two rows near the hinge; specimens ranging in size up to 86 mm wide and 64 mm long.

Internal. Pedicle valve. Diductor muscle scars elongate, pointed posteriorly, rounded anteriorly, and situated on high platforms separated by a low median ridge; adductor muscle scars large, flabellate, strongly striated, and impressed into the shell. Brachial valve. Adductor muscle scars obscurely subdivided into a dendritic posterior pair and smooth anterior pair; posterior scars subround to elongate, impressed, in large specimens diverging laterally from buttresses in front of the cardinal process and flanking the anterior scars; anterior muscle scars trigonal to subround, usually forming elevated platforms, but occasionally lower and nearly level with the floor of the valve; median septum buttressing the base of the cardinal process, wide rounded and high posteriorly, and narrow near the front of the muscle field; cardinal process with two elongate internal lobes separated by a deep furrow; posterior face of process with a wedge-shaped median ridge at the junction between the two deeply concave lobes; lateral ridges straight and parallel with the hinge in small specimens, but in large individuals laterally diverging from the hinge; brachial ridges originating horizontally from the front of the muscle field; brachial discs large, smooth, and subround; fine pits present on thickened areas of the shell on the postero-lateral margins of the muscle field of large specimens; the remainder of the visceral disc and the trail bearing prostrate endospines.

EXPLANATION OF PLATE 10

Figs. 1-8. *Stegacanthia leviatha* sp. nov. 1, rubber cast of a brachial valve interior. F10461b GSQ, holotype, $\times 1$. 2-3, rubber casts of the interior and exterior of a brachial valve. F10464b GSQ and F10464a GSQ, $\times 1$. 4, rubber cast of the apical portion of a brachial valve. F12148 GSQ, $\times 1$. 5, rubber cast of a brachial valve interior. F10462b GSQ, paratype, $\times 1$. 6, rubber cast of the exterior of a pedicle valve. F10465 GSQ, paratype, $\times 1$. 7, rubber cast of a brachial valve exterior. F10462a GSQ, paratype, $\times 1$. Figs. 1-7 from locality L988 GSQ. 8, internal mould of a pedicle valve. F30198 UQ from locality L2187 UQ, $\times 1$.



ROBERTS, Australian productaceans

Remarks. Specimens of *Stegacanthia larga* (Cvancara) (1958, pp. 864–865, pl. 110, figs. 14–19) from Barrington, New South Wales, are morphologically comparable to some of the smaller specimens of *S. leviatha*: features which are close include the finely spinose external ornament, the fold and sinus, the cardinal process, lateral ridges, median septum, and the outline of the dorsal muscle field. When compared with *S. larga*, *S. leviatha* is much larger, more transverse, and has a short dorsal anterior geniculation. In the interior of the brachial valve the muscle field is larger but not entirely set on high platforms as in *S. larga*, the lateral ridges are divergent from the hinge line, and there are very coarse endospines around the front of the visceral disc and on the trail. In Queensland *S. larga* is present in the Baywulla Formation at locality K63 GSQ near Monto, and in the Lion Creek Limestone near the Stanwell–Dalma road.

S. strigis Roberts (1971, pp. 118–120, pl. 27, figs. 1–9) from the Utting Calcarenite and Burvill Beds of the Bonaparte Gulf Basin resembles *S. leviatha* in size and in the possession of a fold and sinus. *S. strigis* is distinguished by the possession of a coarser spinose ornament, a more dorsally recurved cardinal process, slightly more divergent lateral ridges, and a shorter dorsal median septum; large individuals of *S. strigis* lack the massive thickening around the dorsal muscle field and cardinal process, but this may be of ontogenetic rather than of specific significance. *S. sibirica sibirica* (Sarycheva) from the late Tournaisian and early Viséan of the Kuznetsk Basin, Siberia (Sarycheva *et al.* 1963, pl. 18, figs. 1–3), is smaller, and has a weaker median sinus. The internal morphology of the Russian subspecies has not been illustrated, but a closely related form *S. s. artyshtensis* (Sarycheva) figured by Sarycheva *et al.* (1963, pl. 17, fig. 4, and fig. 59) has a dorsally recurved cardinal process.

Occurrence. Locality 988 GSQ, the type locality (equals L2187 UQ), in the Baywulla Formation at 43169275, Major Mitchell Creek, Monto 1:100000 Sheet, Kalpowar, Queensland. Late Viséan to Early Namurian *Marginirugus barringtonensis* Zone.

Material. F10461b, F10462a and b, F10464a and b, F10465, F12148 GSQ. F30198 UQ. Holotype F10461b; paratypes F10462a and b, F10465.

Genus RUGAURIS Muir-Wood and Cooper, 1960

Type species. *Rugauris paucispina* Muir-Wood and Cooper, 1960 from the Lower Kinderhook oolitic limestone, Iowa.

Rugauris? brookeri sp. nov.

Plate 9, figs. 1–12

1975 *Rugauris* sp., Roberts, Table 1.

Diagnosis. Pedicle valve subrectangular to subquadrate in outline, and having small ears; hinge slightly less than the greatest width of the valve; spines near the hinge medianly coiled; ten rugae on the exterior of mature individuals; brachial valve aspinose; rugae branching on the umbonal shoulders and up to eighteen in number on the visceral disc.

Description. External. Shell of average size for the genus, moderately concavo-convex, widest at the mid-length; individuals ranging in size up to 20 mm wide and 16 mm long. Pedicle valve with an evenly rounded venter, highest at about one-third the length of the valve, and with flat ears; umbo low, tapered, and weakly

incurred; rugae strongest on the umbonal shoulders, extending across the venter, and up to ten in number on large individuals; spine ridges originating on or between the rugae, arranged in concentric rows, and subtending prostrate spines; spine ridges short on the posterior and median parts of the valve, but longer anteriorly; a single row of about twelve erect spines originating from larger spine bases near the hinge, and curving behind the umbo; a group of larger suberect spines also present on the postero-lateral extremities. Brachial valve with flat auriculate postero-lateral extremities; in large individuals a slight anterior geniculation produces a short trail; exterior of valve bearing depressions between the rugae in positions corresponding to the spine ridges on the pedicle valve; rugae strongest on the postero-lateral margins, continuous across the visceral disc, slightly irregular, and becoming bunched on the trail; from ten to twelve rugae present along the hinge of large individuals, but branching on the umbonal shoulders and increasing in number to eighteen on the visceral disc.

Internal. Pedicle valve. Adductor muscle scars subtriangular to subovate in outline, and separated by a faint median ridge; diductor muscle scars not observed; internal surface bearing impressions of the external rugae, and very fine endospines; posterior half of the visceral disc bearing elongate radially oriented hollow tubules connected with the external spines; other spines having subcircular openings into the interior of the valve. Interior of brachial valve unknown.

Remarks. The present material is tentatively referred to *Rugauris* because of similarities in shape and external ornament. The features of the brachial valve interior, which are particularly distinctive in *Rugauris*, are unknown and it is possible that this form belongs to another genus. When compared with *R.?* *brookeri* sp. nov., *R. paucispina* Muir-Wood and Cooper (1960), the type species, has larger ears, a relatively wider hinge, a more abrupt geniculation at the front of the brachial valve, and a spinose dorsal exterior.

Spinorugifera chichesterensis gen. et sp. nov. from the Flagstaff Sandstone at Upper Chichester, New South Wales, is a spiny rugose productacean with features similar to those of *R.?* *brookeri* sp. nov. It is difficult to make a complete comparison between the two forms because the brachial valve interior of *R.?* *brookeri* is unknown, but it is clear that they belong to different species and genera: *S. chichesterensis* is characterized by the possession of a broader and higher ventral umbo, steeper umbonal shoulders, and the absence of an anterior geniculation on the brachial valve; externally, the spines are erect rather than prostrate, and arise from bases which are larger in diameter but shorter than the spine ridges of *R.?* *brookeri*, and there is a greater number of rugae, some of which are lamellose.

Occurrence. Locality 29-1 (the type locality) in the Woolooma Formation at Malumla, Rouchel district, New South Wales. Viséan *Orthotetes australis* Zone.

Material. F57049-F57058 AM. Holotype F57049; paratypes F57051a, F57053, F57055.

Family MARGINIFERIDAE Stehli, 1954
 Subfamily MARGINIFERINAE Stehli, 1954
 Genus EOMARGINIFERA Muir-Wood, 1930

Type species. *Productus longispinus* J. Sowerby, 1814.

Remarks. Brunton (1966) amended the concept of *Eomarginifera* by the recognition of a subgenus, *Eomarginiferina*, which is distinguished by its globose profile, three symmetrically arranged spines on the body of the pedicle valve, and the absence of hinge spines; an anterior fold is present on many specimens. The present material resembles the type species of *Eomarginiferina*, *E. trispina* Brunton, in having a similar

profile and pronounced ears, but it is distinguished by the possession of a greater number of body spines and spines near the hinge on the pedicle valve, and the absence of a ventral anterior fold.

