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CARBONIFEROUS, PERMIAN, AND TRIASSIC CONCHOSTRACANS OF AUSTRALIA – THREE NEW STUDIES

P. Tasch* & P. J. Jones

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by

P. Tasch & P. J. Jones

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by

P. Tasch & P. J. Jones

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by

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FOREWORD

The fossil conchostracans described in this Bulletin are from the collections of the Geological Branch of the Bureau of Mineral Resources, Geology & Geophysics, Canberra. Much of the material was collected by geologists from companies, notably West Australian Petroleum Pty Ltd, and the Bureau of Mineral Resources. Some samples were collected by such pioneers of West Kimberley geology as Dr A. Wade (1936) and Dr R. O. Brunnschweiler (1952). Our indebtedness to all these individuals, and the organisations which they represented, is expressed in the relevant parts of this report.

During his visit to Australia in January 1970, Professor Paul Tasch of the Department of Geology, Wichita State University, Wichita, Kansas, examined the material, which was later made available to him for systematic description. The results are presented as three separate papers, the basis for the division being mainly geographic rather than stratigraphic. Conchostracans are described from (1) the Carboniferous Anderson Formation and the Lower Triassic Blina Shale of the Canning Basin; (2) the Lower Triassic shales of the Bonaparte Gulf Basin; and (3) the Upper Permian Blackwater Group and Lower Triassic Rewan Group of the Bowen Basin. In addition, notes are included on an Early Triassic cyzicid from the Carnarvon Basin, a Carboniferous leaiid from the Drummond Basin, environmental considerations, and dispersal routes during Early Triassic time.

The manuscripts were completed in June 1976, but a few revisions have been made to account for stratigraphic studies in Australia since that date.

L. W. WILLIAMS
Acting Director

PAPER 1

Carboniferous and Triassic Conchostraca from the Canning Basin, Western Australia

BY

P. TASCH & P. J. JONES

SUMMARY

The upper part of the Carboniferous Anderson Formation (late Viséan to possibly early Namurian), in its type section (Grant Range No. 1 Well), contains five, possibly six, conchostracan genera: *Leaia, Monoleaia, Rostroleaia, Limnadiopsileaia, Cyzicus,* and possibly *Ellipsograpta.* The ribbed genus *Hemicycloleaia* Raymond is reassigned as a subgenus of *Leaia,* and seven new Carboniferous species are described: *Leaia (Leaia) andersonae, Leaia (Hemicycloleaia) rectangellipta, Leaia (Hemicycloleaia) grantrangicus, Leaia (Hemicycloleaia) tonsa, Leaia (Hemicycloleaia) longicosta, Monoleaia australiata,* and *Limnadiopsileaia carboniferae.*

The Lower Triassic Blina Shale, in scattered outcrops (Bell's Ridge, Erskine Hill, Wongil Ridge, Lake Jones, and Minnie Range), and in Meda No. 1 Well, contains three conchostracan genera: *Estheriina, Palaeolimnadia,* and *Cyzicus.* Two new subgenera are established: *Estheriina (Nudusia),* and *Palaeolimnadia (Grandilimnadia). Estheriina (Nudusia)* is distinguished from *E. (Estheriina)* Jones by the absence of growth bands on the umbonal area; and *Palaeolimnadia (Grandilimnadia)* is distinguished from *P. (Palaeolimnadia)* Raymond by its smaller umbonal area—without growth bands—relative to the entire valve, and its lower valve form (height/length) ratio. Four new Triassic species are described: *Cyzicus (Lioestheria) erskinehillensis, Palaeolimnadia (Grandilimnadia) medaensis,* and *Estheriina (Nudusia) blina* from the Canning Basin, and *Palaeolimnadia (Grandilimnadia) mitchelli* from the Sydney Basin. *Belgolimnadiopsis australensis* Novozhilov, present in the Triassic of both the Sydney and Canning Basins, is referred to the subgenus *Cyzicus (Lioestheria).*

The only genus that persisted from the Carboniferous into the Triassic of the Canning Basin was *Cyzicus.* Upper Permian palaeolimnadids from the Newcastle Coal Measures of the Sydney Basin were available for passive dispersal westward. The Knocklofty Formation of Tasmania, a correlate of the Blina Shale, also has a *Palaeolimnadia-Cyzicus* fauna.

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1. INTRODUCTION

Fossil Conchostraca were first recognised in the Canning Basin, and indeed, Western Australia, by Teichert (1950), who recorded 'Estheria' from Mayall's bore, near Derby, in shales now referred to the Blina Shale. Brunnschweiler (1954, 1957) later recorded two species under the names of *Isaura* cf. *minuta* and *I.* cf. *ipsviciensis* from beds of phosphatic conchostracan coquinites within the Blina Shale, which he regarded as Late Triassic in age. He suggested that the bivalved shells which Wade (1936) collected from his 'Upper Ferruginous Series', and Chapman & Parr (1937) described as pelecypods, are also conchostracans. Subsequent geological exploration by the Bureau of Mineral Resources (BMR), and the West Australian Petroleum Pty Ltd (WAPET), identified the widespread distribution of the Blina Shale partly on its characteristic conchostracan fauna both in outcrop and subsurface sections (Guppy et al., 1958; McWhae et al., 1958; Veevers & Wells, 1961; and Casey & Wells, 1964). The age of the Blina Shale is now established as Early Triassic from studies of spores and microplankton (Balme, 1969), and amphibians (Cosgriff, 1974).

Shortly after Brunnschweiler (1954) recognised the presence of conchostracans in Triassic rocks, Öpik in 1955 identified leaiid conchostracans in core samples taken from the Carboniferous Anderson Formation, penetrated by WAPET Grant Range No. 1 Well (Öpik, in McWhae et al., 1958).

The present study describes the Conchostraca in both the Carboniferous and Triassic collections, which are deposited in the Bureau of Mineral Resources, Canberra, Australia. All type and figured specimens from these collections are deposited in the Commonwealth Palaeontological Collection of this organisation, and are designated by the prefix CPC. In addition, this study revises some earlier described conchostracan species from the Triassic of the Sydney Basin, New South Wales (Etheridge Jr, 1888; Mitchell, 1927), which have been previously discussed by Raymond (1946), Kobayashi (1954), and Novozhilov (1958). The type and figured specimens from the Triassic of the Sydney Basin are deposited in the Palaeontological Collection of the Australian Museum, Sydney, and are designated by the prefix F.

Responsibility of authors

PT is responsible for the systematic descriptions of all genera and species, and all statements which evaluate their palaeobiogeographical significance. PJJ is responsible for the introduction and the locality and stratigraphic data for the collections.

Acknowledgements

It is a pleasure to record our thanks to Dr A. Ritchie and Miss Dorothy Jones of the Australian Museum, Sydney, who allowed us to study the Etheridge (1888) and Mitchell (1927) conchostracan collections in their care; Messrs Timothy J. Petta and Scott Fitch of the Department of Geology, Wichita State University, Kansas, who were responsible for the photography; Messrs A. T. Wilson and P. W. Davis (BMR), who prepared the prints and plates for this paper; Mr Dennis Carlton of the Department of Geology, Wichita State University, who aided with measurements and original drafting; and Mr R. R. Melson (BMR), who drafted the final version of the figures.

Abbreviations used in the systematic descriptions

L = length of valve
H = height of valve
H/L = height/length ratio of valve
GB = number of growth bands
Ldm = length of dorsal margin
Ldm/L = length of dorsal margin/length of valve ratio
lu = length of umbo
hu = height of umbo
hu/lu = height/length ratio of umbo

All measurements are given in millimetres.

2. CARBONIFEROUS CONCHOSTRACA

COLLECTION LOCALITY AND STRATIGRAPHY (PJJ)

Grant Range No. 1 Well (18°00′48″S, 124°00′22″E), drilled by WAPET between the years 1954 and 1955, is situated about 90 km south-southeast of Derby (Mount Anderson 1:250 000 Sheet area). Structurally, it is located on the axis of the Grant Range Anticline, at the western end of the Central Anticlinal Belt (Veevers & Wells, 1961, p. 227, pl. 2) within the Fitzroy Trough (Fig. 1).

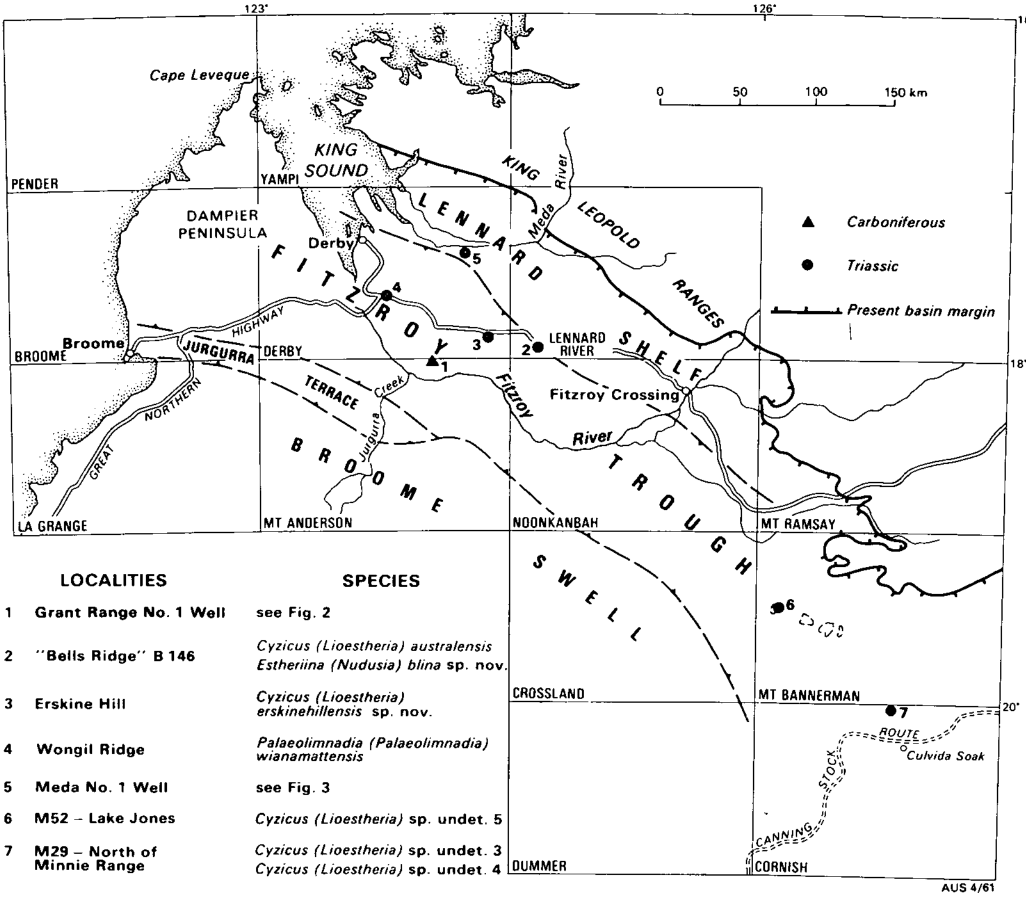

Fig. 1. Localities of Carboniferous (Anderson Formation) and Lower Triassic (Blina Shale) Conchostraca, Canning Basin.

The well passed through 7900 feet of sandstone and siltstone of the Grant Formation (Lower Permian-Upper Carboniferous), and penetrated an essentially paralic sequence, more than 5000 feet thick, before reaching the total depth of 12 915 feet. The sequence below 7900 feet, designated by McWhae et al. (1958) the type section of the *Anderson Formation,* consists of 'alternating sandstone, shale and siltstone, with thin beds of limestone, dolomite and anhydrite, especially in the upper part' (Fig. 2). This part of the Anderson Formation conforms to the sequence identified by Bischoff (1968) as 'Carboniferous Unit A' which he delimited on lithological and electric log characteristics between the depths of 7865 and 10 165 feet. Its age was regarded by Öpik (*in* McWhae et al., 1958) as Late Carboniferous (Westphalian-early Stephanian) mainly on the basis of his study of the conchostracans, e.g. *Leaia* (*Hemicycloleaia*), between 7907 and 8536 feet. This conclusion was supported by Dickins (*in* McWhae et al., 1958), who regarded the pelecypods which he identified from 9796 to 9799 feet, viz. *Anthracosia* and *Naiadites* cf. *modiolaris,* as early Westphalian in age. Copeland (1957), however, has shown that in eastern Canada *Leaia* (*Hemicycloleaia*) of the *tricarinata* species-group is present in the Namurian, and Tasch (this volume) records an even earlier appearance of this subgenus in rocks of early Viséan (or ?late Tournaisian) age from the Drummond Basin of eastern Australia. The apparent absence of the genera *Anomalonema, Paraleaia,* and *Palaeolimnadiopsis* in the Anderson Formation may suggest a pre-Westphalian age, because they have yet to be found in rocks older than Westphalian elsewhere in the world. On the other hand, the value of this negative evidence has

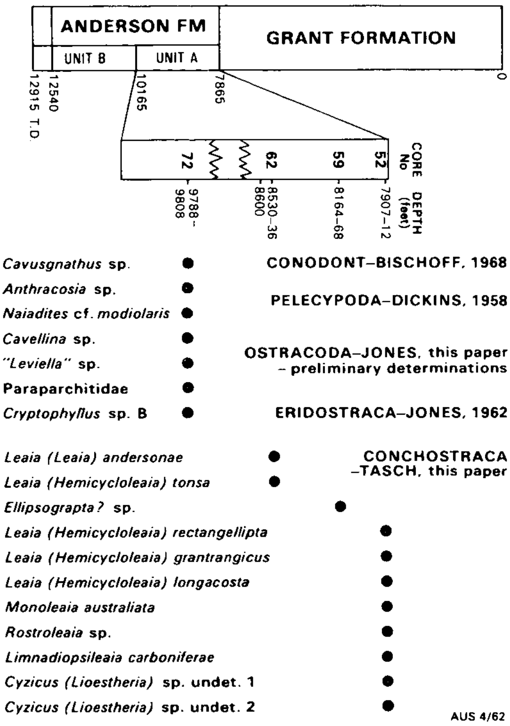

Fig. 2. Distribution of Carboniferous Conchostraca and other fossils in the upper part of the Anderson Formation in Grant Range No. 1 well (type section). Note: for *Leaia (H.) longacosta* **read** *longicosta.*

to be balanced against the fact that the species which Tasch (this volume) has referred to *Monoleaia, Rostroleaia,* and *Limnadiopsileaia* represent the first records of these genera in pre-Permian rocks. For these reasons, and because all the species described in the present study are new, the conchostracan fauna suggests only a general Carboniferous age.

Better precision is provided by the conodont evidence. Bischoff (*in* Jones et al., 1973) has shown that the presence of *Cavusgnathus* in core 72 (9788-9808 feet)—the core from which Dickins identified pelecypods—suggests a late Viséan to possible early Namurian age for the upper part of the Anderson Formation. A Viséan age is supported by the palynological evidence, because this sequence contains the *Granulatisporites frustulentus* Microflora of Kemp et al., (1977)—previously named the Lycosporoid Microflora, by Balme (1964)—which indicates Early Carboniferous (Dinantian).

The Anderson Formation is not definitely known to be exposed at the surface, and further studies are necessary in order to clarify its identification and biostratigraphic relations in subsurface sections.

Three core samples from Grant Range No. 1 Well, taken from the upper part of the Anderson Formation, were examined: core 52 (7907-12 feet), core 59 (8164-68 feet), and core 62 (8530-36 feet). The positions and faunal content of these cores and that of core 72 (9788-9808 feet) are shown in figure 2.

Fauna (PT)

Composition

Five, possibly six, conchostracan genera—*Monoleaia, Leaia, Rostroleaia, Limnadiopsileaia, Cyzicus,* and *Ellipsograpta?*—are represented in the three core samples examined in this study (Fig. 2). Of these genera, *Monoleaia, Rostroleaia, Limnadiopsileaia,* and *Ellipsograpta?* are represented by a single species, *Cyzicus* (*Lioestheria*) is represented by two species, and *Leaia* is represented by five species (one assigned to the subgenus *Leaia,* and four assigned to the subgenus *Hemicycloleaia*). Only *Leaia* (*Hemicycloleaia*) occurs at more than one level (viz., in core 52 and in core 62).

The fauna is dominantly composed of forms bearing ribs, only species of *Cyzicus* (*Lioestheria*) and *Ellipsograpta?* being exceptions. A coquina of one such ribbed type (Pl. 2, fig. 3) occurs in core 62 (8530-36 feet).

Comparison with extra-Australian faunas

Carboniferous Conchostraca from the United States and eastern Canada (Nova Scotia), as well as those from the European Coal Measures, include *Cyzicus* and *Leaia*—several species of each. There are in addition numerous other genera not found in Western Australian cores of Carboniferous age. These include: *Palaeolimnadia, Palaeolimnadiopsis, Anomalonema,* non-ribbed forms, and the ribbed *Paraleaia.*

The Carboniferous of the USSR (lower Stephanian of the Donetz and Westphalian of the Karaganda Coal Basins) has numerous species of *Hemicycloleaia* (reassigned in this paper as a subgenus of *Leaia*), and many ribbed types originally assigned to distinct genera, now reassigned to *Leaia* (Tasch, 1958). In addition, there are many species of *Cyzicus,* and the ribbed genus *Massagetes.*

Thus, during Carboniferous time, *Cyzicus* and *Leaia* had a cosmopolitan distribution. Other Carboniferous genera are now known to have been dispersed between two or more continents, for example, *Anomalonema, Gabonestheria* and *Palaeolimnadia* (Tasch 1960, and unpublished notes). For the genus *Leaia,* worldwide distribution during Permo-Carboniferous time has been attributed to greater proximity of continents of both Northern and Southern Hemispheres prior to continental drift (Tasch, 1972). A similar explanation might clarify dispersal of other Carboniferous conchostracan genera.

Exotic affinitites of some Australian genera

One of the Carboniferous genera from Western Australia reported in this paper was previously known only from the Russian Permian (*Rostroleaia* from the Kazanian of the Urals), one from the American Permian (*Limnadiopsileaia* from the Leonardian Wellington Formation of Kansas), and one from the Chinese Cretaceous (*Ellipsograpta* from the Nenkiang Shale of Heilungkiang).

The occurrence of *Rostroleaia* and *Limnadiopsileaia,* two very distinctive genera, in the same core (Fig. 2) is of special interest. Martynov (1928) observed that the Kazanian insects of the European part of the USSR had strong affinities with (indeed, probably derived from) the insects of the Lower Permian Wellington Formation of Kansas, and also had affinities with some species of the Newcastle Coal Measures. The two conchostracan genera noted above point to a post-Carboniferous dispersal between the Canning Basin area, the Urals, and the Wellington Formation sites in Kansas and Oklahoma.

Permian marine faunas of Western Australia have long been known to have Uralian and Tethyan affinities (Brown, Campbell & Crook, 1968). The above data suggest nonmarine dispersal as well as direct marine connections during the post-Carboniferous of Western Australia.

A west-to-east dispersal of Carboniferous ribbed forms (leaiid conchostracans) can account for such forms in the Permian Blackwater Group of the Bowen Basin and the Newcastle Coal Measures of the Sydney Basin, both in eastern Australia (Tasch, 1972). The last named faunas are under study by one of us (P.T.) and detailed comparisons with the Canning Basin fauna will be forthcoming when this study is completed.

Wass (1972) noted the similarity between some groups of marine Permian fossils in eastern and Western Australia, particularly polyzoans and bivalves, but also other forms (e.g., aberrant crinoids). For polyzoans he inferred a west-to-east migration. Clearly, marine and nonmarine dispersal routes were available during the late Palaeozoic of Australia. For additional data on more precise correlations of the Permian of eastern and Western Australia, the reader is referred to the recent work of Dickins (1976).

3. EARLY TRIASSIC CONCHOSTRACA

COLLECTION LOCALITIES (PJJ)

Six collections were made available for study from localities of the Lower Triassic Blina Shale in the northwestern (Derby and Lennard River 1:250 000 Sheet areas), and northeastern (Cornish and Mount Bannerman 1:250 000 Sheet areas) parts of the Canning Basin (Fig. 1).

Lennard River 1:250 000 Sheet area

'B 146 Bell's Ridge', collected by A. Wade, 1936. 'Fossils from the calcareous ferruginous stone scattered on the surface, at south-west corner of the North-east Structure at Bell's Ridge, Kimberley'—(Prendergast *in* Chapman & Parr, 1937, p. 176). Although 'Bell's Ridge' has not been found on any topographic map, Brunnschweiler (1954, p. 44) regarded Wade's locality as being the Erskine Range, about 100 km SE of Derby, and lying within the Blina Shale. However, 'Bell's Ridge' is one of two localitities mentioned by both Wade (1936) and Chapman & Parr (1937) from the 'Upper Ferruginous Series'. Both reports refer to a locality 6 miles NW of North-West Hill. Presumably the second locality mentioned by Wade (1936, p. 49)—'6 miles to the north of the 4 mile bore on Mt Wynne Creek and 10 miles west-north-west of Ellendale Homestead (Bell's) outcrops of Ferruginous beds . . . '—and the 'Bell's Ridge' of Chapman & Parr, refer to one and the same locality. This suggests that the 'North-east Structure' mentioned by Chapman & Parr (1937) probably refers to the 'Ellendale Structure' of Wade (1936).

Derby 1:250 000 Sheet area

Erskine Hill, collected by Mines Exploration Pty Ltd, Adelaide, 1965 (BMR Reg. No. 65630004), 100 km SE of Derby.

Wongil Ridge, collected in 1952 by R. O. Brunnschweiler (1957, p. 5), 12 km ESE of Yeeda Station (17°38′30″S; 123°45′00″E).

Meda No. 1 Well (17°24'00"S; 124°11'30"E) located 56 km E of Derby on the Lennard Shelf, was drilled by WAPET in 1958, to the total depth of 8809 feet. It passed through 48 feet of alluvium before it penetrated 654 feet of Blina Shale between the depths of 60 and 714 feet.

Mount Bannerman 1:250 000 Sheet area

M52 (19°27'17"S; 126°06'22"E) NE bank of Lake Jones, collected in 1955 by J. N. Casey & A. T. Wells (1964, p. 28).

Cornish 1:250 000 Sheet area

M29 (20°01'35"S; 126°50'49"E), Minnie Range, 23.3 km NNW of Culvida Soak, collected in 1955 by J. N. Casey & A. T. Wells (1964, p. 28).

STRATIGRAPHY OF THE BLINA SHALE (PJJ)

The Blina Shale, a name introduced by Reeves (1951)—see Brunnschweiler (1954; 1957) for the historical development of the concept of this formation—consists of grey to brown shale and claystone with minor lenses of sandy shale, siltstone, and very fine-grained micaceous, finely glauconitic sandstone. The section measured by McKenzie (1961) in the Erskine Range, accepted as the type section (Geol. Surv. W.A., 1975), represents the upper 32 m of the formation, which is disconformably overlain by the Erskine Sandstone. The base of the Blina Shale is not exposed in this area, but it is known from boreholes to overlie, with disconformity, the Late Permian Liveringa Formation. The Blina Shale is 199 m thick in WAPET Meda No. 1 Well, 277 m thick in the Derby Town bore, and about 290 m, the maximum known thickness, in Bakers No. 2 bore on Kimberley Downs station.

In the northeast Canning Basin, the Blina Shale is less than 45 m thick, and consists of micaceous shale and fine sandstone. It disconformably overlies the Permian Liveringa and Noonkanbah Formations, and at Chilpada Chara and at M29 it conformably overlies the Lower Triassic Culvida Sandstone.

Besides conchostracans, the Blina Shale contains foraminifera, lingulid brachiopods, pelecypods (including cf. *Pseudomonotis*), fish (including *Ceratodus, Saurichthys,* and a coelacanthid), and amphibians—two trematosaurids, and the labyrinthodonts *Deltasaurus kimberleyensis* and *Blinasaurus henwoodi* (Cosgriff, 1965; 1969). *Deltasaurus kimberleyensis,* also found in the Knocklofty Formation of Tasmania (Cosgriff, 1974), is closely related to *D. pustulatus* found in the Kockatea Formation of the Perth Basin (Cosgriff, 1965); and *Blinasaurus henwoodi* is closely related to *B. townrowi* of the Knocklofty Formation (Cosgriff, 1974). From his studies of the Blina-Knocklofty amphibians, Cosgriff (1974, p. 91) suggested an early Triassic age, because 'this type of vertebrate fauna probably did not survive beyond the Owenitan'.

The Blina Shale also contains the *Taeniaesporites* Microflora of Balme (1964; 1969), a microflora first recognised in the Kockatea Shale of the Perth Basin (Balme, 1963), where it marks a complete break with those from the Permian. Dolby & Balme (1976) have recently referred the microflora of the Kockatea Shale to their *Kraeuselisporites saeptatus* Assemblage Zone, the lowermost microfloral zone for the Triassic of Western Australia, which is dated by the molluscan evidence of McTavish & Dickins (1974) as early Griesbachian to early Smithian.

McKenzie (1961), from the sedimentary characters and the palaeoecological implications of the fauna and flora, postulated that the Blina Shale was deposited on the subaqueous topset plain of a marine delta. For further details of the depositional environment of the Blina Shale the reader is referred to the more recent account by Gorter (1978).

FAUNA (PT)

Composition

Three conchostracan genera—*Estheriina, Palaeolimnadia,* and *Cyzicus*—occur in the Lower Triassic Blina Shale in WAPET Meda No. 1 Well (cuttings between 320 and 720 feet; Fig. 3), and in samples from five other localities (Fig. 1). Of the three new species, *Estheriina* (*Nudusia*) *blina* and *Palaeolimnadia* (*Grandilimnadia*) *medaensis* occur together between the depths of 580 feet and 600 feet in Meda No. 1 Well. *Estheriina* (*Nudusia*) *blina* also is associated with *Cyzicus* (*Lioestheria*) *australensis* (Novozhilov) in the sample from Bell's Ridge (Fig. 1). The other new species, *Cyzicus* (*Lioestheria*) *erskinehillensis,* is restricted in occurrence to Erskine Hill. The five undetermined species of *Cyzicus* (*Lioestheria*), in which preservation is incomplete, also may contain other new species.

The genus Palaeolimnadia *and its significance*

The genus *Palaeolimnadia* is represented by species both in Meda No. 1 Well and at the Wongil Ridge site (Figs. 1, 3). Two subgenera are here established for this genus, *Palaeolim-*

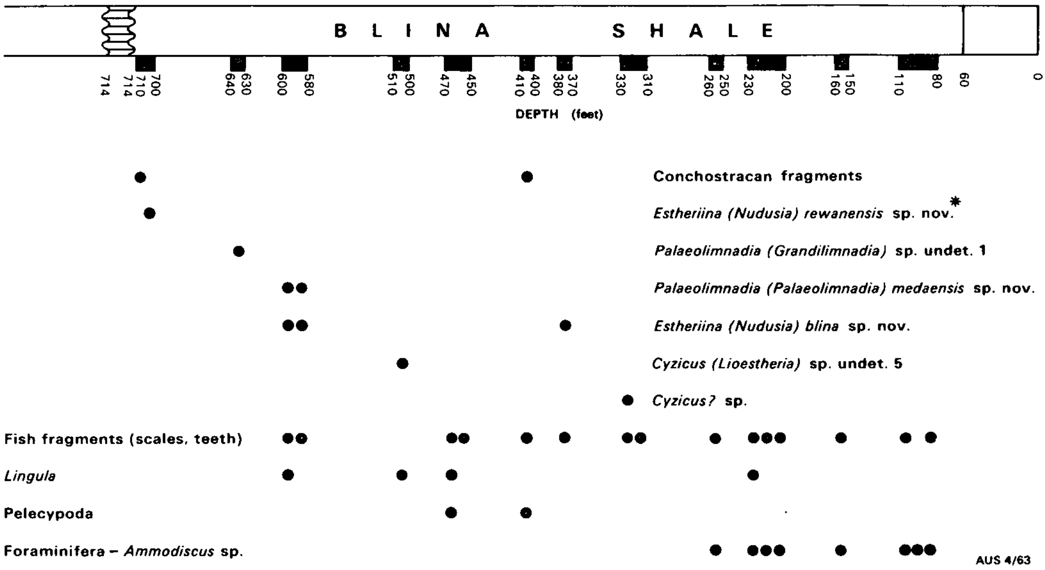

Fig. 3. Distribution of Lower Triassic Conchostraca (described by P. Tasch) and other fossils (identified by P. J. Jones) in the Blina Shale in Meda No. 1 well; based on cuttings.

* *Estheriina (Nudusia) rewanensis* **is a new species described by Tasch (this volume, Paper 3).**

nadia (*Palaeolimnadia*) and *Palaeolimnadia* (*Grandilimnadia*). The lectotype of Mitchell's (1927, pl. 2, fig. 8, *non* fig. 7) species *Estheria wianamattensis,* as chosen by Novozhilov (1958), is selected in this paper as the type species for the subgenus *Palaeolimnadia* (*Palaeolimnadia*). Thus, the new combination for the name of Mitchell's species is *Palaeolimnadia* (*Palaeolimnadia*) *wianamattensis* (Mitchell, 1927). This species also occurs in the Wongil Ridge sample (Fig. 1).

The second of Mitchell's (1927, pl. 2, fig. 7, *non* fig. 8) specimens, originally assigned to *Estheria wianamattensis,* is here selected as the holotype of a new species—the type species of the new subgenus *Palaeolimnadia* (*Grandilimnadia*)—namely, *Palaeolimnadia* (*Grandilimnadia*) *mitchelli* sp. nov. A new species belonging to this subgenus is present in Meda No. 1 Well (580-600 feet), and is described herein as *Palaeolimnadia* (*Grandilimnadia*) *medaensis* sp. nov; an undetermined species of this subgenus also occurs in the same well (630-40 feet).

The numerous limnadiid types from the Russian Lower Mesozoic and older beds (Novozhilov & Kapel'ka, 1968) suggest other dispersals than those noted earlier. A *Palaeolimnadia-Cyzicus* fauna has been reported from the Knocklofty Formation—a correlate of the Blina Shale; the older Ross Sandstone (Poatina, Tasmania) also had palaeolimnadids (Tasch, 1975).

The Genus Estheriina

As with *Palaeolimnadia,* it was found desirable to set up two subgenera of *Estheriina*: *Estheriina* (*Nudusia*) to accommodate the Blina Shale material, and *Estheriina* (*Estheriina*) to cover the original Brazilian specimens from the Lower Cretaceous.

Kobayashi (1954) reassigned two of Mitchell's Newcastle Coal Measures specimens to *Estheriina*: *Estheria glabra* and *Estheria glenleensis.* These species were previously placed under the new genus *Palaeolimnadia* (Raymond, 1946). The present study favors Raymond's assignments of the two named species. *Estheria glabra* with prominent umbo and few growth bands is here placed in *Palaeolimnadia* (*Palaeolimnadia*). *Estheria glenleensis* with a greater number of growth bands is assigned to *Palaeolimnadia* (*Grandilimnadia*). Another of Mitchell's species, *Estheria linguiformis,* was questionably placed under *Palaeolimnadia* by Raymond. This assignment is doubtful.

Further material from the Japanese Triassic (Carnian), described by Kobayashi (1952), was placed under *Estheriina*: *Estheriina nakazawai* and *Estheriina atsuensis.* Of these the former appears to fit the description of the new subgenus *Estheriina* (*Nudusia*), and should be placed under it; the last named species does not fit the description given for either of the two *Estheriina* subgenera.