Eomarginifera (Eomarginifera) megalotis sp. nov.

Plate 11, figs. 13-26

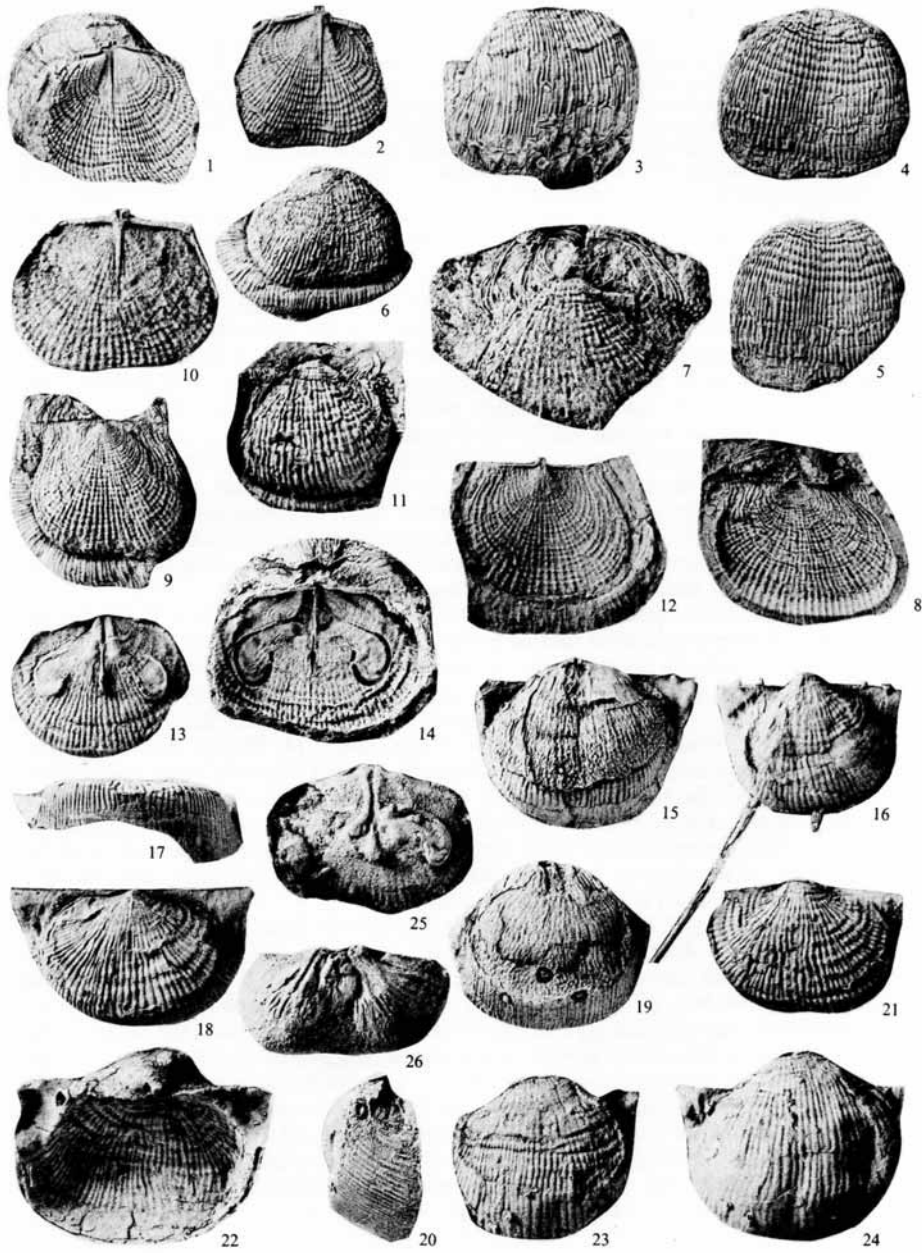
- 1960 *Dictyoclostus paradoxus* Campbell; Maxwell, pp. 4-5, pl. 1, figs. 8-12.
 1964 *Eomarginifera paradoxa* (Campbell); Hill and Woods, pl. 6, figs. 22-27.
 1975 *Eomarginifera* sp., Roberts, Table 1.

Diagnosis. Shell with prominent well-differentiated auricles and a narrow ventral umbo; costellae having a density of 10-12 per 5 mm at 10 mm from the umbo; brachial valve with a sharp anterior geniculation; marginal ridge extending across the ears to the mid-part of the lateral margins; median septum narrow, commencing well in front of the cardinal process and extending to the mid-point of the valve.

Description. External. Shell slightly smaller than average for the genus, semicircular in outline, and widest at the hinge; specimens ranging in size to 19.5 mm wide and 15.5 mm long. Pedicle valve with well-differentiated flat auricles; umbo small and gently incurved; costellae increasing by bifurcation and intercalation, and frequently bearing small spine bases behind points of bifurcation; costellae on the trail more regular than those on the visceral disc; rugae low, crossing the visceral disc, producing a faintly reticulate ornament, and numbering thirteen or fourteen on a large individual; five large halteroid spines, more than 20 mm long, extending in a row around the lateral slopes and the trail; two smaller erect spines along the hinge on each of the postero-lateral extremities, and smaller probably low-angle spines arising from costae on the visceral disc. Brachial valve. Visceral disc flat to gently convex; ears separated by a strong ridge from nearly vertical lateral slopes; anterior margin of valve geniculate and produced into a curved trail; rugae extending across the visceral disc but absent from the ears and trail.

EXPLANATION OF PLATE 11

- Figs. 1-12. *Margincinctus reticulatus* sp. nov. 1-3, a mould and rubber cast of the dorsal interior, and a rubber cast of the ventral exterior of the holotype. F57076a and b, $\times 1$. 4-5, internal mould and rubber cast of the exterior of a pedicle valve. F57077, $\times 1$. Figs. 1-5 from locality 88-3. 6, rubber cast of a pedicle valve exterior showing the prominent cincture and flange. F57078, $\times 1$. 7, coiled spines at the apex of a pedicle valve. F57079, $\times 2$. 8, rubber cast of a brachial valve exterior and coiled spines from the pedicle valve. Note the prominent flange. F57080, $\times 1$. 9, external mould of a brachial valve showing a partly preserved flange. F57081, $\times 1$. Figs. 6-9 from locality L466 U Newcastle. 10, rubber cast of a brachial valve interior from locality 85-8. F57082, $\times 1.5$. 11, rubber cast of a pedicle valve exterior from locality L577 U Newcastle. F57083, $\times 1.5$. 12, rubber cast of a brachial valve interior from locality 89-1. F57113, $\times 1.5$.
- Figs. 13-26. *Eomarginifera megalotis* sp. nov. 13, rubber cast of a brachial valve interior. F57084, $\times 2$. 14, mould of a dorsal interior. F57085, the holotype, $\times 2$. 15, internal mould of a pedicle valve. F57086, paratype, $\times 2$. 16, rubber cast of a pedicle valve exterior showing the configuration of spines. F57087, paratype, $\times 2$. 17-18, anterior and dorsal views of an external mould of the brachial valve showing the sharply geniculate trail and large ears. F57088, a paratype, $\times 2$. 19-20, ventral and lateral views of an internal mould of the pedicle valve. Note the large spine bases. F57089, $\times 2$. 21-22, rubber casts of the exteriors of a pedicle and a brachial valve. F57090 and F57091, both paratypes, $\times 2$. 23-24, rubber casts of two pedicle valve exteriors. F57092, and F57093 a paratype, $\times 2$. Figs. 13-24 from locality 92-1. 25-26, rubber cast of the dorsal interior, and internal mould of the ventral interior of a specimen from locality K31 GSQ. The strength of the muscle scars and brachial ridges suggest the specimen is gerontic. F10453a GSQ.



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Internal. Pedicle valve. Adductor muscle scars narrow, rectangular, situated on high muscle platforms, and separated by a narrow median ridge; diductor muscle scars large, flabellate, and bearing longitudinal grooves and ridges; internal surface bearing small pustulose endospines, and openings of the large halteroid spines; ears separated from the visceral region by ridge-like swellings. Brachial valve. Cardinal process bilobed internally, and bordered anteriorly by two elongate ridges, possibly muscle tracks, on either side of a median furrow; posterior face of process not observed; inner adductor muscle scars smooth, subround to subquadrate, and located on platforms immediately in front of the elongate ridges; outer adductor muscle scars weakly dendritic, slightly impressed, and subround in outline; median septum slender, and arising from the trough between the anterior adductor scars; brachial ridges originating at a low angle from the front of the outer adductor muscle scars, and having discontinuous distal terminations; endospines small and situated on radial ribs.