Palaeolimnadia petri Almeida, 1950 from the Botucatú Sandstone (Rhaetic-to-Liassic) was placed under *Estheriina* by Kobayashi. As described by Almeida (1950), the umbonal region is elongate and there are about twelve growth bands. This would place it under *Palaeolimnadia* (*Grandilimnadia*), since it also has the other features of this subgenus, an H/L ratio, determined from photographs, of 0.69 and numerous growth bands.

From the above discussion it follows that some Blina Shale *Estheriina* species (Lower Triassic) can only be compared to *Estheriina nakazawai* Kobayashi, 1952 from the Upper Triassic of Japan. Thus, exotic affinities noted for certain Canning Basin Carboniferous conchostracan genera would apply to the Triassic genus *Estheriina*.

Changes within the conchostracan fauna of the Canning Basin in Triassic time

In the Canning Basin, only one of the six genera present in the Carboniferous was found in Triassic rocks, namely *Cyzicus;* furthermore, this genus is represented in the Blina Shale by species which appear to be confined to the Triassic System. The absence of leaiid conchostracans in the Blina Shale conforms with the absence of this group in post-Permian rocks in other parts of the world. The same observation also applies to two other ribbed genera of the Carboniferous fauna, *Rostroleaia* and *Limnadiopsileaia,* which have a more restricted geographical distribution than *Leaia.* Besides the disappearance of several generic types in the Canning Basin between Carboniferous and Triassic time, the appearance of the two genera *Palaeolimnadia* and *Estheriina,* unknown in the Carboniferous of the Canning Basin, needs further consideration.

Definite *Palaeolimnadia* species were collected in situ in the Upper Permian Newcastle Coal Measures of eastern Australia (Tasch, 1970, unpublished field notes), and were also found in Mitchell's collections on deposit at the Australian Museum. Thus late Palaeozoic palaeolimnadids were available for passive dispersal westward, to account for the presence of this genus in the Blina Shale, and in the east, to account for their presence in the younger Wianamatta Group.

The remaining genus, *Estheriina,* appears to have been a migrant, since it is unknown in Palaeozoic rocks in both eastern and Western Australia.

4. SYSTEMATIC DESCRIPTIONS (PT)

Order **CONCHOSTRACA** Sars, 1867

Suborder **SPINICAUDATA** Linder, 1945

Superfamily **LEAIOIDEA** Raymond, 1946

Family **LEAIIDAE** Raymond, 1946

Genus **Leaia** Jones, 1862

There has been a tendency among authors (e.g., Kobayashi, 1954; Novozhilov, 1956) to erect new genera among the ribbed conchostracans, i.e. leaiids. Many of these were so close to *Leaia* that Tasch (1969) put them into synonomy of that genus. However, after examination of many collections of ribbed types it became clear that among the leaiids there were really two distinct groupings, and that to so distinguish these on the subgeneric level would increase precision in taxonomy and stratigraphy. Accordingly within the genus *Leaia* two subgenera are recognised here; *Leaia* (*Hemicycloleaia*) to cover circular to ovate forms, and *Leaia* (*Leaia*) to cover rectangular, subquadrate to subelliptical forms.

Kobayashi (1954) also placed *Hemicycloleaia* in synonomy of *Leaia,* and Dechaseaux (1953) recognised that Raymond's genus *Hemicycloleaia* should rank as a subgenus, as here proposed.

Subgenus **Leaia** Jones, 1862

1862 *Leaia* Jones, appendix, p. 116; pl. 5, figs. 11, 12.

1969 *Leaia* Jones; (in part) Tasch, p. 159; fig. 55, 1.

Type species: Leaia leidyi (Lea), 1855.

Type level: Lower Carboniferous (Mississippian, Chesterian), Mauch Chunk shale, one mile southeast of Pottsville, Pennsylvania.

Leaia (Leaia) andersonae sp. nov.

(Pl. 1, fig. 1)

Derivation of name: After the Anderson Formation.

Holotype: Left valve (CPC 17135), from WAPET Grant Range No. 1 Well, core 62, 8530-36 feet. Anderson Formation.

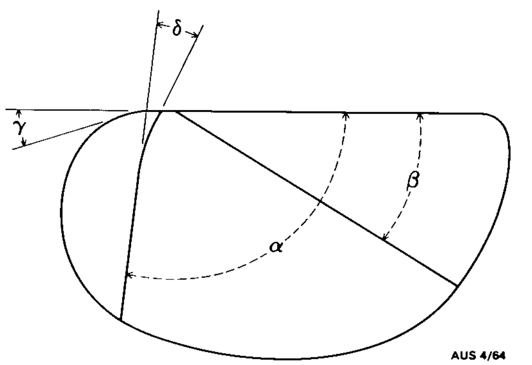

Fig. 4. Ribbed conchostracan valve angles. Delta and gamma measure angular deviations from a straight line, represented respectively by the anterior rib (delta angle) and dorsal margin (gamma angle). Alpha and beta angles are both measured from dorsal margin to the anterior rib (alpha angle) and posterior rib (beta angle).

Diagnosis: Subelliptical bicarinate valves; arcuate anterior rib does not reach ventral margin ending on the third from last growth band; posterior rib reaches next to last growth band. Ribs are separated where they originated on umbo; dorsal margin thickened into a carina. Twenty-two growth bands.

*Measurements:**

Specimen	L	H	H/L	α	β	γ	δ
Holotype							
CPC 17135	7.2	~4.1	~0.57	81°	23.5°	27°	9.5°

Remarks: This species, based on a single left valve, is distinguished from other leaiids by its distinctive elongate outline in lateral view.

Subgenus **Hemicycloleaia** Raymond, 1946

1946 *Hemicycloleaia* Raymond, p. 286, pl. 6, fig. 2

1953 *Leaia* (*Hemicycloleaia*) Raymond; Dechaseaux, p. 263.

1969 *Leaia* Jones; (in part) Tasch, p. 169.

Type species: Hemicycloleaia laevis Raymond, 1946.

Type level: Upper Pennsylvanian, Conemaugh Series, (Missourian) shale above lower Mahoning Sandstone, Conemaugh, Pennsylvania.

Emended diagnosis: Bi-to-tricarinate leaiids with circular-to-ovate valve configuration.

Leaia (Hemicycloleaia) rectangellipta sp. nov.

(Pl. 1, figs. 2-4)

Derivation of name: After the outline of the valves (see diagnosis).

* See Figure 4 for key to Greek symbols

Holotype: Left valve (CPC 17136), from WAPET Grant Range No. 1 Well, core 52, depth 7907-12 feet. Anderson Formation.

Material: Two pieces of black carbonaceous shale bearing a mirror image of the same carbonised valve.

Diagnosis: Left valve with subrectangular configuration posteriorly and subelliptical anteriorly. Dorsal margin bears a rib (reflected as a flange on the internal mould). Face of valve bears two ribs: posterior rib straight and reaches ventral margin; anterior rib gently arcuate, fades out around the 16th growth band. Ribs do not converge on umbo.

Number of growth bands: 28+; vari-spaced; youngest, umbonal set of four bands/0.42 mm; middle of valve, 4 bands/1.5 mm; near ventral margin 4/0.64 mm. Posterior margin of valve missing.

Measurements:

Specimen	L	H	H/L	α	β	γ	δ
Holotype							
CPC 17136	7.4	4.4	0.59	96°	27.5°	14°	12.5°

Distance apart of ribs on umbo = 0.6.
Width of flange reflection of dorsal rib = 0.3.

Remarks: This species is unlike any described leaiid in the combined features—configuration, rib types and their angles and/or deviations from straight line.

Leaia (Hemicycloleaia) grantrangicus sp. nov.

(Pl. 1, figs. 5, 6)

Derivation of name: After the Grant Range.

Holotype: Right valve (CPC 17137), from WAPET Grant Range No. 1 Well, core 52, depth 7907-12 feet. Anderson Formation.

Material: Two pieces of black carbonaceous shale which bear a mirror image of the same carbonised valve.

Diagnosis: Right valve with broadly subovate configuration; dorsal margin bears a rib reflected as a narrow flange; face of valve bears two ribs: posterior rib straight, does not reach margin and widens posteriorly to 10th growth band then tapers to point at 18th growth band; anterior rib gently arcuate, fades out by the twelfth growth band. The rib bears weakly expressed nodes where growth bands cross it, and widens anteriorly. Ribs do not converge at umbo.

Number of growth bands = 20, occurring in two major cycles, one of 13 wider spaced bands, and one of 7 more tightly spaced bands; in first cycle there are 4 bands/0.89 mm; at base of first cycle, 4 bands/1.37 mm; second cycle: less than 4/0.70 mm.

Measurements:

Specimen	L	H	H/L	α	β	γ	δ
Holotype CPC 17137	7.8	4.8	0.62	83°	29°	8°	15.5°

Remarks: This species differs from *Leaia* (*H.*) *rectangellipta* in configuration and in angles alpha and gamma; and in having a posterior rib that does not reach central margin. It resembles *Hemicycloleaia haynesi* Raymond in H/L ratio but differs in having an arcuate anterior rib (straight in *H. haynesi*) and markedly smaller alpha and beta angles. By casual inspection it appears to resemble *Siberioleaia* ex gr. *haynesi* (Raymond) (Zaspelova, 1966, p. 132, pl. 8, figs. 2, 3) but differs in all measured angles—delta and gamma angles, which respectively reflect curvature of the dorso-anterior valve margin and of the anterior rib, and alpha and beta angles as well.

Leaia (Hemicycloleaia) tonsa sp. nov.

(Pl. 1, figs. 7, 8)

Derivation of name: Latin, *tonsum*, shorn or clipped.

Holotype: Right and left valves (CPC 17138), from WAPET Grant Range No. 1 Well, core 62, 8530-36 feet. Anderson Formation.

Material: Right valve (interior aspect), slightly covering left valve (external aspect). (Sphere opposite posterior rib of left valve is a clump of pyrite crystals.)

Diagnosis: Left and right valve with subrectangular configuration posteriorly, and subovate anteriorly. Bicarinate: ribs begin on third growth band of umbonal region. Posterior and anterior ribs end at eighth growth band above ventral margin.

Dorsal margin straight; 30 growth bands; umbonal: 4/0.4 mm; middle of valves: 4/0.7 mm; last 4 bands/0.5 mm (measured on right valve).

Measurements:

Specimen	L	H	H/L	α	β	γ	δ
Holotype CPC 17138	6.0	4.4	0.73	112.5°	34.5°	14°	13°

Distance apart of ribs on umbo = 0.7.

Remarks: Non-persistence of both ribs beyond the 23rd growth band is a distinctive feature.

Leaia (Hemicycloleaia) longicosta sp. nov.

(Pl. 2, figs. 1, 2)

Derivation of name: Latin, *longus*, long + *costa*, a rib.

Holotype: Right valve (CPC 17139), from WAPET Grant Range No. 1 Well, core 52, 7907-12 feet. Anderson Formation.

Material: An external mould of right valve and a rubber impression of this.

Diagnosis: Ovate valves, robust and bicarinate; anterior rib ending on fifth growth band from ventral margin, and posterior rib reaching ventral margin.

Measurements:

Specimen	L	H	H/L	α	β	γ	δ
Holotype CPC 17139	5.3	3.7	0.70	94°	33°	18°	12°

Remarks: Both ratio and angular measurements are close to those of *Leaia* (*H.*) *tonsa* sp. nov. The species differ in the extent of the ribs. In *L.*, (*H.*) *tonsa* both ribs end on eighth growth band above ventral margin, in the new species rib termination is unequal.

Genus **Monoleaia** Tasch, 1956

Type species: Leaia unicostata Reed, 1929, pl. figs. 17, 17a.

Type level: Upper Permian, Brazil.

Monoleaia australiata sp. nov.

(Pl. 2, fig. 4)

Holotype: Right valve (CPC 17140), from WAPET Grant Range No. 1 Well, core 52, 7907-12 feet. Anderson Formation.

Diagnosis: Subrectangular posteriorly to subovate anteriorly; bearing a single rib crossed by growth bands and appearing segmented. Dorsal margin straight to umbonal area, and thickened slightly compared to the single body carina; dorsal margin thickness disappears near umbo; umbonal area crushed. Twelve growth bands below crushed umbonal area followed by three at base of umbonal area; younger growth bands obscured. Posterior margin partially covered. Umbonal growth bands: 3 bands/0.25 mm, bands directly below umbonal area: 4/0.48 mm; terminal bands of valve: 4/0.35 mm.

Measurements:

Specimen	L	H	H/L	β	γ
Holotype CPC 17140	3.2	1.4	0.43	22°	12°

Remarks: Monocarinate leaiids are known from the Upper Permian of Brazil and the USSR. A previously reported monoleaiid (*Monoleaia karagandica* Miroschnichenko, 1956) from rocks of late Namurian age from the Karaganda Basin (USSR) was reassigned by Tasch (1969) to *Monoleiolophus* Raymond, 1946. Thus the Canning Basin specimen is the first monoleaiid from the Carboniferous.

Genus **Rostroleaia** Novozhilov, 1952

Type species: Rostroleaia martynovae Novozhilov, 1952, p. 1369, fig. 1; by original designation.

Type level: Upper Permian (Kazanian).

Type locality: Nikolaevsk Gorge, Kargaline Mine, Ural Mountain Region, USSR, at the boundary with the Kungurian.

Diagnosis: Elongate bicarinate valve with posterodorsal sector limnadiform, this feature being expressed in some species by sharply pointed termination of dorsal margin.

Emended diagnosis: Posteriorly, dorsal margin may be gently deflected upward from usual straightness and/or prolonged posterodorsally.

Rostroleaia sp.

(Pl. 2, fig. 5)

Material: A left valve, from WAPET Grant Range No. 1 Well, core 52 (7907-12 feet), Anderson Formation, which unfortunately was accidentally destroyed after it had been described.

Diagnosis: Valves subovate, with thickened posterior rib and dorsal margin. Dorsal margin deflected (see arrow on figure) and posterior growth bands gently recurved in postero-dorsal sector. Both ribs reach ventral margin. Anterior rib straight; 15 growth bands.

Measurements:

Specimen	L	H	H/L	α	β	γ	δ	λ*
Destroyed	3.0	2.1	0.70	92°	31.5°	23.5°	0°	15°

* angle of deflection of dorsal margin from a straight line (see arrow in Pl. 2, fig. 5).

Remarks: One of Novozhilov's species, *Rostroleaia sarbalensis* (1956, pl. 9 fig. 3) as reconstructed has the deflected rostrate dorsal margin comparable to the new species. The two species are close in alpha and beta angles and general size, but the species described here has (a) a straight not a curved posterior rib, (b) a markedly thickened posterior rib, and (c) a slight but more extensive deflection of the dorsal margin which in *R. sarbalensis* is proximate to the posterior termination of the margin. The Australian specimen was considered at the time of description to represent a new species.

Superfamily **VERTEXIOIDEA** Kobayashi, 1954

Family **LIMNADIOPSIDAE** Tasch, 1969

Genus **Limnadiopsileaia** Tasch, 1962

Type species: Limnadiopsileaia noblensis Tasch (W.U. 104.00), 1962, p. 820-821, pl. 120, figs. 2-4.

Type level: Lower Permian (Leonardian).

Type locality: Tasch Station Noble 1E, Noble County, Oklahoma, Wellington Formation.

Original diagnosis: Valves resembling *Palaeolimnadiopsis* but bearing an anterior rib.

Emended diagnosis: Single rib may be anterior or posterior.

Limnadiopsileaia carboniferae sp. nov.

(Pl. 2, figs. 6-8)

Derivation of name: After the Carboniferous Period

Holotype: A single left valve (CPC 17141), from WAPET Grant Range No. 1 Well, core 52, 7907-12 feet. Anderson Formation.

Diagnosis: Umbonal region and anterodorsal area obscured by crushing yet bearing diagnostic features: posterodorsal margin recurved; presence of a single rib—posterior rib.

Original configuration apparently subovate; dorsal margin straight but slightly upturned at posterior end. Twelve growth bands from ventral margin to crushed umbonal area.

Measurements:

Specimen	L	H	H/L	β
Holotype CPC 17141	6.2*	3.4*	0.54*	34°

* estimated.

Remarks: This is obviously a new species, only one other being known (Tasch, 1969). Shell repair (cf. Tasch, 1961) is excellently seen in the upturned growth bands on the ventral margin (two bands are upturned at site of original injury).

Superfamily **CYZICOIDEA** Stebbing, 1910

Family **ASMUSSIIDAE** Kobayashi, 1954

Genus **Ellipsograpta** Chang, 1957

Type species: Ellipsograpta elliptica Chang, 1957, p. 491; by original designation.

Type level: Middle or Upper Cretaceous Nenkiang Shale, northwestern Heilungkiang province, China.

Ellipsograpta? sp.

(Pl. 3, fig. 2)

Material: A single valve from WAPET Grant Range No. 1 Well core 59 (8164-68 feet), Anderson Formation, which unfortunately was accidentally destroyed after it had been described.

Diagnosis: Narrow elliptical carapace with straight (asmussid type) dorsal margin; umbo almost subcentral and rising above dorsal margin. Few growth bands (roughly 10-12); ornamentation consists of small tubercles.

Measurements:

Specimen	L	H	H/L
Destroyed	1.8	1.0	0.55*

* Chang's species had an H/L ratio of 0.5-0.6.

Remarks: This specimen was considered at the time of description to represent a new species, and the first known Palaeozoic representative of the genus *Ellipsograpta.* Dr P. J. Jones (pers. comm.) has pointed out that the specimen, as illustrated, resembles *Cryptophyllus* sp. B. Jones, 1962, which he described from core 72 (9796-99 feet) of the same well. Adamczak (1961) assigned the genus *Cryptophyllus* to the Eridostraca, which he considered as a suborder of the Ostracoda. Neither Jones (1968) nor Langer (1973) included the Eridostraca in the Ostracoda, and Jones (op. cit.) has suggested that this taxon may belong to a previously unrecognised, extinct group (subclass?) of marine branchiopods. I do not accept this assignment to the Branchiopoda, and know of no marine branchiopods in the fossil record (post-Devonian), although brackish types are known. Regardless of the true biological affinities of the Eridostraca, the specimen designated here as *Ellipsograpta?* sp. is ornamented with small tubercles, a feature not present in *Cryptophyllus* sp. B. Moreover, since this specimen is now destroyed, it is not possible to determine whether its carapace structure was eridostracan or conchostracan in cross-section.

Family **CYZICIDAE** Stebbing, 1910

Genus **Cyzicus** Audouin, 1837

Subgenus **Lioestheria** Depéret & Mazeran, 1912

Type species: Estheria (*Lioestheria*) *lallyensis* Depéret & Mazeran, 1912, p. 167; by original designation.

Type level: Lower Permian, Autun, France.

Cyzicus (Lioestheria) sp. undet. 1

(Pl. 3, fig. 1)

Material: One flattened carbonised impression of right valve (CPC 17142).

Locality: WAPET Grant Range No. 1 Well, core 52, 7907-12 feet. Anderson Formation.

Diagnosis: Elongate-ovate (lozenge-shaped) valves, with posterior margin sharply rounded, dorsal margin straight, and anterior margin sharply arcuate. Six umbonal growth bands widely spaced; tighter spacing of bands in younger parts of shell; ornamentation punctate.

Measurements:

Specimen	L	H	H/L
CPC 17142	4.1	2.4	0.58

Remarks: The distinctive features of this species are lozenge-shaped valve, and curvature of anterior margin.

Cyzicus (Lioestheria) sp. undet. 2

(Pl. 3, fig. 4)

Material: A single left valve (CPC 17143).

Locality: WAPET Grant Range No. 1 Well, core 52, 7907-12 feet. Anderson Formation.

Diagnosis: A single crushed specimen (length 1.7 mm) with an ovate configuration (when restored). Hachure markings on growth bands place this specimen in sugenus *Lioestheria.* Growth bands more than 8.

Remarks: This very poor material is figured because it clearly represents a species distinct from *Cyzicus* (*Lioestheria*) sp. undet. 1 from the same core and elevation.

Cyzicus (Lioestheria) erskinehillensis sp. nov.

(Pl. 3, fig. 3)

Derivation of name: After Erskine Hill, Canning Basin.

Holotype: Right valve (CPC 17144), from Erskine Hill; Blina Shale.

Material: Khaki brown shale bearing a coquina of whitened internal (but one external) moulds of conchostracans (BMR Reg. No. 65630004); right and left valves. Unfigured paratypes CPC 17146, 17147, and other specimens CPC 17145, 17148 and 17149. Many valves buried or incomplete; umbonal and marginal areas often eroded. No other fauna visible on planes packed with these valves.

Diagnosis: Subelliptical to subovate valves with umbo on anterior third of valve. Dorsal margin straight; growth bands broadly spaced, bearing minute pores; umbonal area eroded. On mid-valve below the umbo, spacing of growth bands; 4 growth bands/5 mm; last 4 growth bands/3 mm. Dorso-posterior narrow; flat flare beyond umbo in some specimens (including holotype), no flare in others.

Characteristic H/L ratio = 0.60–0.70; ratio of length of dorsal margin (Ldm) to length of valve: 1:2 or 1:2+.

Specimen		L	H	H/L	Ldm	Ldm/L
Holotype	CPC 17144	3.2	2.0	0.62	1.3	0.41
Paratype	CPC 17146	2.1	1.4	0.66	1.1	0.52
Paratype	CPC 17147	2.0	1.4	0.70	1.1	0.55
	CPC 17145	2.3	1.6	0.69	1.1	0.48
	CPC 17148	2.5	1.6	0.64		
	CPC 17149	2.0	1.3	0.65		

Locality: Erskine Hill, 100 km SE of Derby, Canning Basin; Blina Shale; BMR Reg. No. 65630004.

Remarks: The new species is unlike any described by Mitchell, Kobayashi, Pruvost, Chernyshev, Raymond, and others in its distinctive valve properties.

Population density: On a given plane surface of a fossiliferous slice, 4 mm wide x 10 mm long, 117 valves were counted. This density was maintained through a thickness of 25 mm (the thickness of the slice bearing the coquina). As determined by valves partly exposed on a side face, approximately twenty successive generations occur, separated by variable small increments of sediments generally 1.0 mm or less.

Cyzicus (Lioestheria) australensis (Novozhilov, 1958)

(Pl. 3, fig. 5)

1888 *Estheria?* sp., Etheridge Jr, p. 7, pl. 1, figs. 6-9 (?10).

1927 *Estheria coghlani* Etheridge Jr; Mitchell, p. 106, pl. 2, fig. 5. (*non* figs. 3; or 4 = *Cornia coghlani*).

1946 *Palaeolimnadia coghlani* (Etheridge Jr); Raymond (in part), p. 264.

1958 *Belgolimnadiopsis australensis,* Novozhilov p. 97, fig. 2 (= fig. 5 of Mitchell, 1927).

Holotype: A right valve illustrated by Mitchell (1927, pl. 2, fig. 5) which is identical to F 25492 on deposit at the Australian Museum, and came from Glenlee, near Campbelltown, Wianamatta Group, Middle Triassic, Sydney Basin, NSW: originally designated by Novozhilov, 1958, p. 97.

Paratypes: Valves illustrated by Etheridge Jr (1888, pl. 1, fig. 6) (F 35720—depth 1483 feet); fig. 7 (F 35721); fig. 8 (F 35723—depth 1932 feet); fig. 9 (F 35722—depth 2000 feet); fig. 10(?) (F 35719) all from Dents Creek Bore, Holt Sutherland Estate, Georges River, except fig. 10, which is from Narrabeen Bore. All from the Lower Triassic Narrabeen Group, Sydney Basin, NSW.

Diagnosis: Subovate valves with central to subcentral umbonal region crossed by growth bands; slope on either side of umbo confers a triangular aspect where umbo is centrally located. Lacks polygonal ornamentation.

Measurements:

Specimen	L	H	H/L	Growth band count: Umbonal	Growth band count: Below umbonal area
Holotype (F 25492)	2.8	2.1	0.75	4	11+
Paratype (F 35723)	3.0	2.4	0.80	3-4	10

Remarks: Etheridge Jr (1888, p. 7) suggested there might be two distinct species: in the upper level of Dents Creek Bore, a small species, 1.25-2.00 mm long, and a larger species, 2.0-5.0 mm long, below the 1915 feet level (*Estheria* sp.). He considered the smaller species conspecific with Cox's Moore Park species, named *Estheria coghlani* but unfigured (Cox, 1881, p. 276). It is the second species (*Estheria* sp.) of Etheridge Jr that is identified here as *Cyzicus* (*Lioestheria*) *australensis* (Novozhilov, 1958) nov. comb. *Estheria coghlani* was figured by Etheridge (1888) on the basis of Cox's original drawings. The original specimens used by Cox were lost by then (Etheridge, 1888, figs. 1-5). However, the originals for figures 6-10 are not lost and are included in the listings of Museum specimens below.

From Etheridge's discussion and figures, and my study of Australian Museum specimens labelled *'Estheria coghlani'* and numbered F 25474, F 25492, F 35719, F 35720, F 35721, and F 35723, it is clear that his typical representative of this species (1888, pl. 1, fig. 1) was a specimen (F 25474) that bore an umbonal node or spine and hence was a *Cornia*-type as now understood.

Mitchell (1927) illustrated three specimens under the name *'Estheria coghlani'* (pl. 2, figs. 3-5) of which only the one represented by figure 5 is clearly Etheridge's *'Estheria* sp.' (pl. 1, figs. 6-9; 10?). This specimen was designated the holotype of *Belgolimnadiopsis australensis* by Novozhilov (1958).

The recurrence of *Cyzicus* (*Lioestheria*) *australensis* in Dents Creek Bore, through a thickness of some 517 feet, is a measure of the persistence of this species.

A specimen (CPC 17150) belonging to *Cyzicus* (*Lioestheria*) *australensis* was found in Wade's (1936) material collected from the Lower Triassic Blina Shale at Bell's Ridge, Canning Basin, and is figured in Plate 3, fig. 5. It occurred on the same slab that contained the holotype of the pelecypod *'Carbonicola' minutissima* (Chapman & Parr, 1937).

Cyzicus (Lioestheria) sp. undet. 3

(Pl. 3, fig. 6)

Material: A left valve (CPC 17151) from BMR locality M29, Chilpada Chara, Minnie Range, Cornish 1:250 000 Sheet. Lower Triassic Blina Shale.

Diagnosis: Subovate valve, with posterior and dorsal margins eroded. Umbo terminal; anterior margin, gently arcuate. First 7 growth bands widely spaced; last 5 bands following, tightly spaced; type ornamentation: hachure-type markings.

Measurements:

Specimen	L	H	H/L
CPC 17151	3.9	2.15	0.55

Cyzicus (Lioestheria) sp. undet. 4

(Pl. 3, fig. 7)

Material: A right valve (CPC 17152) from BMR locality M29, Chilpada Chara, Minnie Range, Cornish 1:250 000 Sheet. Lower Triassic Blina Shale.

Diagnosis: Ovate valve with beak subterminal; 24 growth bands below eroded umbo; ornamentation: hachure-type markings.

Measurements:

Specimen	L	H	H/L
CPC 17152	3.2	2.5	0.78

Remarks: Differs from *Cyzicus* (*Lioestheria*) sp. undet. 3 in configuration and umbonal position.

Cyzicus (Lioestheria) sp. undet. 5

(Pl. 4, figs. 1, 2)

Material: Figured specimens CPC 17153 from BMR locality M52, Lake Jones, Mount Bannerman 1:250 000 Sheet, and CPC 17154 from WAPET Meda No. 1 Well (cuttings from 500-10 feet); both the Lower Triassic Blina Shale.

Diagnosis: Subovate valves bearing some 11 growth bands; punctation poorly displayed; medial and posterior sectors crushed. Coloration, red-brown.

Measurements:

Specimen	L	H	H/L
CPC 17153	1.9	1.3	0.68
CPC 17154	2.0	1.5	0.75

Superfamily **LIMNADIOIDEA** Baird, 1849

Family **LIMNADIIDAE** Baird, 1849

Subfamily **ESTHERIININAE** Kobayashi, 1954

Genus **Palaeolimnadia** Raymond, 1946

1958 *Kontikia* Novozhilov, fig. 2, p. 91.

Type species: Estheria wianamattensis Mitchell, 1927, pl. 2, figs. 7, 8 (syntypes).

Type locality and horizon: Cutting on the Great Southern Railway, near Glenlee homestead, Wianamatta Group.

Lectotype: Specimen F 25490 on deposit at the Australian Museum, illustrated as figure 8 on Mitchell's (1927) plate 2 (see remarks under *Palaeolimnadia* (*Palaeolimnadia*)).

Diagnosis: Relatively long oval carapaces; large, smooth umbonal area and few growth lines.

Emended diagnosis: The genus was succinctly described (Tasch, 1975) as consisting of two subgenera: *Palaeolimnadia* (*Palaeolimnadia*), with a few growth bands and a form ratio of height to length (H/L) of about 0.82 and *Palaeolimnadia* (*Grandilimnadia*) with few to numerous bands and a form ratio of about 0.63.

Remarks: The paper published in 1975 was written after the original typescript of this paper, while the present manuscript was being revised. It had been anticipated the present paper would be printed first and carry the full description and designation of type species. As will be seen below, the proper 'indication' on the subgeneric level (the same as for genus) is given. The current paper thus carries the first 'indication' of the two *Palaeolimnadia* subgenera. [The same applies to the two subgenera, described subsequently, of *Estheriina.*]

Novozhilov (1950, *in* Novozhilov, 1958) erected a new genus *Kontikia* (type species *Estheria wianamattensis* Mitchell, 1927, p. 108, pl. 2, fig. 8) based on slight recurvature of the dorsal margin of *Palaeolimnadia* (which does not actually occur) and a new interpretation of the ornamentation pattern between growth bands (which cannot be confirmed from Mitchell's specimens). Even if one could find such a pattern it would not merit generic status (Tasch, 1969, R144).

Subgenus **Palaeolimnadia** Raymond, 1946

Type species: Palaeolimnadia (*Palaeolimnadia*) *wianamattensis* (Mitchell, 1927), 108, pl. 2, fig. 8 (*non* fig. 7 = *Palaeolimnadia* (*Grandilimnadia*) *mitchelli* sp. nov.).

Diagnosis: A permanent naupliid carapace; swollen umbonal area occupies a considerable area of valves, and is surrounded by a few growth bands.

Remarks: Mitchell did not indicate which of his figures is the holotype, and Raymond (1946, p. 263, pl. 3, figs. 7, 8) did not designate a lectotype when he selected *Estheria wianamattensis* as the 'genotype' (= type species) of the genus *Palaeolimnadia.* Novozhilov (1958, p. 88) pointed out, however, that Mitchell's type specimens represented two different species, and by suggesting that the first (pl. 2, fig. 7) was synonymous with the holotype (by monotypy—pl. 2, fig. 6) of *Palaeolimnadia glenleensis* (Mitchell, 1927), he concluded that the second (pl. 2, fig. 8) remained as the type specimen of *Estheria wianamattensis.* Thus it is clear that (i)

Novozhilov's (1958) paper was the first published designation of a lectotype for *Estheria wianamattensis* Mitchell, 1927 (International Code of Zoological Nomenclature, 1961, article 74, p. 79); and (ii) because *Estheria wianamattensis* is the type species of *Palaeolimnadia* Raymond, 1946, its later selection as the type species of *Kontikia* Novozhilov, 1958, is invalid. *Kontikia,* already shown to be invalid on morphological grounds, is therefore a junior synonym of both the genus *Palaeolimnadia* Raymond and its nominate subgenus.