Remarks. A number of specimens from locality K31 in the Dakiel Formation, Queensland, have strongly sculptured internal features and appear to be gerontic individuals; these are exemplified by the specimen illustrated in Plate 11, figs. 25–26. In the pedicle valve the adductor muscle scars are deeply impressed and strongly dendritic posteriorly, and form a high platform anteriorly. The diductor muscle scars are flabellate, smooth and pointed posteriorly, and wide and longitudinally ribbed anteriorly. The dorsal adductor muscle field is located well in front of the cardinal process, the inner adductor muscle scars being located at the anterior of ridge-like muscle tracks. The median septum is short, commences at approximately one-third the length of the valve between the inner adductor scars, and rises to a short high spine-like septum. Brachial ridges originate at low angles from the outer adductor muscle scars and enclose elevated ovoid brachial discs.

E. paradoxa (Campbell) (Campbell 1957, pp. 60–62, pl. 13, figs. 9–17) has an external ornament similar to that of *E. megalotis*. It is distinguished from *megalotis* by the possession of a shorter hinge, smaller ears, and a wider ventral umbo. Internally, the median septum forms a broad rounded ridge immediately in front of the cardinal process, the septum has a knob-like termination, and the brachial ridges are weaker. *E. tenuimontis* Roberts (1965*b*, pp. 61–63, pl. 10, figs. 6–10) is larger, has smaller ears, coarser costellae, fewer rugae, a small fold and sinus, and a more concave dorsal visceral disc. Internally *tenuimontis* is distinguished from *megalotis* by its coarsely striated diductor muscle scars in the pedicle valve, stronger median septum which forms a broad ridge near the front of the cardinal process, and the possession of an anterior knob on the median septum, and larger and strongly dendritic outer dorsal adductor muscle scars.

The type species, *E. longispina* (Sowerby), described by Muir-Wood (1928, pp. 156–163, pl. 11, figs. 1–4) from the Viséan and early Namurian of Great Britain, has finer costae, and fewer and weaker rugae over the visceral disc. *E. frechi* Paeckelmann (1931, pp. 339–341, pl. 41, figs. 7–10) appears to be morphologically close to *E. megalotis*, having wide ears which are well differentiated from the body of the shell, a comparable lateral profile, and a similar density of costellae. The internal features of *E. frechi* are undescribed. *E. frechi* is recorded from the Oberen Kohlenkalk at Altwasser and Hansdorf, Germany. *E. kaschirica* Ivanov, from the C₂ of the Moscow Basin, illustrated by Sarycheva and Sokolskaya (1952, pl. 45, fig. 235), resembles *E. megalotis* in the shape of the pedicle valve; the valve has a similar outline and convexity, well-defined auricles, and a comparable costellate ornament. Other details of *E. kaschirica* are not illustrated.

Occurrence. Localities 92-1, the type locality, 90-5, 90-6, and possibly 103-3 in an unnamed formation at Salisbury, New South Wales. In Queensland the species is identified at locality K31 GSQ, Dakiel Formation, locality L1920 UQ, Baywulla Station; and from a locality 5.5 km south-east of Bancroft. Late Viséan *Rhipidomella fortimuscula* Zone.

Material. F57084-F57093 AM, F10453a GSQ. Holotype F57085; paratypes F57086-F57088, F57090, F57091, F57093.

Subfamily COSTISPINIFERINAE Muir-Wood and Cooper, 1960
Genus INFLATIA Muir-Wood and Cooper, 1960

Type species. *Productus inflatus* McChesney, 1860.

Inflatia engeli sp. nov.

Plate 12, figs. 11-28

1964 *Antiquatonia* sp., Hill and Woods, pl. 7, figs. 18-21.

1967 *Inflatia(?) elegans* Roberts; McKellar, p. 13.

1975 *Inflatia* sp., Roberts, Table 1.

Diagnosis. Shell widest medially, having small auricles, and with a reticulate ornament on the visceral disc; costae having a density of 16-18 per 10 mm at 10 mm from the umbo; pedicle valve with irregularly developed spines on the flanks and on the trail, and lacking a median sinus; ventral adductor muscle scars in two pairs, a narrow elongate inner pair situated on platforms, and an impressed lachrymose outer pair; posterior of dorsal median septum grooved by an antron.

Description. External. Ventral umbo low, and extending only a short distance behind the hinge; ornament reticulate on the visceral disc, but regularly costate on the flanks and trail; costae increasing by bifurcation, and on the trail occasionally unifying behind spine bases; density of costae 16-18 per 10 mm at 10 mm from the umbo, and 10-12 per 10 mm on the front of the trail of large individuals; rugae extending from the hinge line across the entire visceral disc, and numbering up to 14; large spines irregularly developed on the flanks and on the trail; some specimens with one large spine base on each of the postero-lateral margins, and one or two spines on the trail; others with a concentric row of up to 6 spines on the trail. Brachial valve with a strongly incurved elongate trail; specimens from the type locality range in size up to 34 mm wide and 32 mm long.

Internal. Pedicle valve. Apex of valve filled with callus and bearing a strong median ridge at the posterior extremity of the adductor muscle field; inner adductor scars narrow, elongate, elevated on a muscle platform, and separated by a median furrow; outer adductor scars impressed, lachrymose in outline, and bearing longitudinal furrows; diductor muscle scars weakly impressed anteriorly, large, flabellate, either smooth or concentrically striated posteriorly, and radially striated anteriorly; internal surface finely spinose; ginglymus narrow. Brachial valve. Ginglymus pronounced, and modified by thickening around the lateral ridges on the flanks of the cardinal process; cardinal process bilobed, the posterior face having medianly fused lobes forming a slender wedge-shaped median projection between deep furrows; inner face with rounded tubercular lobes separated by a furrow extending posteriorly on to the median projection; tubercle-like lobes absent in juveniles; lateral ridges extending to the middle of the hinge; median septum extremely broad posteriorly, grooved by an antron, tapering abruptly at the adductor muscle field, and extending slightly beyond the mid-length; inner adductor muscle scars elevated, elongate, rounded at either end and irregularly sculptured; outer adductor scars subround in outline and strongly dendritic; brachial ridges extending at a high angle (30°) from the antero-lateral margins of the outer adductor scars to beyond the end of the median septum, weak proximally, but much higher and discontinuous distally; brachial discs mainly smooth, grooved posteriorly, highest anteriorly, and club-shaped; internal surface of valve pitted and spinose; small and presumably juvenile specimens lacking lateral ridges, and having a deep circular alveolus at the front of the cardinal process; median septum low, narrow elongate, and commencing in front of the cardinal process; muscle field obscure.