Palaeolimnadia (Palaeolimnadia) wianamattensis (Mitchell, 1927)

(Pl. 4, fig. 3)

1927 *Estheria wianamattensis* Mitchell, p. 108, pl. 2, fig. 8 (*non* fig. 7).
1946 *Palaeolimnadia wianamattensis* (Mitchell); Raymond, pp. 263-4, pl. 3, fig. 8 (*non* fig. 7).
1954 *Estherites wianamattensis* (Mitchell); Kobayashi (in part), pp. 30, 110.
1958 *Kontikia wianamattensis* (Mitchell); Novozhilov, pp. 87-88, fig. 2, p. 91.

Material: Brunnschweiler's Wongil Ridge locality, Lower Triassic Blina Shale. Specimens CPC 17156 and 17157 on red shale slab.

Diagnosis: Ovate to subovate valves with an umbo very large compared to rest of valve: growth bands, about 3 to 6.

Measurements:

Specimen	L	H	H/L	GB
CPC 17156	2.3	2.0	0.87	5 to 7
CPC 17157	1.9	1.4	0.74	4
Lectotype F 25490	2.1	1.5	0.71	3 to 4

Remarks: The H/L ratio, the large umbo, and few growth bands all are close to Mitchell's species from the Wianamatta Group. Valves are piled on top of one another in a coquina-type accumulation on the surface of a thin red shale slab. Most species on the slab are incomplete, crushed and/or eroded. The chief characteristics of the species—tumid umbo and few growth bands—are visible on numerous specimens.

Subgenus **Grandilimnadia** nov.

Type species: Palaeolimnadia (Grandilimnadia) mitchelli, sp. nov. (= *Estheria wianamattensis* Mitchell, 1927, p. 108, pl. 2, fig. 7 (*non* fig. 8).

Derivation of name: Latin, *grandis,* large + the generic name *Limnadia.*

Diagnosis: Ovate to subovate valves with comparatively large smooth umbo of variable position (from medial to terminal); umbo occupies a smaller shell volume than in *Palaeolimnadia* (*Palaeolimnadia*). Growth bands 4 or more (to 20+).

Palaeolimnadia (Grandilimnadia) mitchelli sp. nov.

1927 *Estheria wianamattensis* Mitchell, p. 108, pl. 2, fig. 7 (*non* fig. 8).
1946 *Palaeolimnadia wianamattensis* (Mitchell); Raymond, pp. 263-4, pl. 2, fig. 7 (*non* fig. 8).
1954 *Estherites wianamattensis* (Mitchell); Kobayashi (in part), pp. 30, 110.
1970 *Limnadia* (*Palaeolimnadia*) *wianamattensis* (Mitchell); Novozhilov, p. 108, fig. 82 (*non* fig. 83 = *P.* (*Grandilimnadia*) *glenleensis* (Mitchell, 1927)).

Derivation of name: In honour of John Mitchell, an educator from Newcastle, New South Wales, who made important contributions to our knowledge of Australian conchostracan faunas in the first few decades of the twentieth century. His work stimulated many investigators to search out conchostracan faunas in their own countries, Raymond (USA), Kobayashi (Japan), and Novozhilov (USSR) among others.

Holotype: A slightly crushed right valve figured by Mitchell, 1927, pl. 2, fig. 7 (F 25487).

Type locality: Railway cutting near Glenlee homestead, Campbelltown area; Wianamatta Group, Middle Triassic, Sydney Basin, NSW.

Diagnosis: Subovate valve with a submedial, comparatively large umbo (that occupies a small volume of the valve); 4 growth bands.

Remarks: *Palaeolimnadia* (*Grandilimnadia*) *mitchelli* is easily distinguished from *P.* (*Grandilimnadia*) *glenleensis* (Mitchell, 1927) by the position of its submedial umbo, and few growth bands.

Palaeolimnadia (Grandilimnadia) medaensis sp. nov.

(Pl. 4, fig. 4)

Derivation of name: After Meda No. 1 Well.

Holotype: A carbonised specimen (CPC 17158) from WAPET Meda No. 1 Well (cuttings at 590-600 feet).

Material: 3 specimens—the holotype and incomplete specimens from the same well in cuttings at 580-90 feet and 590-600 feet.

Diagnosis: Ovate valves, umbo comparatively large, smooth, terminal. Dorsal margin gently curved. 15 growth bands.

Measurements:

Specimen	L	H	H/L
Holotype CPC 17158	2.8	1.8	0.64*

* H/L ratio of 0.60 from an incomplete specimen from cuttings at 590-600 feet.

Remarks: The new species differs from the type species of this subgenus in having a terminal umbo, dorsal margin curvature, and different configuration. The water-body in which this species lived appears to have refilled, as seen by last 7 growth bands which widen in direction of ventral margin. (Note closer spacing of bands above last 7).

Palaeolimnadia (Grandilimnadia) sp. undet. 1

(Pl. 4, fig. 5)

Material: A left valve (CPC 17159).

Locality: WAPET Meda No. 1 Well, cuttings from 630-40 feet. Lower Triassic Blina Shale.

Diagnosis: Partially covered, ovate valve, with subgeneric characteristics of large umbo associated with more than 4 growth bands. Growth bands, 11 swollen, giving deeply incised appearance; last 5 bands tighter spaced than younger ones. Umbo medial, longer than high.

Measurements: H/L ratio = 0.57 (estimated, due to sediment cover and erosion).

Remarks: This is clearly a species differing from *Palaeolimnadia (Grandilimnadia) medaensis* in position and configuration of the umbo (elliptical).

Genus **Estheriina** Jones, 1897

Type species: Estheriina bresilensis Jones, 1897, pl. 8, figs. 1-5; (syntypes): (pl. 8, fig. 5 = 'genotype' (Raymond, 1946) = lectotype, this paper). Jones did not designate which of his five figures was the type species of his genus. Raymond (1946, pl. 4, fig. 5) selected fig. 5 from Jones's figures as the 'genotype' (= type species). However, according to ICZN (1961) Raymond's 'genotype' should be regarded as a 'lectotype' at present.

Type locality: Jones (1897) gave the distances in kilometres (viz. 3.85, 4.0, 5.0 km) from Bahia (Brasil) on the railway (San Francisco Railroad).

Diagnosis (abridged): Valves subovate, with earlier (umbonal) part of the valves very much more convex than the other part of the surface. On the limited umbonal convexity the lines of growth are marked by 8 or 9 concentric growth bands, relatively coarse and wide apart.

Remarks: As originally described (Jones, 1897) and elaborated by Raymond (1946) the umbonal region was more convex (swollen) than lower down on the valve, resulting in an abrupt descent from umbo to rest of the valve. Further, this region bore numerous growth bands. Kobayashi (1954, fig. 16, j, m) noted that two Japanese Triassic species could be assigned to this genus on morphic similarity, even though each of these species lacked umbonal growth bands. Greater taxonomic precision seems possible in formalising this distinction, by subdividing *Estheriina* into two subgenera.

Emended diagnosis: The genus *Estheriina* is subdivided into two subgenera: *Estheriina (Estheriina)* with a more convex umbo bearing growth bands, and *Estheriina (Nudusia)* with a swollen umbonal area lacking growth bands.

Subgenus **Estheriina** Jones, 1897

Type species: Estheriina (Estheriina) bresilensis Jones, 1897, pl. 8, fig. 5.

Type locality: Same as for genus. Cardosa (1966) gave more details than Jones. He located the species in the Ilhas Formation (Wealden age) at 'Estrado de Ferro Leste Brasileiro a 5 km de Salvador proximo ao contacto o cristalino Bahia'.

Diagnosis: *Estheriina*-type valves with a more convex umbonal region bearing growth bands.

Subgenus **Nudusia** nov.

Derivation of name: Latin, *nudus*, naked, bare.

Type species: Estheriina (Nudusia) blina sp. nov.

Type locality: WAPET Meda No. 1 Well.

Diagnosis: Estheriina-type valves with swollen umbonal region barren of growth bands, and slightly elevated above rest of valve.

Estheriina (Nudusia) blina sp. nov.

(Pl. 4, figs. 6, 7)

Derivation of name: After the Blina Shale.

Material: Four specimens and fragments.

Holotype: A left valve (CPC 17160) from WAPET Meda No. 1 Well (cuttings at 590-600 feet), figured in pl. 4, fig. 6.

Paratypes: A right valve (CPC 17161) from locality B-146, Bell's Ridge (formerly an unfigured paratype of *'Carbonicola' minutissima* Chapman & Parr, 1937), now figured in Pl. 4, fig. 7. A carapace (CPC 17162) from WAPET Meda No. 1 Well (cuttings at 370-80 feet), unfigured. An unfigured specimen and fragments also occur in the same well in cuttings at 580-90 feet.

Diagnosis: Subovate valves with large smooth swollen umbo, umbo subterminal, and elevated above dorsal margin; narrow, curved dorsal-anterior shoulders, posterior margin eroded; 16 growth bands.

Measurements:

Specimen	L	H	H/L	lu	hu	hu/lu
Holotype CPC 17160	2.8	2.2	0.78	1.0	0.8	0.80
Paratype CPC 17161	3.2	2.6	0.81	1.2	0.9	0.76
Paratype CPC 17162	~3.5	2.4	—	1.0	0.8	0.80

Remarks: Chapman & Parr (1937) assigned an unfigured paratype of *Estheriina* (*Nudusia*) *blina* (CPC 17161) to the pelecypod genus *Carbonicola;* it is figured here (pl. 4, fig. 7) and reassigned. The specimen is incomplete on the anteroventral, posteroventral, and postero-dorsal sectors, yet displays the characteristics of the conchostracans genus and subgenus described above. The irregular spacing of growth bands (wide, narrow, wide) is characteristically conchostracan, as is the umbonal area.

The holotype of *Carbonicola minutissima* (CPC 2310, pl. 4, fig. 8), bears a crushed umbonal area, which on restoration would be much smaller (different umbonal hu/lu ratio) than the reassigned paratype (pl. 4, fig. 7). The configuration of the holotype denotes a different valve H/L ratio, but the paratype corresponds to a valve which on reconstruction would be more elongate posteriorly. There is thus no basis for conspecificity of Chapman & Parr's holotype (CPC 2310) and paratype (CPC 17161) —the latter reassigned as indicated above.

PAPER 2

Lower Triassic Conchostraca from the Bonaparte Gulf Basin, northwestern Australia (with a note on Cyzicus (Euestheria) minuta [?] **from the Carnarvon Basin).**

BY

P. TASCH & P. J. JONES

SUMMARY

The Lower Triassic conchostracan fauna of the Bonaparte Gulf Basin consists of two genera: *Cyzicus* and *Palaeolimnadia.* Cyzicids were dominant in shales which crop out in the Port Keats area, and throughout the interval between the depths 10 512-11 000 feet penetrated by the offshore Petrel No. 1 Well.

Four cyzicid species are described, two of which are new: *Cyzicus* (*Euestheria*) *dickinsi* and *Cyzicus* (*Euestheria*) *bonapartensis.* Two new palaeolimnadid species are described: *Palaeolimnadia* (*Grandilimnadia*) *arcoensis* and *Palaeolimnadia* (*Grandilimnadia*) *profunda.*

The fauna displays the following characteristics: (i) not a single conchostracan species persisted through the time represented; (ii) no conchostracan species found in the Canning, Sydney, and Bowen Basins are present; (iii) the two conchostracan genera of the Bonaparte Gulf Basin also occur in the Canning Basin fauna, suggesting egg dispersal between the two basins during Early Triassic time; (iv) seasonal control is indicated for the water bodies in which the Bonaparte Gulf Basin conchostracans lived, because they endured from 1-3 months; (v) sparse lingulid brachiopods, the only faunal associate of the conchostracans at certain times, denote brackish water conditions; the complete absence of vegetation signifies temporary pond conditions.

The report of *Cyzicus* (*Euestheria*) *minuta* (von Zieten) from the Lower Triassic Kockatea Shale of the Carnarvon Basin (Cockbain, 1974) is discussed, and its specific identification and supposed marine dispersal are questioned.

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1. INTRODUCTION (PJJ)

Fossil Conchostraca were first recognised in the Bonaparte Gulf Basin by R. Etheridge Jr (1907), who described 'estheriids' from beds of micaceous mudstone encountered in cores recovered from coal bores drilled in 1905 in the Port Keats area, Northern Territory. Etheridge regarded them as of post-Permian age, a concept later supported by Brunnschweiler (1954), when he recorded conchostracans from the Blina Shale of the Canning Basin. Many reports on the regional geology of the Port Keats area (Noakes, 1949; Noakes et al., 1952; Traves, 1955; Thomas, 1957; Dickins et al., 1972) make reference to Conchostraca, but Etheridge's illustrated specimen has never been redescribed, and the present whereabouts of his material is unknown.

No further specimens of Conchostraca were collected from the Bonaparte Gulf Basin until the Bureau of Mineral Resources (BMR) studied the Port Keats area in 1965, and Arco Limited and Australian Aquitaine Petroleum (ARCO-AAP) drilled their offshore well, Petrel No. 1, in 1969 (Dickins et al., 1972; Roberts & Veevers, 1973). The Port Keats collection was considered by Dickins to represent a single variable group (Dickins et al., 1972), and the offshore specimens, originally submitted by Mr A. R. Lloyd (consultant for ARCO) to BMR, were assigned by one of us (Jones *in* Arco & Australian Aquitaine Petroleum, 1969) to a single species of *Euestheria,* probably conspecific with those described by Etheridge (1907).

The present study, which describes both of these collections, shows that the conchostracan fauna is more diverse than either Dickins or Jones originally thought, and compares it with that from the Canning Basin (Tasch & Jones, this volume). All type and figured specimens from these collections are deposited in the Commonwealth Palaeontological Collection of the Bureau of Mineral Resources, Canberra, Australia, and are designated by the prefix CPC.

Responsibility of authors

PT is responsible for the systematic descriptions of all genera and species, and all statements which evaluate their interbasinal relations and palaeoecological significance. PJJ is responsible for the introduction and the locality and stratigraphic data for the collections.

Acknowledgements

We gratefully acknowledge the assistance of Messrs Timothy J. Petta and Scott Fitch of the Department of Geology, Wichita State University, Kansas, who were responsible for the photography; Messrs A. T. Wilson and P. W. Davies (BMR) who prepared the prints and the plate for this paper; and Mr R. R. Melsom (BMR), who drafted the final version of the locality map.

Abbreviations used in the systematic descriptions

L	=	length of valve
H	=	height of valve
H/L	=	height/length ratio of valve
GB	=	number of growth bands
lu	=	length of umbo
hu	=	height of umbo
hu/lu	=	height/length ratio of umbo

All measurements are given in millimetres.

2. EARLY TRIASSIC CONCHOSTRACA

Collection localities and stratigraphy (PJJ)

(i) Locality 619—Lower Triassic shales south of Mount Goodwin, 6 km SE of Port Keats Mission (14°15′53″S; 129°33′37″E), examined by J. M. Dickins in 1965 (Dickins et al., 1972, p. 81, fig. 5), who collected the conchostracans here described by Tasch (Fig. 1).

(ii) ARCO-AAP Petrel No. 1 Well (12°47′30″S; 128°26′50″E) was drilled offshore, 265 km WSW of Darwin down to 13 057 feet (3980 m), the total depth, where a blowout occurred in Upper Permian rocks (Arco & Australian Aquitaine Petroleum, 1969).

Conchostraca, found in the lower part of the Lower Triassic sequence (Nonmarine unit 'C'; Roberts & Veevers, 1973, fig. 15) and determined by Tasch, are listed in Figure 1 together with the depths from which they were recovered.