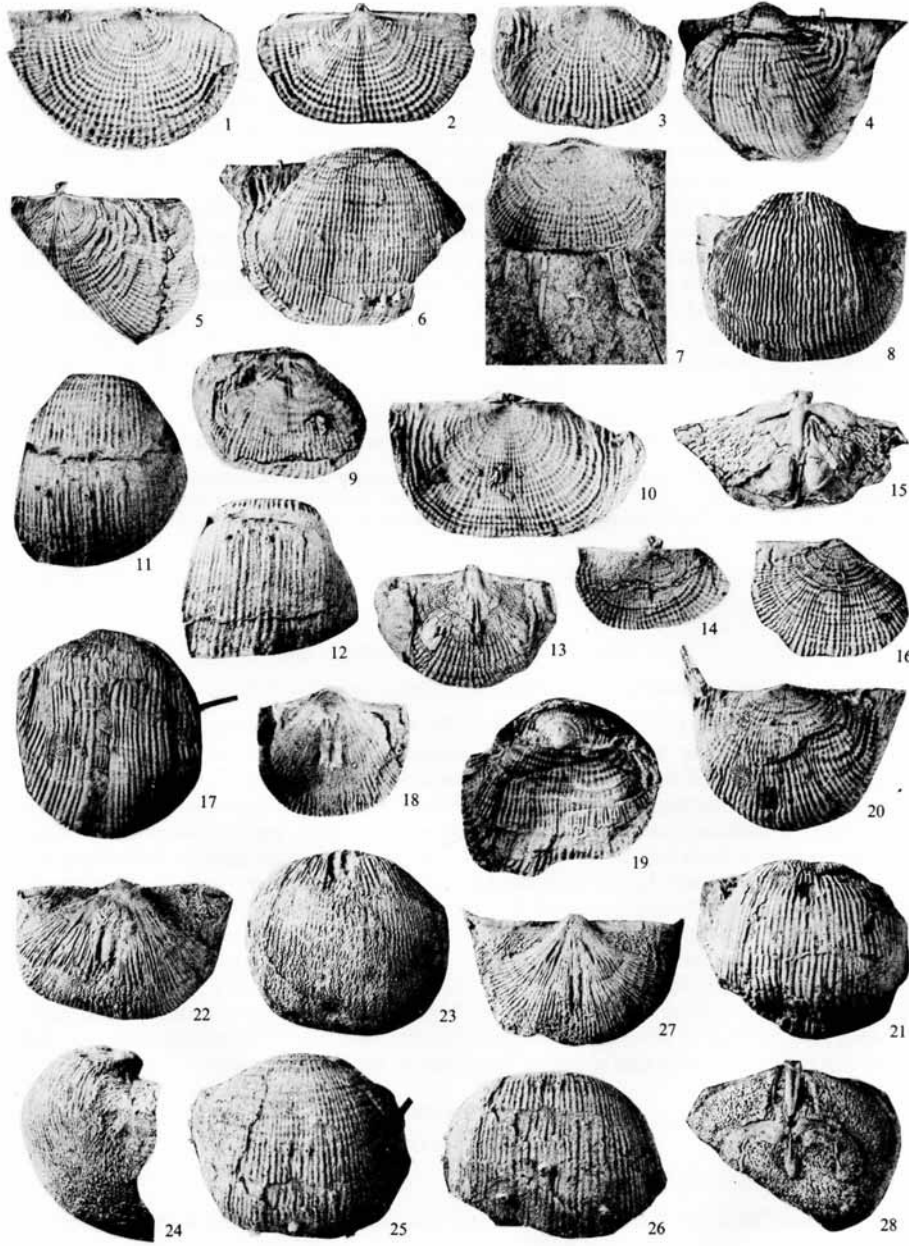
Remarks. Specimens from locality K31 in the Dakiel Formation on the western limb of the Yarrol Syncline, Queensland, are identified as *Inflatia engeli* sp. nov.; McKellar (1967) previously referred this form to *I.(?) elegans* Roberts. The Queensland specimens (Pl. 12, figs. 22–28) are slightly larger than those from Barrington, but have the same density of costae and rugae, and an irregular distribution of spines on the pedicle valve. A single large brachial valve from locality K31 has a number of features differing from those of the Barrington specimens; the adductor muscle field is larger and impressed into a substantially thickened shell; the grooved posterior shaft of the median septum is longer and extends nearly to the front of the muscle field, and the blade-like anterior portion has a swollen distal extremity; two depressions which resemble muscle scars are located immediately behind the tip of the septum and are impressed into elevated antero-median parts of the brachial apparatus; the brachial ridges originate from the front of the muscle field and initially curve posteriorly before enclosing club-shaped brachial discs; median portions of the brachial markings, as well as the brachial discs themselves form smooth elevated platforms; the unusual angle of origin of the brachial ridges from the front of the muscle field appears to have been caused by the forward movement of the adductor muscle field; the posterior margin of the valve has ridge-like thickening of either side of the cardinal process, and the valve has a marginal groove around the postero-lateral shoulders. In the pedicle valve the Queensland forms are thickened apically, have a wide well-defined ginglymus, and lack a median ridge behind the adductor muscle field; differentiation of the adductor muscle scars into two pairs is not as apparent as in the specimens from Barrington.

I. elegans Roberts (1964a, pp. 202–204, pl. 2, figs. 1–18), from the lower part of the *Delepinea aspinosa* Zone, has an over-all appearance close to that of this species.

EXPLANATION OF PLATE 12

Figs. 1–10. *Marginatia patersonensis* Roberts. 1–2, rubber casts of the ventral exterior and interior. F57094a and b, locality L361 U Newcastle, $\times 1.5$. 3, rubber cast of a brachial valve exterior, F57095, locality 74–7A, $\times 1$. 4, rubber cast of a pedicle valve exterior. F57096, locality L361 U Newcastle, $\times 1$. 5, rubber cast of a brachial valve interior. F57097, locality 29–6, $\times 1$. 6, rubber cast of a pedicle valve exterior. F57098, locality L361 U Newcastle, $\times 1$. 7, rubber cast showing a dorsal view of F57099a from locality 72–18. The spines arise from the pedicle valve, $\times 1$. 8, internal mould of a pedicle valve. F57100, locality L361 U Newcastle, $\times 1$. 9, rubber cast of a brachial valve interior showing brachial markings. F57101, locality 17–9, $\times 1$. 10, rubber cast of a brachial valve exterior. F57102 from locality L361 U Newcastle, $\times 1$.

Figs. 11–28. *Inflatia engeli* sp. nov. 11–12, ventral and anterior views of a rubber cast. F57103, a paratype, $\times 1$. 13, rubber cast of a brachial valve interior, F57104, a holotype, $\times 1$. 14, rubber cast of the apical portion of the brachial valve exterior. F57105, a paratype, $\times 1$. 15, rubber cast of the apical portion of a brachial valve. F57106, $\times 2$. 16, rubber cast of an 'immature' brachial valve interior. F57107, $\times 1$. 17, rubber cast of the trail of a pedicle valve. F57108, $\times 1$. 18, rubber cast of the apical portion of a pedicle valve. F57109, a paratype, $\times 1$. 19, dorsal view of a rubber cast of F57110, a paratype, $\times 1$. 20–21, dorsal and anterior views of the external mould of a brachial valve. F57111, a paratype, $\times 1$. Figs. 11–21 from locality L442 U Newcastle. 22–24, posterior, ventral, and lateral views of an internal mould of the pedicle valve. F8631a GSQ, $\times 1$. 25–26, ventral and anterior views of a rubber cast of a pedicle valve. F8631b GSQ, $\times 1$. 27, apical portion of an internal mould of a pedicle valve. Note the ginglymus. F12071, $\times 1$. 28, rubber cast of a 'gerontic' brachial valve interior. F8630 GSQ, $\times 1$. Figs. 22–28 from locality K31 GSQ.



ROBERTS, Australian productaceans

I. elegans is differentiated from *I. engeli* by possession of spines on either side of the hinge, finer costae, fewer rugae, a single pair of platform-like ventral adductor muscle scars, and brachial ridges which consistently originate horizontally from the muscle field; the internal surfaces of both valves bear weaker ribbing than those of *I. engeli*. *I. inflatia* (McChesney), the type species, differs from this species in being slightly narrower and more elongate, and in having a median fold and sinus, a wider hinge line with a row of spines on either side of the umbo, brachial ridges which originate nearly horizontally from the muscle field, and a coarsely spinose trail on the interior of the brachial valve; the posterior part of the dorsal median septum is smooth rather than grooved. *I. inflatia* is from the Chester Series of U.S.A., and has been figured by Muir-Wood and Cooper (1960, pl. 55, figs. 1-14). Two species of *Inflatia* have been described from central Kazakstan by Litvinovich (1969), but neither are morphologically close to *I. engeli*: *I. patria* Litvinovich from rocks of Viséan age (Litvinovich *et al.* 1969, pl. 52, figs. 1-3) is more elongate and possesses a ventral median sinus; and the Namurian species *I. uschkarensis* Litvinovich (*ibid.*, pl. 53, figs. 1-3) is larger, wider at the ears, and has a ventral median sinus.

Occurrence. L442 U Newcastle, the type locality, in the Copeland Road Formation at Barrington, New South Wales; locality 114-1 in the Wootton Beds at Rawdon Vale, New South Wales; and localities K4 and K31 GSQ in the Dakiel Formation near Monto, Queensland. Late Viséan *Rhipidomella fortimuscula* Zone.

Material. F57103-F57111 AM. F10271, F8630, F8631 GSQ. Holotype F57104; paratypes F57103, F57105, F57109, F57110, F57111.

Genus SCOLOCONCHA Gordon, 1966

Type species. *Productus indianensis* Hall, 1858 from the Salem Limestone, Indiana.

Remarks. Gordon (1966) suggested that the marginiferid cardinal process and the morphology of the marginal ridge of *Scolococoncha* indicated an affinity with the Marginiferidae and especially the Costispiniferinae. In the present material there are no specimens showing the posterior face of the cardinal process, and hence a comment cannot be made on that criterion. Other features, however, such as the external ornament and the morphology of the dorsal interior suggest an affinity with *Krotovia* Fredericks, 1938 and hence with the Overtoniidae. Genera in the latter family are characterized by the possession of a sessile bilobate cardinal process.

In North America the genus *Scolococoncha* appears to range throughout the Meramecian and Chester Series (Gordon 1966; Nelson 1961), although there is a report of a form resembling the type species in the Chappel Limestone of Texas (Girty 1926). Carter (1967), however, in his revision of the latter fauna could not find any specimens assigned by Girty to *Productus* cf. *indianensis*. In Australia the single species assigned to the genus, *S. geniculata* sp. nov., is middle to late Viséan in age.

Scolococoncha geniculata sp. nov.

Plate 9, figs. 13-23

1975 *Scolococoncha* sp., Roberts, Table 1.

Diagnosis. Shell large for the genus, and usually with well-defined aurications;

pedicle valve bearing quincuncially arranged spine ridges, and having faint rugae on the umbonal shoulders; ventral muscle field with small subovate adductor muscle scars and obsolete diductor muscle scars; brachial valve geniculate, having a moderately concave visceral disc and an external ornament of irregular elevations and depressions and small erect spines; dorsal interior with a strong marginal ridge, and elevated adductor muscle platforms.

Description. External. Pedicle valve semicircular in outline, strongly convex, evenly rounded across the venter, and widest at the mid-length; umbo narrow, incurved, and with steep lateral shoulders; postero-lateral margins flat, well differentiated from the body of the valve, and frequently auriculate; spine ridges prominent, widely spaced, and quincuncially arranged; ridges short and bearing small spines posteriorly, but longer and with larger spine bases 0.15 mm in diameter anteriorly; spine bases also on postero-lateral margins; rugae present on the umbonal shoulders, but weak and almost completely absent from the body of the valve; micro-ornament of concentric growth lines. Brachial valve. Visceral disc bordered anteriorly by an abrupt geniculation, postero-lateral margins flat and slightly auriculate; most of the valve, particularly the visceral disc and to a lesser extent the trail, ornamented by dimples; rugae present on the ears but obscure on the visceral disc; small erect spines, 0.15 mm in diameter on the visceral disc, trail and ears; specimens range in size up to 9 mm wide and 7.5 mm long.

Internal. Pedicle valve. Adductor muscle scars small, subovate, and separated by a narrow median furrow; diductor muscle scars poorly defined, and probably also subovate in outline; marginal rim present on the inner margins of the ears; fine endospines sparsely distributed immediately in front of the muscle field but concentrated in subconcentric rows on the trail; large hollow tubules, in depressions in the floor of the valve corresponding to the external spine ridges, connected externally with the spines. Brachial valve. Median septum arising from a callus at the front of the cardinal process, located mainly in a trough between the adductor muscle platforms, but extending to between one-third and nearly one-half the length of the valve; adductor muscle scars in a single pair, smooth, subrectangular to subtriangular, and widest and highest anteriorly; cardinal process with two small lobes internally, but unknown posteriorly; lateral ridges supporting the sides of the cardinal process, diverging from the hinge and forming a prominent marginal ridge extending, on some specimens, more than half the length of the visceral disc; brachial ridges poorly defined, originating from the vicinity of the adductor muscle scars, enclosing subovate brachial discs, and always with high distal extremities; internal surface of the valve ornamented by fine radially arranged endospines.

Remarks. *S. geniculata* sp. nov. is closest morphologically to the type species, *S. indianensis* (Hall), from the Salem Limestone, Indiana, described by Gordon (1966, pp. 583-584, pl. 70, figs. 22-27). *S. indianensis* is slightly smaller, has less well-defined ears, and may have slightly fewer spines on the pedicle valve; the brachial valve interior has a more convex visceral disc, a weaker marginal ridge, and a less-pronounced geniculation. The external face of the cardinal process has not been observed in *S. geniculata* and cannot be compared with the marginiferid process on *S. indianensis*. *Pustula laevicula* Moore (1928, p. 269, pl. 11, figs. 13-14) from the Lower Burlington Limestone and possibly the Sedalia Limestone, Missouri, has a weaker ventral umbo, smaller ears, and fewer and less-prominent spine bases. The brachial valve of *P. laevicula* is unknown. *P. globosa* Mather (1915, pp. 167-168, pl. 10, figs. 7-9) from the Morrow Group of Arkansas and Oklahoma, U.S.A., has a comparable spherical shape and curvature on the pedicle valve. It is distinguished from *S. geniculata* by its smaller ears and fewer spines.

'*Avonia*' *ratingensis* Paeckelmann (1931, pp. 92-94, pl. 4, figs. 15-17) from the Upper Kohlenkalk of Ratingen, Germany, has a similar ornament on the posterior of the pedicle valve, but has longer spine ridges anteriorly. *S. geniculata* has a stronger and more incurved ventral umbo. *P. minima* Tolmachoff figured by Besnosova *et al.*

(1962, pl. 13, figs. 12-13) may belong to *Scolococoncha*. When compared with *S. geniculata* it is slightly larger, and has longer spine ridges. Specimens from Eastern Kazakhstan referred to *A. karpinskiana* (Janishevsky) by Sarycheva (1968, pl. 5, figs. 5-8) also appear to belong to *Scolococoncha*. The exterior of the shell bears random spine bases which are more elongate than those of *S. geniculata*, the brachial valve interior has comparable musculature and a slender median septum, but the lateral ridges do not recurve and form a marginal ridge around the postero-lateral parts of the visceral disc. The name of this species is derived from the Latin *geniculatus*, like the bent knee, and refers to the geniculate brachial valve.

Occurrence. Locality 17-8, the type locality in the Woolooma Formation, Rouchel district, New South Wales. Other localities in the Rouchel district include 17-6, 7 and 9, 27-1, 29-7, 30-13, 41-1, and 66-22, all in the Woolooma Formation. In the Gresford-Dungog district *S. geniculata* is present at localities 16-1, 2 and 3, 72-18, 74-7A, and 79-10 in the Bonnington Siltstone, and L53 UNE in the Flagstaff Sandstone. At Salisbury, at localities 85-10, 90-2, 100-1 and 2 in the Flagstaff Sandstone, and localities 90-5 and 103-2 in an unnamed unit. In the Werrie Syncline the species is present at locality 112-15 in a marine intercalation in the Merlewood Formation. The species is Viséan in age, ranging from the *Orthotetes australis* into the *Rhipidomella fortimuscula* Zone.

Material. F57059-F57067 AM. Holotype F57063; paratype F57064.

Family BUXTONIIDAE Muir-Wood and Cooper, 1960
Subfamily BUXTONINAE Muir-Wood and Cooper, 1960
Genus MARGINICINCTUS Sutton, 1938

Type species. *Marginicinctus marginicinctus* (Prout) from the St. Louis Limestone of Missouri.

Diagnosis. See Muir-Wood and Cooper (1960, p. 264).

Marginicinctus reticulatus sp. nov.

Plate 11, figs. 1-11

- 1957 *Dictyoclostus* sp., Campbell, p. 62, pl. 13, figs. 18-19.
1975 *Marginicinctus* sp., Roberts, Table 1.

Diagnosis. Shell slightly larger than average for the genus, rugose over the visceral discs of both valves, the rugae producing a reticulate ornament particularly on the brachial valve; costae spinose but not particularly swollen at the spine bases; spines near the hinge in six rows, each with about twenty spines on either side of the umbo; brachial valve interior lacking prostrate endospines.

Description. External. Shell subquadrate to subrectangular in outline, and bearing a flange around the lateral and anterior margins; specimens ranging in size up to 36 mm wide and 26 mm long. Pedicle valve with a shallow median sinus originating a short distance in front of the umbo, and extending to the cincture; trail modified distally by a cincture extending anteriorly from the lateral extremities of the hinge, and bearing a recurved flange; costae increasing by bifurcation and intercalation, and bearing numerous elongate spine bases; costae on the visceral disc crossed by rugae and having a knobby appearance; rugae absent from in front of the visceral disc, and costae pass regularly from the trail through the cincture and on to the flange; costae on the flange bearing occasional spine bases; density of costae 11-14 per 10 mm at 20 mm from the umbo; hinge spines coiled postero-medially behind the umbo. Brachial valve. Fold low, broad, and originating a short distance in front of the umbo; visceral disc reticulate, rugae frequently increasing by splitting; costae on the trail regular, and usually crossing on to the flange; spines more numerous than on the pedicle valve, and tending to project dorsally instead of anteriorly or antero-laterally.

Internal. Pedicle valve with an obscure muscle field, and an internal surface which is ribbed and bears endospines towards the front of the trail. Brachial valve. Cardinal process bilobed internally, having peg-like lobes separated by a deep median groove; posterior face of process with a narrow trigonal ridge between fused lobes; lateral ridges slender, and parallel with the hinge; median septum wide and rounded posteriorly, narrow anteriorly, and extending slightly beyond half the length of the valve; in small individuals septum linked to the front of the cardinal process by two ridges separated by a slit-like antron, but in larger specimens the antron is infilled with shell material and the septum arises from either in front of or from the anterior margin of the cardinal process; adductor muscle field narrow, pointed and slightly dendritic posteriorly, expanding anteriorly, and terminating in smooth slightly elevated platforms; brachial ridges slender, arising from the antero-lateral margins of the muscle field but becoming obsolete laterally; internal surface bearing many endospines on radially arranged ribs.