The *Cyzicus* (*Euestheria*) shales, first recognised in the Port Keats coal bores, are exposed in headlands around Port Keats, and at Mount Goodwin and the Sugarloaf Range, east and southeast of Port Keats Mission

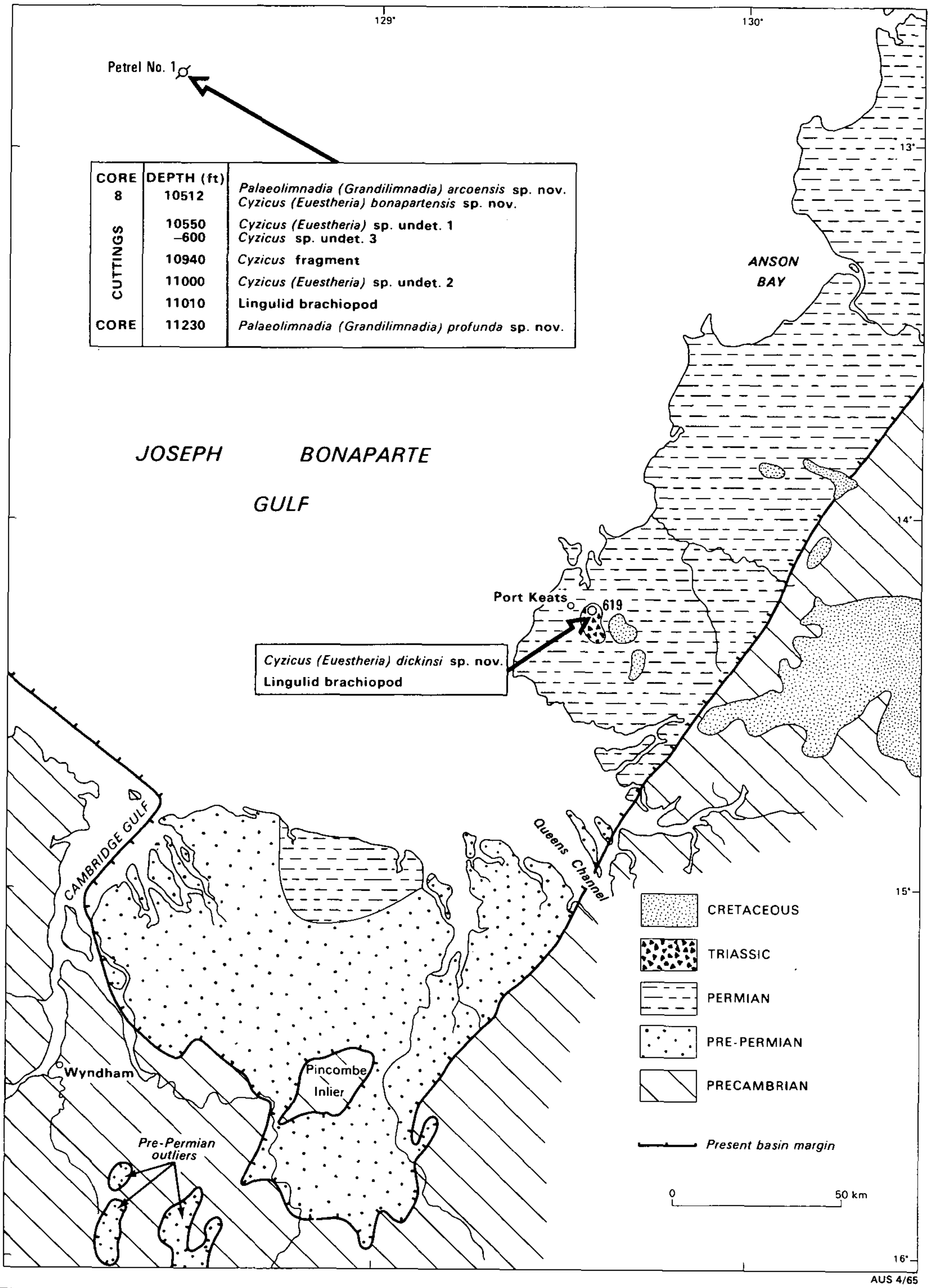

Fig. 1. Lower Triassic conchostracans from the Bonaparte Gulf Basin, and their localities (adapted from figure 2 of Roberts & Veevers, 1973).

(Dickins et al., 1972; Morgan, 1972). This unit, informally named the Mount Goodwin Formation (Laws & Brown, 1976), is widespread offshore, where it averages 400 to 500 m in thickness. In ARCO-AAP Petrel No. 1 Well, it has been assigned on palynological evidence to the *Kraeuselisporites saeptatus* Assemblage Zone of Dolby & Balme (1976), the lowermost microfloral zone of the Triassic of Western Australia. This microfloral zone is present in other conchostracan-bearing shales in Western Australia, viz. the Blina Shale of the Canning Basin and the Kockatea Shale of the Perth Basin, which by correlation are of Early Triassic (early Griesbachian-early Smithian) age (McTavish & Dickins, 1974).

FAUNA (PT)

Composition

Two conchostracan genera occur in the Bonaparte Gulf Basin: *Cyzicus* and *Palaeolimnadia. Palaeolimnadia* first appeared in the ARCO-AAP Petrel No. 1 Well at a depth of 11 230 feet, then did not recur until a lapse of time represented by 718 feet of well section (Fig. 1). Once *Cyzicus* appeared in the well section (cuttings at 11 000 feet depth) it repeatedly recurred after lapses of time represented by 60 feet, 340 feet, and 38 feet respectively (from oldest to youngest). Obviously it persisted intermittently through the entire span represented by 488 feet of well section (Fig. 1). Cyzicids were dominant in this fauna.

Analysis of faunal characteristics

The non-persistence of even a single species through the time represented (in both genera, *Cyzicus* and *Palaeolimnadia*) is one of the characteristics of the Bonaparte Gulf Basin fauna. Another is the absence of any species known from other basins (Canning in particular, but also Bowen and Sydney Basins). Local (basinal) speciation is not unusual in conchostracan populations, both living and fossil. Seasonal warming often evaporates portions of ephemeral non-marine water bodies, leaving isolated ponds which bring about fractionation of parental gene pools into sub-pools (i.e. genetic isolation—Tasch & Zimmerman, 1961).

Comparison of Triassic conchostracan genera from the Bonaparte Gulf Basin with those of the Canning Basin

Of the three Triassic genera which lived in the Canning Basin, two—*Palaeolimnadia* and *Cyzicus*—constitute the known conchostracan fauna of the Bonaparte Gulf Basin. *Cyzicus* is the dominant genus in the Bonaparte Gulf Basin, but whereas it is prominent in the Canning Basin in the Blina Shale surface localities (Bell's Ridge, Erskine Hill, Minnie Range, and Lake Jones), it forms only a minor part of the conchostracan fauna of Meda No. 1 Well.

There are subgeneric differences between the two basins; e.g., two subgenera of *Palaeolimnadia*—*Palaeolimnadia* and *Grandilimnadia*—occur in the Canning Basin, but only *Grandilimnadia* is present in the Bonaparte Gulf Basin. Likewise, of the two subgenera of *Cyzicus*, only *Lioestheria* occurs in the Canning Basin, and only *Euestheria* is present in the Bonaparte Gulf Basin. There is one possible exception to this statement—a shell fragment from BMR locality 619 may bear obscure hachure-type markings on growth bands, which would place it in the subgenus *Cyzicus* (*Lioestheria*).

Accordingly, on the generic level, there is evidence of conchostracan dispersal between the two basins during Early Triassic time. Geographic and then reproductive isolation can explain absence of linkages at the specific level.

Two differences between Canning Basin and Bonaparte Gulf Basin faunas at the specific level

There are still other differences between the two basins' conchostracan faunas at the specific level: (1) Two species recur in the Blina Shale section: *Estheriina* (*Nudusia*) *blina* Tasch and *Palaeolimnadia* (*Grandilimnadia*) *medaensis* Tasch (this volume, Paper 1), while none recur in the Bonaparte Gulf Basin well section; and (2) One eastern species—*Palaeolimnadia* (*Palaeolimnadia*) *wianamattensis* (Mitchell)—occurs in the Canning Basin; none are known from the Bonaparte Gulf Basin.

PALAEOECOLOGICAL OBSERVATIONS (PT)

Population density

Cyzicid coquinas characterise the Port Keats sample (Bonaparte Gulf Basin) as well as such Blina Shale samples as those from Erskine Hill. Other than coquinas, which clearly denote high population density, and from this the attending suite of factors favouring growth, there is some evidence of sparse conchostracan distribution in several Bonaparte Gulf Basin samples (ARCO-AAP Petrel No. 1 Well).

Persistence of freshwater bodies

Cyzicus (*Euestheria*) *bonapartensis* sp. nov. has 34+ growth bands, which are estimated to be equivalent to 102 days of growth. If a correction factor (Tasch & Zimmerman, 1961) is applied, this value becomes 87 days, or approximately three months. That designates the probable duration of the pond or pool (Core 8, 10 512 feet, see Fig. 1) inhabited by this creature during life. *Palaeolimnadia* (*Grandilimnadia*) *profunda* sp. nov. has only 9 growth bands, and these suggest that the water body it inhabited lasted slightly less than one month (junk basket core, 11 230 feet, see Fig. 1).

These data on growth bands, though incomplete owing to erosion and poor preservation of most specimens, nevertheless suggest that ponds lasted from one to three months, and so may have been subject to seasonal control.

Biotic associates

Other than sparse lingulid brachiopods found in two samples (Fig. 1), one fossilised with *Cyzicus,* and rare probable plant fragments in a Port Keats rock slice, there are no macrobiotic associates of the conchostracans. Lingulids also occur as conchostracan associates in the Blina Shale fauna along with silicified bone fragments, fish teeth, pelecypods, and microspores. The *Lingula*/*Cyzicus* occurrence was interpreted as indicating deposition in a shallow bay (Veevers & Wells, 1961).

Lingulids are not infrequent in brackish water facies, and their occurrence with conchostracans in the Bonaparte Gulf Basin probably has the same connotation. The single occurrence of a lingulid in the ARCO-AAP Petrel No. 1 Well (Fig. 1) may be taken as signifying the presence of a marine tongue within a dominantly freshwater facies.

The sparsity of biotic asociates also implies that the water bodies inhabited by Bonaparte Gulf Basin conchostracans were ephemeral. These fresh/brackish water bodies appear to have lacked vegetation, either submerged, emerged, or peripheral.

NOTE ON Cyzicus (Euestheria) minuta(?) FROM THE CARNARVON BASIN (PT)

The conchostracan *Cyzicus* (*Euestheria*) *minuta* (von Zieten) has been figured and described from the Kockatea Shale (early Triassic of southern Carnarvon Basin) by Cockbain (1974). While this report is a welcome addition to our knowledge of conchostracan distribution in Western Australia, there are several qualifications that ought to be raised.

Those fossils were identified as *Cyzicus* (*Euestheria*) *minuta* on the basis of size and general shape, micro-ornament being completely lacking between growth lines. Minute size (length alone, as give, being less useful than height over length, H/L) and ovate shape are not uncommon in many species of several genera, and in themselves can hardly be definitive. The only other useful criterion, besides measurement of the angle made by anterior and posterior margins respectively, would be micro-ornament, which in *C.* (*Eu.*) *minuta* consists of a pattern of minute polygons between growth bands. Without H/L and angle measurements, and in the absence of micro-ornamentation, assignment at best could be *C.* (*Eu.*) cf. *minuta,* which denotes a speculative and not a definitive assignment.

Let us, nevertheless, for the present discussion assume that the Carnarvon Basin specimens are correctly assigned to *minuta.* Cockbain then suggests that since the species is widespread (Triassic of Greenland, Europe, etc), that implies 'dispersal over wide stretches of land and sea with equal ease'. Dispersal of conchostracan eggs over land is well established for both living and fossil conchostracans. However, dispersal over oceanic distances by fortuitous winds is not (Tasch, 1971).

Experiments by Tasch on eggs of modern conchostracans indicated that they will not hatch in salt water, so dispersal in salt water is improbable. Furthermore, fossil evidence suggests that conchostracan transition from marine to nonmarine environments occurred in phases during Devonian-Carboniferous time (Tasch, 1963). Finally, land dispersal routes to Western Australia were available since Australia and India were close together and did not drift apart until about the start of the Cretaceous (Johnson et al., 1976).

3. SYSTEMATIC DESCRIPTIONS (PT)

Order **CONCHOSTRACA** Sars, 1867

Suborder **SPINICAUDATA** Linder, 1945

Superfamily **CYZICOIDEA** Stebbing, 1910

Family **CYZICIDAE** Stebbing, 1910

Genus **Cyzicus** Audouin, 1837

Subgenus **Euestheria** Depéret & Mazeran, 1912

Type species: Posidonia minuta Von Zieten, 1833, p. 453, by subsequent designation of Raymond, 1946, p. 238.

Type level: Lower Triassic 'Oberer Bunsandstein', BRD (West Germany)—Reible (1962).

Cyzicus (Euestheria) dickinsi sp. nov.

(Pl. 5, figs. 1-3)

Derivation of name: In honour of Dr J. M. Dickins (BMR) who collected the specimens on which it is based.

Holotype: Right valve CPC 17163, from BMR locality 619, Port Keats area, Bonaparte Gulf Basin.

Paratypes: Right valves CPC 17164 and 17165 from same locality as holotype.

Diagnosis: Ovate to subovate valves; umbo submedial to subterminal. Dorsal margin straight; anterior and posterior margins rounded, varispaced growth bands; ornamentation, granular.

Measurements:

Specimen	L	H	H/L	GB
Holotype CPC 17163	4.5	3.3	0.73	18+
Paratype CPC 17164	3.9	2.8	0.72	—
Paratype CPC 17165	3.9(?)	2.6	—	—

Remarks: The new species is represented by a coquina of valves, mostly very poorly preserved. On a slab 38 mm x 42 mm, the coquina of valves (all of the new species) consists of more than 34 moulds of right and left valves.

Canning Basin cyzicids, all belonging to subgenus *Lioestheria,* are unlike those of the new species. Similarly species described by Mitchell, Kobayashi, Novozhilov, and others differ from the species described above.

Cyzicus (Euestheria) bonapartensis sp. nov.

(Pl. 5, fig. 4)

Derivation of name: After the Bonaparte Gulf Basin.

Holotype: Right valve, CPC 17166. ARCO-AAP Petrel No. 1 Well core 8, 10 512 feet.

Diagnosis: Ovate, robust valves. Dorsal margin straight from beak to posterodorsal juncture; anterior margin rounded. Umbo subterminal. Growth bands varispaced; faint granular pattern in intervals.

Measurements:

Specimen	L	H	H/L	GB
Holotype CPC 17166	4.44	3.04	0.68	34+

Remarks: There appear to be three cycles of growth bands. A given growth band cycle came to an end (indicated by markedly closer spacing between terminal bands than between preceding bands on the valve) presumably when volume of the pond decreased, with attendant decrease in oxygen. Revival of growth (next cycle) occurred when volume of the pond increased, either from inflow or from chance precipitation. In this context, the pond in which this species lived is estimated to have lasted some three months. Within this span, its volume decreased three times.

The robust ovateness of the valves is very distinctive.

Cyzicus (Euestheria) sp. undet. 1

(Pl. 5, fig. 5)

Material: CPC 17167 left and right valve in contact, and flattened. ARCO-AAP Petrel No. 1 Well, cuttings 10 550-600 feet.

Diagnosis: Subelliptical valves; umbo terminal; growth bands tighter spaced ventrally: last 5 bands/0.2 mm; previous 6 bands/0.7 mm. Anterior margin more gently rounded ventrally; dorsal margin straight (eroded posteriorly), joining sharply arched posterior margin abruptly. Umbonal area eroded but early growth bands decipherable. Faint granular ornamentation between bands.

Measurements:

Specimen	L	H	H/L
CPC 17167	3.46	2.18	0.63

Cyzicus (Euestheria) sp. undet. 2

(Pl. 5, fig. 6)

Material: Right valve CPC 17168. ARCO-AAP Petrel No. 1 Well, cuttings 11 000 feet.