Remarks. *Marginicinctus reticulatus* sp. nov. is morphologically close to specimens of *M. projectus* (Muir-Wood) from the Viséan of Eire, illustrated by Muir-Wood and Cooper (1960, pl. 76, figs. 12-16). The brachial valve of *projectus* has a reticulate appearance similar to that of *reticulatus*; Muir-Wood (1928, p. 103) also records *M. projectus* from Derbyshire, England. The type species, *M. marginicinctus* (Prout) from the St. Louis Limestone, Missouri, differs from *reticulatus* by its smaller size, and the possession of a slightly narrower flange, weaker rugae particularly on the pedicle valve, costae which enlarge at spine bases, and long prostrate spines on the interior of the brachial valve. There is no available information on the distribution of the hinge spines in either *M. projectus* or *M. marginicinctus*. Specimens identified as *Productus redesdalensis* Muir-Wood by Monakhova (1959, pl. 4, figs. 1-3) from the early Viséan of Uglia, Kazakhstan, have a cincture and flange and probably should be placed in *Marginicinctus*. The latter specimens resemble *M. reticulatus* in the form of ornament on the brachial valve, but appear to have a less rugose pedicle valve. Neither of the forms referred to *P. redesdalensis* by Muir-Wood (1928, pp. 61-64, pl. 2, figs. 9-11) or Sarycheva and Sokolskaya (1952, pl. 37, fig. 185) belong to *Marginicinctus*.

Occurrence. The type locality is 88-3 in an unnamed formation at Brownmore. Other localities include 85-8, 86-1, 5 and 6, 88-1, 90-1, 2 and 5, 100-3 and 13, 103-1, 106-5, and L466 and L414 U Newcastle in the Flagstaff Sandstone in the Salisbury-Brownmore district; localities 89-1 and 2 in the Flagstaff Sandstone at Mirannie; possibly at locality 73-8, Flagstaff Sandstone at Gresford; localities 85-15, 88-3, and 106-12 in an unnamed unit above the Flagstaff Sandstone at Salisbury and Brownmore; localities 114-1 and possibly 2 in the Wootton Beds at Rawdon Vale; locality L442 U Newcastle in the Copeland Road Formation at Barrington; locality L457 Flagstaff Sandstone, and L577 (both U Newcastle), Wootton Beds east of Dungog; locality 112-14, Watts, Babbinboon in a marine intercalation in the Merlewood Formation; and locality L246 UNE in the Caroda Formation at Caroda. In Queensland the species is recorded at localities K4 and K31 GSQ in the Dakiel Formation near Monto. Late Viséan *Delepineia aspinosa* and *Rhipidomella fortimuscula* Zones.

Material. F57076-F57083 and F57113 AM. Holotype F57076.

Genus MARGINATIA Muir-Wood and Cooper, 1960

Type species. *Productus fernglenensis* Weller, 1909 from the Fern Glen Formation, Missouri.

Marginatia patersonensis Roberts

Plate 12, figs. 1-10

1965b *Marginatia patersonensis* Roberts, pp. 63-65, pl. 10, figs. 1-5.

Remarks. Material collected since the original description of this species has clarified

a number of morphological features. Amongst these is the earlier suggestion that *M. patersonensis* differed from the type material by the possession of non-dendritic dorsal adductor muscle scars. This is the case in most specimens, but large and presumably gerontic specimens have dendritic muscle scars. Details of additions and emendations to the concept of the species are given below:

1. Spines near the hinge are fine in small individuals, but grow to a large diameter in gerontic forms. The row of spines on the front of the trail is irregular and may contain up to about ten long halteroid spines; the spines are at least 30 mm in length.

2. Musculature of the pedicle valve. Ventral muscle scars are poorly defined in small- to medium-sized specimens, but in large forms are impressed into the shell. Adductor muscle scars are elongate, strongly dendritic, and are separated from one another by a median groove. Diductor muscle scars are large, triangular to flabellate in outline, relatively smooth, and ornamented by an indistinct concentric ornament posteriorly, and by irregular discontinuous radial grooves and ridges anteriorly. In smaller specimens the adductor muscle scars are mainly smooth, and the diductor muscle scars are marked by regular grooves and ridges.

3. Dorsal adductor muscle scars of small- to medium-sized individuals consist of two pairs: a smooth slightly elevated inner pair which are triangular to semicircular, and an outer pair which are pointed posteriorly, inflated anteriorly, and are partly dendritic. In large and presumably mature specimens the adductor muscle scars are strongly dendritic and it is difficult to differentiate inner and outer pairs.

4. Brachial ridges originate at the postero-lateral margins of the outer adductor scars and diverge at 20° from horizontal.

Specimens of *M. patersonensis* now at hand suggest an even closer similarity with *M. burlingtonensis* (Hall) than originally suggested by Roberts (1965b). The new specimens are in many cases larger than the type specimens and exhibit adult characters which were absent in the type material. *M. patersonensis* differs from *M. burlingtonensis*, figured by Weller (1914, pl. 9, figs. 1-10) from the Burlington Limestone of U.S.A., only in the possession of a row of spines along the hinge and a slightly larger number of body spines. *M. monachovae* Litvinovich (Litvinovich *et al.* 1969, pl. 31, figs. 4-6) from the early Viséan of Zakhastan resembles this species in having auriculate postero-lateral extremities and large body spines. The Russian species differs from *M. patersonensis* in having coarser costae and in lacking a row of spines along the ventral hinge.

Occurrence. The type locality is L233 UNE in the Bonnington Siltstone at Trevallyn in the Gresford-Dungog district. Other localities in this district include 74-7A (=L270 UNE), 72-18, L86 UNE, L215 UNE, L217 UNE, L50 UNE, L204 UNE, L206 UNE, L208 UNE, L496 U Newcastle, L573 U Newcastle in the Bonnington Siltstone, and localities 88-2 and L53 UNE in Flagstaff Sandstone. The species is also present at locality L361 U Newcastle at Clarencetown; in the Rouchel district, New South Wales, at localities 1-22 and 23 in the Dangarfield Formation; possibly from locality 63-5 in the Waverley Formation, and from localities 6-10, ?11 and 13, 17-5, 6, 7, 8, 9 and 11, 29-2, 6 and 7, 30-9 and 13, and 41-1 and 2 in the Woolooma Formation. In northern New South Wales the species is present at locality L1537 UNE in the Namoi Formation near Bingara. Viséan *Pustula gracilis* Subzone to the *Inflatia elegans* Subzone.

Material. F57094-F57102 AM.

Family DICTYOCLOSTIDAE Stehli, 1954
Subfamily DICTYOCLOSTINAE Stehli, 1954
Genus ANTIQUATONIA Miloradovich, 1954

Type species. *Productus antiquatus* J. Sowerby, 1821.

Remarks. Specimens from throughout New South Wales and Queensland referred to *Antiquatonia spinulicosta* sp. nov. have a number of morphological features which differ from those of the type species. Externally, the arrangement of major spine rows and the ornament are close to those of the type species, but the body spines are more dense. The ears of *A. spinulicosta* are smaller, and the greatest width of the shell is at the mid-length rather than at the hinge. Internally, particularly in the brachial valve, there are a greater number of features inconsistent with those of *A. antiquata*. In this material the lateral ridges are parallel with the hinge rather than divergent, the median septum is slightly shorter than that of the type species, and the adductor muscle scars are smooth rather than dendritic.

Antiquatonia spinulicosta sp. nov.

Plate 7, figs. 19-25; Plate 8, figs. 30-41

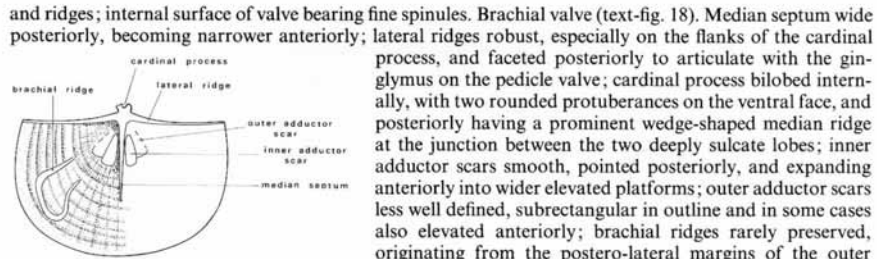
1964 *Antiquatonia* sp. Hill and Woods, pl. 7, figs. 15-17.

1975 *Antiquatonia* sp. Roberts, Table 1.

Diagnosis. Shell small for the genus, rounded-rectangular in outline, and widest at the mid-length; pedicle valve with a short trail, and small auricles; costae bearing a large number of prostrate spines posteriorly and erect spines anteriorly; seven larger spines in a curving row on the flanks, and three to four spines on the ears; ventral adductor muscle scars apparently non-dendritic; brachial valve having a short trail; dorsal median septum extending half the length of the valve; lateral ridges parallel with the hinge; dorsal adductor muscle scars smooth.