Diagnosis: Ovate valves with straight dorsal margin and rounded anterior margin. Granular ornamentation. Ventral and dorso-posterior margins eroded. Both valves in contact, compressed.

Measurements:

Specimen	L	H	H/L	GB
CPC 17168	3.12	1.98	0.63	6+

Remarks: Incompleteness of the specimen prevents species determination. The species is, however, distinct from *Cyzicus* (*Euestheria*) sp. undet. 1 in configuration and in dorsal margin contact with posterior edge. In H/L ratio both undetermined species are alike.

Cyzicus sp. undet. 3

(Pl. 5, fig. 7)

Material: Right valve CPC 17169. ARCO-AAP Petrel No. 1 Well, cuttings 10 550-600 feet.

Diagnosis: Subovate valve; eroded umbo, subterminal; dorsal margin straight for one-half its length, then merges into arcuate dorso-posterior margin; anterior margin covered. Growth bands widely spaced (3/0.45 mm), but final bands more tightly spaced (5/0.19 mm). Ornamentation obscure.

Measurements:

Specimen	L	H	H/L	GB
CPC 17169	2.3+	1.6	0.69	15 (estimated)

Superfamily **LIMNADIOIDEA** Baird, 1849

Family **LIMNADIIDAE** Baird, 1849

Subfamily **ESTHERIININAE** Kobayashi, 1954

Genus **Palaeolimnadia** Raymond, 1946

Subgenus **Grandilimnadia** Tasch (this volume, Paper 1)

Type species: Palaeolimnadia (*Grandilimnadia*) *mitchelli* Tasch (= *Estheria wianamattensis* Mitchell, 1927, 108, pl. 2, fig. 7, *non*, fig. 8); Tasch, this volume, p. 18.

Palaeolimnadia (Grandilimnadia) arcoensis sp. nov.

(Pl. 5, figs. 8, 9)

Derivation of name: After ARCO, the operating company which drilled Petrel No. 1 Well.

Holotype: Right valve CPC 17170. ARCO-AAP Petrel No. 1 Well, core 8, 10 512 feet.

Paratype: Left valve CPC 17171; same locality as holotype.

Diagnosis: Ovate to subovate valves. Umbo subterminal, smooth, comparatively large and elongate; growth band spacing variable.

Measurements:

Specimen	L	H	H/L	GB
Holotype CPC 17170	3.90	2.78	0.71	21
Paratype CPC 17171	3.28	2.12	0.65	—

Discussion: This species differs from Canning Basin species of *Palaeolimnadia* (*Grandilimnadia*) as follows: from *P.* (*G.*) *medaensis* Tasch, in more subdued dorsal margin curvature; smaller, less prominent umbo; greater H/L ratio; from *P.* (*G.*) sp. undet. 1, in a much smaller umbonal area confined to subterminal region of valve, and in H/L ratio.

Palaeolimnadia (Grandilimnadia) profunda sp. nov.

(Pl. 5, fig. 10)

Derivation of name: Latin *profundus*, deep, to designate the species obtained from the greatest depth in Petrel No. 1 Well, and hence presumably the geologically oldest.

Holotype: Carbonised internal mould of right valve, CPC 17172. ARCO-AAP Petrel No. 1 Well, junk basket core, 11 230 feet.

Diagnosis: Valves ovate; large umbo lacking growth bands, subterminal in position. Dorsal margin straight; anterior margin arcuate. Growth bands varispaced.

Specimen	L	H	H/L	lu	hu	hu/lu	GB
CPC 17172	3.17	2.22	0.70	1.35	1.05	0.78	9

Remarks: This species differs from *Palaeolimnadia* (*Grandilimnadia*) species as follows: from *P.* (*G.*) *arcoensis* sp. nov. (Bonaparte Gulf Basin) and *P.* (*G.*) *medaensis* Tasch (Canning Basin) by a much larger umbonal area and straight dorsal margin; from *P.* (*G.*) sp. undet. 1 (Canning Basin) by lack of deeply incised growth bands, a more ovate (rather than elliptical) umbonal area, and H/L ratio.

PAPER 3

Permian and Triassic Conchostraca from the Bowen Basin (with a note on a Carboniferous leaiid from the Drummond Basin), Queensland

BY

P. Tasch

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SUMMARY

The Upper Permian Blackwater Group of the Bowen Basin contains two conchostracan genera and three species—*Leaia (Hemicycloleaia) deflectomarginis* sp. nov., *Leaia (Hemicycloleaia)* sp., and *Palaeolimnadia (Grandilimnadia)* cf. *glenleensis* (Mitchell)—which indicate that conchostracan eggs (of the subgenus *Grandilimnadia*) were dispersed between the Bowen and Sydney Basins, and those of ribbed types (of the subgenus *Hemicycloleaia*) were dispersed from the Canning Basin to the Bowen Basin.

The Lower Triassic Rewan Group contains six or seven conchostracan species, represented in three genera and four subgenera: *Cyzicus (Lioestheria)*, *Palaeolimnadia (Palaeolimnadia)*, *Palaeolimnadia (Grandilimnadia)* and *Estheriina (Nudusia)*. Two species are new: *Estheriina (Nudusia) circula* and *Estheriina (Nudusia) rewanensis* of which the latter, together with *Palaeolimnadia (Palaeolimnadia) wianamattensis* (Mitchell), is also present in the Lower Triassic Blina Shale of the Canning Basin. On the whole, the conchostracan fauna of the Bowen Basin is reminiscent of that of the Canning Basin, while it shares two of the same genera with the Bonaparte Gulf Basin: *Palaeolimnadia* and *Cyzicus*. This suggests that conchostracan eggs were dispersed via widespread freshwater lakes between the Bowen and Canning Basins; the Canning and Bonaparte Gulf Basins; and the Bowen and Sydney Basins, during Early Triassic time.

The Lower Carboniferous (Tournaisian?-early Viséan) Raymond Formation of the Drummond Basin contains a new species of *Leaia (Hemicycloleaia)*—*Leaia (Hemicycloleaia) drummondensis*—which suggests that the Early Carboniferous (late Viséan-?early Namurian) leaiid species from the Canning Basin may have been originally derived from an east-to-west dispersal.

1. INTRODUCTION

Fossil conchostracans were first recorded from Queensland by Etheridge Jnr. (*in* Jack & Etheridge, 1892) from Denmark Hill, Ipswich in Upper Triassic (Blackstone Formation) sediments. He described, but did not figure, a species which he assigned to the Late Triassic *'Estheria' mangaliensis* Jones; it was later figured and redescribed by Mitchell (1927), who regarded it as a new species—*'Estheria' ipsviciensis*—now placed in *Euestheria* (Hill, Playford & Woods, 1965).

The first record of the genus *Leaia* from Queensland was by Hill (1957), who reported on collections made by Shell (Queensland) Development Pty Ltd geologists from two levels in the Lower Carboniferous sequence of the Drummond Basin (Olgers, 1972) viz., the top of the Telemon Formation, and the stratigraphically younger Ducabrook Formation. De Bretizel (1966) recorded a leaiid species from a third level—lying stratigraphically between these formations—from the Raymond Formation. This species has been figured by Hill & Woods (1964) as *Leaia (Dolicholeaia?)* sp., and is described and given a new specific name in the present paper.

From the Bowen Basin, Dickins (*in* Veevers et al., 1964) identified specimens from the Upper Permian Blackwater Group (Upper Bowen Coal Measures) as *'Leaia'* sp., and Jensen (1975) obtained other conchostracans from two localitities (A27, B63) and cores from drilling by BHP Co. Ltd in the Lower Triassic Rewan Group. The author (*in* Jensen, 1975) identified palaeolimnadiids and *Cyzicus (Lioestheria)* from a preliminary examination of the conchostracans from the Rewan Group. The present paper describes the material from both the Blackwater Group and the Rewan Group, and further details of the localities are given below and in Figures 1 and 3.

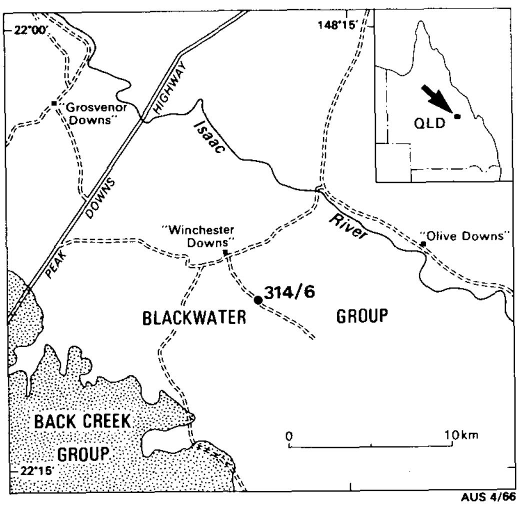

Fig. 1. Upper Permian conchostracans—Bowen Basin: *Leaia (Hemicycloleaia) deflectomarginus* **sp. nov.,** *L. (Hemicycloleaia)* **sp. undet. 1, and** *Palaeolimnadia (Grandilimnadia)* **cf.** *glenleensis* **(Mitchell).**

All type and figured specimens with the prefix CPC are deposited in the Commonwealth Palaeontological Collection of the Bureau of Mineral Resources, Geology & Geophysics, Canberra, Australia. The type specimen of *Leaia (Hemicycloleaia) drummondensis* sp. nov. is from the collections of the Department of Geology of the University of Queensland, Brisbane, Australia.

Acknowledgements

It is a pleasure to record my thanks to Drs J. M. Dickins and A. R. Jensen, who provided the conchostracan material, Dr P. J. Jones, who edited the entire manuscript; Mr John Webb (Department of Geology, University of Queensland), who provided the photograph and measurements of *Leaia (Hemicycloleaia) drummondensis* sp. nov; Messrs Timothy J. Petta and Scott Fitch (Department of Geology, Wichita State University, Kansas, who were responsible for the photography; Messrs A. T. Wilson and P. W. Davis (BMR), who prepared the prints and plates for this paper; Mr Dennis Carlton (Department of Geology, Wichita State University, Kansas), who aided with measurements and original drafting; and Mr R. R. Melsom (BMR), who drafted the final version of the figures.

Abbreviations used in the systematic descriptions

L = length of valve
H = height of valve
H/L = height/length ratio of valve
GB = number of growth bands
Ldm = length of dorsal margin
Ldm/L = length of dorsal margin/length of valve ratio
lu = length of umbo
hu = height of umbo
hu/lu = height/length ratio of umbo

All measurements are given in millimetres.

LOCALITIES

Bowen Basin

Clermont 1:250 000 Sheet area

CL 314/6 (grid. ref. E 648767 N 2232877) 4.2 km SSW of Winchester homestead—Dickins *in* Veevers et al., 1964, p. 85—Upper Permian Blackwater Group. Collected by M. A. Randal, 1960.

Duaringa 1:250 000 Sheet area

A 27 (grid ref. E 159300 N 2040100) 2.4 km SSW of Taurus Homestead, about 18 km SSW of Blackwater, base of Lower Triassic Rewan Group (Sagittarius Sandstone). Collected by A. R. Jensen in 1968—(Jensen, 1975, p. 35).

B 63 (grid ref. E 155680 N 2044200) 4.8 km WNW of Taurus homestead, about 16 km SSW of Blackwater, base of Lower Triassic Rewan Group (Sagittarius Sandstone). Collected by A. R. Jensen in 1968—(Jensen, 1975, p. 35).

BHP Blackwater No. 2 stratigraphic hole (grid ref. E 165300 N 2059400) 2 km SE of Blackwater, lower part of Lower Triassic Rewan Group (Sagittarius Sandstone). Collected by Broken Hill Pty Co. in 1969—(Malone et al., 1969, pp. 58-9; Jensen, 1975, p. 35).

Drummond Basin

Galilee 1:250 000 Sheet area

Narrien Range—precise locality not known. Lower Carboniferous Raymond Formation. Collected by P. de Bretizel in 1963, from the top of his section 70, and the base of his section 75 (de Bretizel, 1966, pp. 83-4).

2. LATE PERMIAN CONCHOSTRACA

Faunal composition

There are three species in the Bowen Basin Upper Permian collection: two leaiids and a palaeolimnadid. *Leaia (Hemicycloleaia) deflectomarginis* sp. nov. may have derived from the same stock as *Leaia pincombei* Mitchell since both share a gently deflected or slightly sinuous dorsal margin, although differing in configuration and measured valve characters (angles etc.). *Leaia (Hemicycloleaia)* sp. undet. 1 is too incomplete for species determination. Nevertheless, the portion preserved suggests likely affinitities to Canning Basin Carboniferous types that bear nonconvergent ribs on the umbo. There are no equivalent bicarinate, subovate types among Mitchell's Newcastle Coal Measures leaiids.

The single non-ribbed species, *Palaeolimnadia (Grandilimnadia)* cf. *glenleensis* (Mitchell), apparently represents a Permian precursor of Mitchell's Wianamatta species *'Estheria' glenleensis.*

Palaeogeographic and morpho-functional significance

Although sparse and of low diversity in conchostracan genera and species, the Bowen Basin Permian fauna discussed above points to: (a) some conchostracan dispersal between the Bowen Basin and Sydney Basin (Newcastle Coal Measures); (b) West-to-east dispersal of Canning Basin leaiids to the Bowen Basin (for example, same subgenus *Hemicycloleaia* in both basins) (cf. this volume, p. 7).

Dorsal margin flexure or gentle deflection may be an adaptation for breaking out of the burrow, by creating the equivalent of a leading or cutting edge. Livings forms in burrows keep only a small ventral slit open on the mud/water interface. As a pond evaporated, a flexure of the dorsal margin directed downward in the bottom of the burrow could aid more rapid release or ease of breaking out of the shell-fitting mud encasement. A selective advantage would thus be conferred on individuals having this valve feature. Various other shell modifications of adaptive advantage, for attachment to bottom weeds or for stabilisation on the bottom, are known in non-ribbed types (Tasch, 1961).

3. EARLY TRIASSIC CONCHOSTRACA

Faunal composition

Three genera, four subgenera, and possibly 6 to 7 species are represented from three sites in the basal Rewan Group (Fig. 2): *Cyzicus (Lioestheria)*, *Palaeolimnadia (Palaeolimnadia)*, *Palaeolimnadia (Grandilimnadia)*, and *Estheriina (Nudusia)*. There is an important distinction between the fauna from locality B 63 and that from the other two sites: the B 63 fauna is exclusively estheriinids, but these forms are not found in either locality A 27 or the bore (Fig. 3).

One species occurred at two Bowen Basin sites: *Palaeolimnadia (Palaeolimnadia) wiana-*

LOCALITY	CONCHOSTRACAN FAUNA
A 27	*Cyzicus (Lioestheria)* sp. undet. 1 *Palaeolimnadia (Palaeolimnadia) wianamattensis* (Mitchell)
B 63	*Estheriina (Nudusia) rewanensis* sp. nov. *Estheriina (Nudusia) circula* sp. nov.
BHP Blackwater No. 2 Bore 338 ft	*Palaeolimnadia (Palaeolimnadia) wianamattensis* (Mitchell) *Palaeolimnadia (Grandilimnadia)* sp. undet. 1 *Cyzicus (Lioestheria)* sp. undet. 3
350 ft	(Carbonised plants)
647+ ft	*Cyzicus (Lioestheria)* sp. undet. 2

AUS 4/67

Fig. 2. Lower Triassic conchostracans at three Bowen Basin localities.

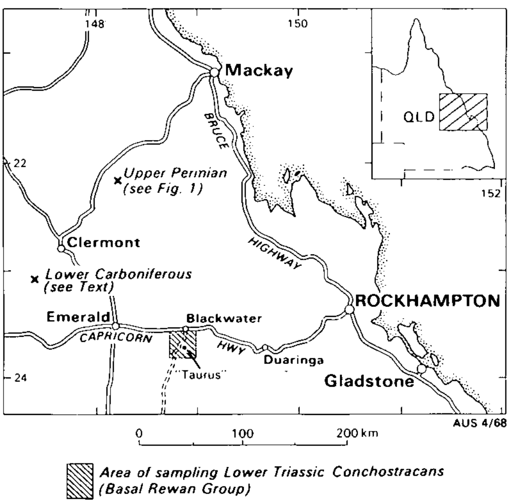

Fig. 3. Lower Triassic conchostracan localities—Bowen Basin.

mattensis (Mitchell), as did the same genus/subgenus, *Cyzicus* (*Lioestheria*).