Description. External. Shell moderately concavo- or plano-convex, with a strongly arched pedicle valve and a geniculate brachial valve; specimens ranging in size up to 30 mm wide and 17 mm long. Pedicle valve particularly convex at the umbo and having a curving trail and steep flanks; postero-lateral margins small, flattened, and auriculate, and well differentiated from concave umbonal shoulders; umbo narrow apically, and projecting a short distance behind the hinge; venter flat or bearing an obsolete median sinus; costae increasing by intercalation, and tending to become obsolete at the front and on the extremities of the flanks of large valves; density of costae 14-16 per 10 mm at 10 mm from the umbo; rugae confined to the posterior half or one-third of the valve, extending from the hinge line across the venter, and producing a slightly reticulate ornament; seven large erect spines arranged in a curving row extending from the groove between the ears and the umbonal shoulders down the flanks, the diameter of spine bases increasing towards the extremities; a second row or group of three to four spines of similar shape and size present on the ears; spines arising from costae on the body of the valve smaller in diameter, those on the anterior half being prostrate and originating from elongate bases, and those on the front of the valve erect, having circular bases and being distributed either randomly or in irregular concentric rows. Brachial valve. Visceral disc having flat or gently convex postero-lateral extremities, and in some instances bearing a low median fold; costae with a small number of minute spine bases particularly near the area of geniculation; rugae low and rounded, continuous across the visceral disc, and producing a faintly reticulate pattern.

Internal. Pedicle valve having a short ginglymus along the hinge; adductor muscle scars elongate, ovoid in outline, faintly impressed posteriorly, and slightly elevated anteriorly; diductor muscle scars large, nearly twice the length of the adductor muscle scars, triangular in outline, and ornamented by longitudinal grooves



TEXT-FIG. 18. Dorsal interior of *Antiquatonia spinulicosta* sp. nov. incorporating details from F57031 AM and F57043. Approximately $\times 3$.

and ridges; internal surface of valve bearing fine spinules. Brachial valve (text-fig. 18). Median septum wide posteriorly, becoming narrower anteriorly; lateral ridges robust, especially on the flanks of the cardinal process, and faceted posteriorly to articulate with the ginglymus on the pedicle valve; cardinal process bilobed internally, with two rounded protuberances on the ventral face, and posteriorly having a prominent wedge-shaped median ridge at the junction between the two deeply sulcate lobes; inner adductor scars smooth, pointed posteriorly, and expanding anteriorly into wider elevated platforms; outer adductor scars less well defined, subrectangular in outline and in some cases also elevated anteriorly; brachial ridges rarely preserved, originating from the postero-lateral margins of the outer adductor scars at angles between 10° and 30° , and enclosing club-shaped brachial discs; internal surface of valve bearing fine spinules immediately in front of the muscle field and coarser spines on the trail.

Remarks. *A. insculpta* (Muir-Wood) from the D_2 of Great Britain (Muir-Wood 1928, pp. 89-92, pl. 3, figs. 10-12) is one of the few species resembling *A. spinulicosta*. *A. insculpta* has a similar rounded-rectangular outline and external ornament, particularly the density of the costae and the rugose nature of the visceral disc. It differs from this species in being slightly larger in size, and in having wider ears, a longer and more incurved trail, and a more pronounced fold and sinus. From Muir-Wood's illustrations, it appears that *A. insculpta* has fewer spines arising from the costae. Her description of an imperfectly preserved brachial valve indicates that the lateral ridges diverge from the hinge whereas those in *A. spinulicosta* are parallel with the hinge. Specimens identified as *A. insculpta* from the C_1^t and C_3^t (late Viséan) of U.S.S.R. by Sarycheva (1949) are distinguished from *A. spinulicosta* by these same features, but they also have a more coarsely costate ornament, fewer and larger spines scattered over the body of the shell, extremely wide ears, and a longer dorsal median septum.

A. spinulicosta resembles *P. sedaliensis* Weller (1914, pp. 108-110, pl. 14, figs. 1-7), from the Chouteau Limestone of Missouri, in over-all shape and in the reticulate nature of the ornament at the posterior of the shell. The arrangement of spines differs, with *P. sedaliensis* having a row of cardinal spines as well as scattered spines on the anterior and on the lateral slopes. *A. spinulicosta* has a large number of spines arising from costae as well as a row of spines down the flanks, and a group of spines on the ears. The interior of *P. sedaliensis* is undescribed. *Dictyoclostus agmenis* Hyde (1953, pp. 236-239, pl. 10, figs. 6-35) from the Logan and Cuyahoga Formations of Ohio, similarly resembles *A. spinulicosta* in the shape and ornament of the shell. *D. agmenis* has rows of spines on the postero-lateral parts of the pedicle valve, but lacks the large number of spines arising from the costae, typical of *A. spinulicosta*.

Occurrence. Locality 10026 ANU, the type locality, in the Namoi Formation in the Boggabri district. Other localities include 72-3, 98-4, 100-6, 7 and 8 in the Bingleburra Formation, and localities L203 UNE and 98-2 in the Ararat Formation in the Gresford district; locality 1-27 in the Dangarfield Formation, and localities 24-7 and 15, 39-16 and 18, 15-3, 31-1, and 41-3 in the Waverley Formation in the Rouchel district; localities 112-1, 2, 4, 6, 7, 8, 9, and 10, L14 UNE, ?L7 UNE, L18 UNE, L23 UNE, L26 UNE, and L30 UNE in the Namoi Formation, Babbinboon district at the northern end of the Werrie Syncline; locality 113-1 (= locality L10024 ANU) in the Namoi Formation in the Boggabri district; and localities F3 of Yeates (1970, unpublished B.Sc. thesis) in the Namoi Formation and possibly F13 of Yeates in the

Luton Formation near Gravesend. Dear (1968) recorded the species in the upper part of the Cania Formation in the Yarrol Trough, Queensland. Late Tournaisian to early Viséan *Schellwienella cf. burlintonensis* Zone.

Material. F57031-F57036 AM and F57043-F57048 AM. Holotype F57036; paratype F57033.

Genus RETICULATIA Muir-Wood and Cooper, 1960

Type species. *Productus huecoensis* King, 1931 from the Early Permian Hueco Limestone, Texas.

Diagnosis. See Muir-Wood and Cooper (1960, p. 284).

Reticulatia cinctifera sp. nov.

Plate 13, figs. 1-15

1964 *Reticulatia* sp. Hill and Woods, pl. 8, figs. 5-8.

Diagnosis. Shell transverse, subovate in outline, and with the exception of the trail bearing a weak reticulate ornament; a single row of divergent halteroid spines near the hinge, but the remainder of the shell aspinose; pedicle valve with a narrow trough-shaped median sinus; brachial discs club-shaped; external face of cardinal process with short strongly incurved lateral lobes, and a large V-shaped lophidium.

Description. External. Pedicle valve widest at or just in front of the hinge line, highest at about one-third of its length, slightly flattened on the venter, and strongly convex at the umbo and at the trail; ginglymus well developed; median sinus narrow, maintaining a constant width anteriorly, and extending from just behind the umbo to the front of the trail; seven large halteroid spines inclined at 40° to the hinge in a single row on either side of the umbo; rugae highest on the postero-lateral margins, extending across the venter, best developed on the posterior two-thirds of the valve, and rare on the trail; costae narrow, increasing by bifurcation and intercalation, and having a density of 13-15 per 10 mm at 20 mm from the umbo, and 10-12 per 10 mm at the front of the trail. Brachial valve flat to moderately concave on the visceral disc, with a prominent geniculation producing a short steep trail; ears wide and flat; median fold low, narrow, and usually affecting the front of the visceral disc and the trail; ornament strongly reticulate on the visceral disc, but rugae absent from the trail; costae increasing mainly by bifurcation; specimens ranging in size up to 61 mm wide and 54-55 mm long.

Internal. Pedicle valve. Muscle field deeply impressed; adductor muscle scars in two pairs, a narrow dendritic posterior pair which is elevated anteriorly, and a smooth lanceolate anterior pair which has an internal longitudinal line of subdivision and forms platforms above the remainder of the muscle field; diductor muscle scars large, smooth or with a faint concentric ornament at the posterior, and with deep radial striae on the flabellate anterior; cincture extending as a ridge along the hinge, cutting across the ears and traversing the anterior just behind the front of the trail; one specimen having a cincture comprised of two ridges and a separating furrow; internal surface of valve between the umbo and the cincture bearing fine randomly oriented or radially arranged pits. Brachial valve. Outer adductor muscle scars strongly dendritic, impressed, and subrectangular in outline; inner adductor scars subovate in outline, possibly longitudinally subdivided into two portions, and situated on high platforms; septum originating as a wide ridge from the callus in front of the cardinal process, narrow through the muscle field, becoming higher at the front, and extending two-thirds the length of the valve; cardinal process supported by a thick callus, bearing two highly convex lobes divided by a narrow groove internally, and on the posterior face having a sulcate wedge-shaped median ridge at the junction of the concave lobes; dorsal portion of the process protected by a V-shaped lophidium; lateral ridges nearly parallel with the hinge, but cutting across the ears and forming a marginal rim around the geniculation at the posterior of the trail; brachial ridges arising from the front of the muscle field, extending normal to the median septum, enclosing smooth elevated club-shaped brachial discs, and returning to the front of the septum; visceral disc between the marginal rim and the brachial markings and muscle scars bearing randomly oriented pits; the front of the visceral disc having radially arranged ribs bearing fine endospines; trail and ears smooth.

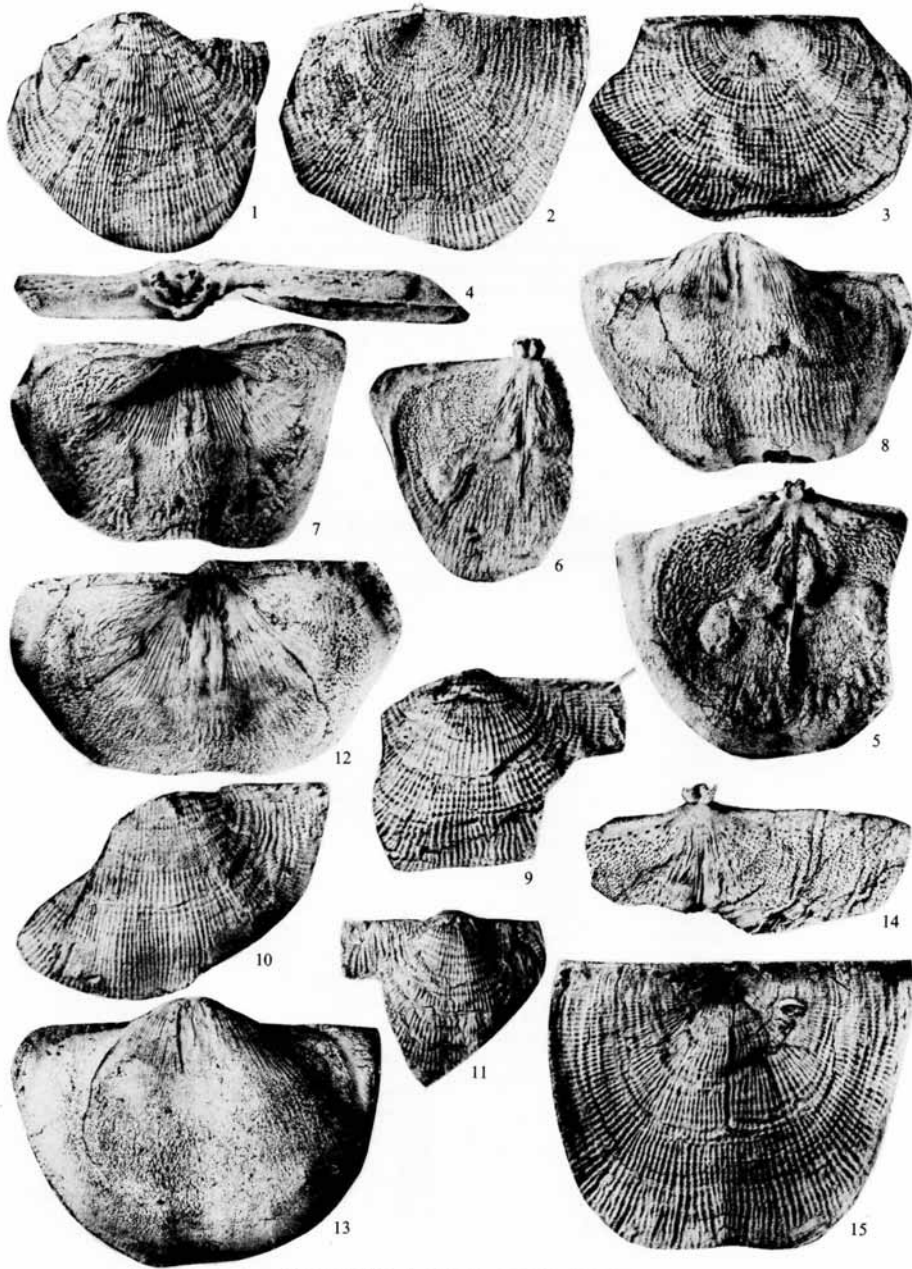
Remarks. *R. cinctifera* sp. nov. is extremely close morphologically to specimens referred to *P. (Dictyoclostus)* aff. *americanus* Dunbar and Condra by Demanet (1943, pl. 2, figs. 4-7) and to *Tolmatchoffia demaneti* by Böger and Fiebig (1963, pp. 133-136, pl. 16, fig. 12; pl. 17, figs. 1-6). The specimens from Belgium, described by Demanet, have the same shape, a cincture in the ventral valve, a single row of spines near the hinge of the pedicle valve, and a comparable reticulate ornament; they come from the base of the Westphalian C (Wn3a). The German material figured by Böger and Fiebig is slightly less transverse, has more erect spines on the pedicle valve, and may have a slightly smaller ventral umbo; it also comes from the Westphalian C.

When compared with the type species, *R. huecoensis* (King) illustrated by Muir-Wood and Cooper (1960, pl. 104, figs. 1-5; pl. 105, figs. 1-8), *R. cinctifera* is more transverse and has a less well-developed reticulate ornament on the visceral disc; spines are present only along the hinge line and are absent from the furrow bordering the ears, the trail, and the visceral disc. In the brachial valve interior the posterior adductor muscle scars in *R. cinctifera* are smaller, the brachial markings are club-shaped, the lateral lobes on the external face of the cardinal process are shorter, and the lophidium is larger than those of the type species. Specimens of *R. americana* (Dunbar and Condra) from the Pennsylvanian of Oklahoma, Kansas, and Texas, which according to Branson (1964) are not synonymous with the type species as alleged by Muir-Wood and Cooper (1960), have a more quadrate shape, a more strongly reticulate ornament, and coarser costae when compared with *R. cinctifera*.

R. rugatia Sturgeon and Hoare (1968, pp. 49-50, pl. 14, figs. 10-16) from the lower part of the Allegheny Group of Ohio is more subquadrate, has smaller ears, and slightly stronger rugae when compared with this species. Specimens of *R. tiawahensis* (Hoare) from the Desmoinesian Tiawah Limestone of Missouri (Hoare 1960, pp. 224-226, pl. 32, figs. 5-9; Hoare 1961, pp. 51-52, pl. 6, figs. 4-8) have a comparable weakly reticulate ornament, but are broader and have much wider ears when compared with *R. cinctifera*. *R. tiawahensis* appears to lack a cincture, has wider and more strongly dendritic ventral adductor muscle scars, and more strongly dendritic dorsal adductor muscle scars. Specimens tentatively referred to *Reticulatia* have been reported from the Desmoinesian (Moscovian) ?*Reticulatia* Zone and equivalents in the Yukon Territory of Canada by Bamber and Waterhouse (1971). These differ from *R. cinctifera* in having large spine bases on the trail, and, in most cases, larger ears. The material

EXPLANATION OF PLATE 13

Figs. 1-15. *Reticulatia cinctifera* sp. nov. 1, rubber cast of a pedicle valve exterior. F10472b GSQ, $\times 1$. 2-3, rubber casts of two brachial valve exteriors. F10472a GSQ and F8612b GSQ, both paratypes, $\times 1$. 4-5, posterior and ventral views of a rubber cast of the brachial valve interior. F10468 GSQ, holotype, $\times 2$ and $\times 1$ respectively. 6, rubber cast of portion of a brachial valve interior. F10469 GSQ, $\times 1$. 7-8, rubber cast of the interior and internal mould of two pedicle valves showing the musculature, mantle canals, and the cincture. F30186 UQ and F30190 UQ from locality L2181 UQ. Both $\times 1$. 9-11, rubber casts of the exteriors of three pedicle valves. Note the single row of hinge spines and the absence of body spines. F8612a GSQ, a paratype, F10470a GSQ, and F10473b. All $\times 1$. 12-13, rubber cast of the apical portion of the ventral interior, and internal mould of the pedicle valve. Note the prominent cincture. F8611 GSQ, a paratype, $\times 1$. 14, rubber cast of the apical part of the dorsal interior. F12149 GSQ, $\times 1$. 15, rubber cast of a brachial valve exterior. F8610 GSQ, a paratype, $\times 1$. All specimens except Figs. 7-8 from locality K33 GSQ.



ROBERTS, Australian productaceans

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