In BHP Blackwater No. 2 bore, cyzicids came in at 647+ feet and recurred at 338 feet depth. Palaeolimnadids also came in at the 338 feet level. It is likely that this level correlates with the palaeolimnadid/cyzicid-bearing bed at locality A 27.

Comparison between the faunas of the Bowen and Canning Basins

The Rewan Group (Bowen Basin) and Blina Shale (Canning Basin) have two conchostracan species in common: *Estheriina* (*Nudusia*) *rewanensis* Tasch, from the base of the Blina Shale in WAPET Meda No. 1 Well, and *Palaeolimnadia* (*Palaeolimnadia*) *wianamattensis* (Mitchell), originally described from the geologically younger Wianamatta Group of the Sydney Basin.

The rest—the bulk—of the conchostracan fauna from the Bowen Basin has the same general aspect as that of the Canning Basin (this volume, p.). Thus estheriinids, palaeolimnadiids, and cyzicids are characteristic of both faunas, though some species differ. The conchostracan-bearing bed at Bowen Basin B 63 (Fig. 2), in which, as already remarked, only estheriinids occur, correlates most closely with the fauna encountered in the lower portion of the Blina Shale in Meda No. 1 Well, Canning Basin (this volume, paper 1, Fig. 3).*

Comparison between the faunas of the Bowen and Bonaparte Gulf Basins

Conchostracan faunas of the two basins share two of the same genera: *Palaeolimnadia* and *Cyzicus*. There are no estheriinids in the Bonaparte Gulf Basin fauna (this volume, paper 2) or in the Bowen Basin, except locality B 63.

Cyzicus (*Lioestheria*) is the dominant subgenus in the Bowen and Canning Basins, while in the Bonaparte Gulf Basin it is *Cyzicus* (*Euestheria*) which is dominant, with a single exception. While both subgenera of *Palaeolimnadia* occur in the Bowen Basin (Fig. 2), only *P.* (*Grandilimnadia*) is found in the Bonaparte Gulf Basin fauna.

Upper Triassic euestheriids (genus *Cyzicus*) are known from the Blackstone Formation, Ipswich (Hill, Playford & Woods, 1965; Mitchell, 1927).

Dispersal indicators

Dispersal of conchostracan eggs during the Early Triassic took place between (1) the Bowen and Canning Basins, as indicated by the common presence of estheriinids, palaeolimnadiids, and lioestheriid cyzicids; (2) the

* Evans (1966, unpubl.) doubtfully assigned the spore-pollen assemblage in the lowermost part of the Sagittarius Sandstone of the Rewan Group, in the area south of Blackwater, to his basal Triassic unit Trla—a unit now referred by Helby (1973), and Balme & Helby (1973) to the latest Permian. The conchostracan fauna of the basal Rewan Group suggests affinities with the fauna of the Blina Shale of the Canning Basin, and the Wianamatta Group of the Sydney Basin—therefore indicating an Early Triassic, rather than a Late Permian age [PJJ].

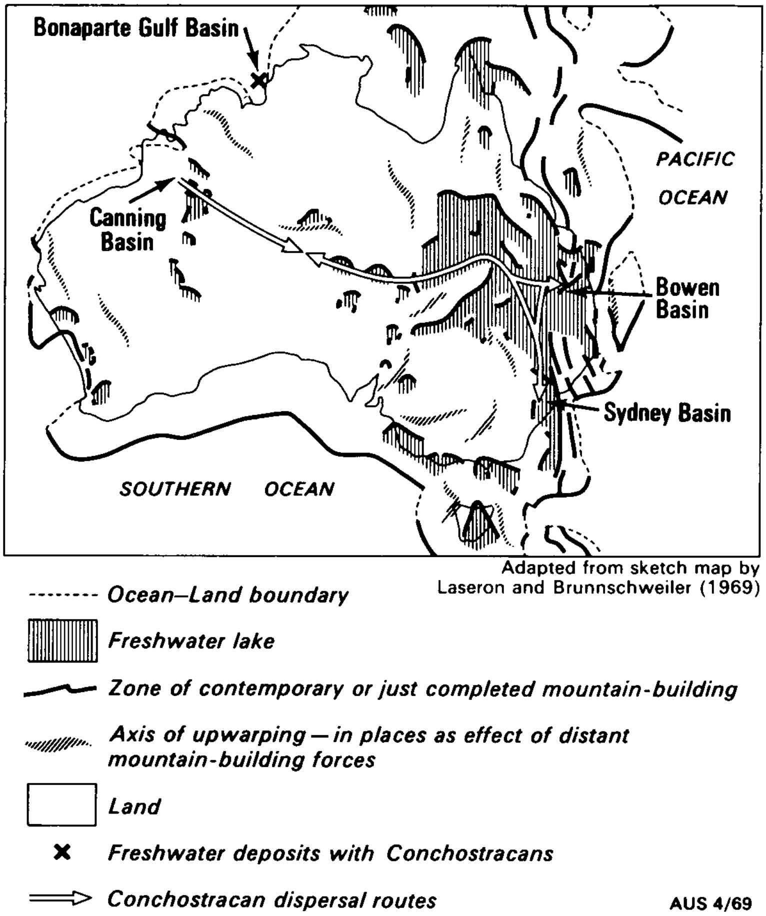

Fig. 4. Lower Triassic conchostracan dispersal routes between Australian basins.

Canning and the Bonaparte Gulf Basins, as indicated by the common presence of palaeolimnadiids, and cyzicids, at the generic level (this volume, paper 2); and (3) the Bowen and Sydney Basins, as indicated by the presence of *Palaeolimnadia* (*Palaeolimnadia*) *wianamattensis* in the Rewan Group (Early Triassic), and in the Wianamatta Group (Middle Triassic), respectively. Dispersal may have been twofold: south from Bowen Basin, and/or west to east, from Canning Basin to Sydney Basin).

In a reconstruction of Australia in Early Triassic time, Laseron & Brunnschweiler (1969, Map 18) depicted a series of freshwater lakes, south and east of the Canning Basin, across to the Bowen and Sydney Basins. Triassic conchostracan egg dispersal along these freshwater 'stepping stones', aided by wind transport, could readily explain the shared aspects of the conchostracan faunas between the several contemporaneous basins discussed above (Fig. 4).

Conchostracan egg dispersal to the Bonaparte Gulf Basin from the Canning Basin and/or Bowen Basin can probably be explained by still other fluviatile and lacustrine routes not depicted in Figure 4.

4. NOTE ON A CARBONIFEROUS LEAIID FROM THE DRUMMOND BASIN

A single leaiid conchostracan, figured by Hill & Woods (1964), is described and reassigned here, and its significance discussed.

Relationship of leaiids between Western and eastern Australia, and their post-Carboniferous dispersal

Leaia (Hemicycloleaia) drummondensis sp. nov. from the Raymond Formation is Tournaisian or early Viséan in age, whereas the leaiids from the Anderson Formation of the Canning Basin are late Viséan to possibly Namurian. This does not negate, however, the possibility (Tasch, this volume, paper 1) of a west-to-east dispersal route to account for Permian leaiids in the Bowen Basin (Blackwater Group) and Sydney Basin (Newcastle Coal Measures).

There are now, with the Early Carboniferous species from the Drummond Basin, two further possibilities:

(i) that the late Viséan-early Namurian leaiid species of the Canning Basin may have been originally derived from an east-to-west dispersal, after which a late-to-post-Carboniferous egg dispersal from west to east could have occurred. Evidence for this possibility is the common occurrence of hemicycloleaiids in both basins;

(ii) there may have been a missing post-Viséan (i.e. younger than the Viséan Ducabrook Formation; Playford, 1977) leaiid record in the Carboniferous of eastern Australia; if so, the Drummond Basin leaiids could have been precursors of stocks that later gave rise to the Permian forms of the Sydney Basin. In the absence of evidence for the second possibility, the first alternative seems the more plausible.

5. SYSTEMATIC DESCRIPTIONS

Order **CONCHOSTRACA** Sars, 1867

Suborder **SPINICAUDATA** Linder, 1945

Superfamily **LEAIOIDEA** Raymond, 1946

Family **LEAIIDAE** Raymond, 1946

Genus **Leaia** Jones, 1862

Subgenus **Hemicycloleaia** Raymond, 1946

1946 *Hemicycloleaia* Raymond, p. 286, pl. 6, fig. 2.

1953 *Leaia* (*Hemicycloleaia*) Raymond; Dechaseaux, p. 263.

1969 *Leaia* Jones; (in part) Tasch, p. 169.

Type species: Hemicycloleaia laevis Raymond, 1946.

Type level: Upper Pennsylvanian, Conemaugh Series, (Missourian) shale above lower Mahoning Sandstone, Conemaugh, Pennsylvania.

Leaia (Hemicycloleaia) drummondensis sp. nov. (Text-fig. 5)

1964 *Leaia* (*Dolicholeaia?*) sp. Hill & Woods, pl. CXIV, fig. 9.

Derivation of name: After the Drummond Basin.

Holotype: A right valve illustrated by Hill & Woods (1964, pl. CXIV, fig. 9), in the University of Queensland Collections UQF 44310. From the Raymond Formation, Narrien Range, NW of Emerald, Drummond Basin; Lower Carboniferous.

Diagnosis: A subovate leaiid, with a dorsal margin sloping anteriorly and posteriorly from the umbo; bicarinate; ribs do not converge on umbo and fade out at third from last growth band. Pseudo-recurvature of posterior margin.

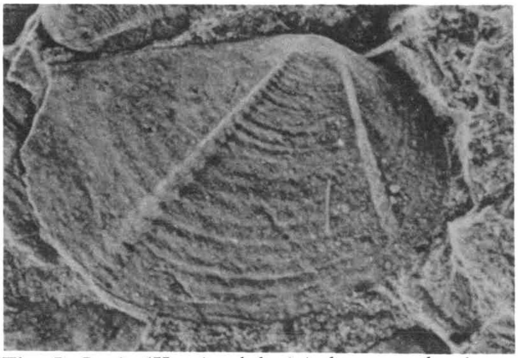

Fig. 5. *Leaia (Hemicycloleaia) drummondensis* **sp. nov. Holotype, UQF 44310 (Department of Geology, University of Queensland collections), a right valve (x15) illustrated in Hill & Woods (1964, pl. CXIV, fig. 9); from the Lower Carboniferous Raymond Formation, Narrien Range, Drummond Basin; collected by P. de Bretizel.**

Measurements:

Holotype	L	H	H/L	α	β	γ	δ	GB*
UQF 44310	4.3	2.9	0.67	110°	40°	33.5°	5°	25+

Distance apart of ribs on umbo = 1.5.

* bands on umbo obscure.

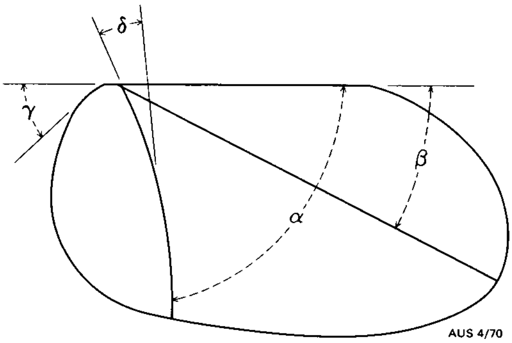

Fig. 6. Ribbed conchostracan valve angles. Delta and gamma measure angular deviations from a straight line, represented respectively by the anterior rib (delta angle) and dorsal margin (gamma angle). Alpha and beta angles are both measured from dorsal margin to the anterior rib (alpha angle) and posterior rib (beta angle).

Remarks: Pseudo-recurvature of posterior margin, i.e. growth bands do not recurve but a slight indentation does occur, is not uncommon in leaiids. For example, *Leaia latissima* Mitchell (1925, pl. xlii, fig. 11) from the Upper Permian Newcastle Coal Measures at Belmont, shows such pseudo-recurvature.

None of the Canning Basin Carboniferous leaiids or the Permian Newcastle Coal Measures leaiids are like the species described above. It is also unlike the leaiids described by Novozhilov from the Russian Carboniferous and Permian.

Leaia (Hemicycloleaia) deflectomarginis sp. nov.

(Pl. 6, figs. 1, 2)

Derivation of name: Latin *deflectere*, to deflect + *marginis*, margin.

Holotype: An incomplete left valve (CPC 17173A) and its more complete external mould (CPC 17173B) on the opposite faces of a split slab. BMR locality CL 314/6, 4.2 km SSW of Winchester homestead, Clermont 1:250 000 Sheet, Bowen Basin; Upper Permian Blackwater Group.

Diagnosis: Left valve subovate, bicarinate. Dorsal margin straight for one-half distance posterior to umbo, and thereafter gently flexed downward. Anterior margin steeply arched; posterior margin broadly arcuate. Ribs diverge from separated positions on the umbo.

Posterior rib straight, extends to next to last growth band; anterior rib slightly curved, reaches ventral margin.

Variably spaced growth bands, last few bands more tightly spaced.

Measurements:

Holotype	L	H	H/L	α	β	γ	δ	λ*	GB
CPC 17173B	2.87	2.06	0.72	77°	37°	62°	0-3°	6°	10+
CPC 17173A	—	2.05	—	77°	36°	—	—	—	—

* angle of deflection of dorsal margin from a straight line (see arrow in pl. 6, figs. 1, 2).

Remarks: Although Mitchell noted as one of the five distinguishing features of *Leaia pincombei* (Newcastle Coal Measures at Belmont) a 'mild sinuosity of the dorsal margin'—a feature shared by the new species described above—the two species are distinct in most other valve characters, given under 'Measurements'.

Flexure of dorsal margin in both species (Newcastle Coal Measures and Bowen Basin) may denote a common original gene pool that subsequently fractionated. There are no similar leaiids in the Canning Basin Carboniferous. Further, the Newcastle Coal Measures leaiids are dominated by types with completely straight (i.e. non-flexed) dorsal margins, with the exception noted here.

Leaia (Hemicycloleaia) sp. undet. 1

(Pl. 6, fig. 3)

Material: A single, incomplete external mould of left valve (CPC 17174), found on bedding plane with a small *Glossopteris* leaf.

Diagnosis: Elongate-ovate bicarinate valves; posterior rib straight, reaches ventral margin; extent of anterior rib cannot be determined owing to erosion of anteroventral sector of the valve. Ribs are separate on the umbo where they originate; dorsal margin is not thickened into a carina.

Measurements:

Specimen	L	H	H/L	α	β	γ	δ	GB
CPC 17174	6.1	3.2+	0.52*	80°	34°	52°	3°	13+

* estimated.

Occurrence: BMR locality CL 314/6, 4.2 km SSW of Winchester homestead, Clermont 1:250 000 Sheet; Bowen Basin, Upper Permian Blackwater Group.

Remarks: Several fragmentary bicarinate leaiids with non-convergent ribs have been described from the Canning Basin. One of these may be close to, or even identical with, the Bowen Basin specimen described here. Mitchell's Newcastle Coal Measures material does not contain any equivalents.

Superfamily **CYZICOIDEA** Stebbing, 1910

Family **CYZICIDAE** Stebbing, 1910

Genus **Cyzicus** Audouin, 1837

Subgenus **Lioestheria** Depéret & Mazeran, 1912

Type species: Estheria (Lioestheria) lallyensis Depéret & Mazeran, 1912, p. 167; by original designation.

Type level: Lower Permian, Autun, France.

Cyzicus (Lioestheria) sp. undet. 1

(Pl. 6, fig. 4)

Material: Left valve (CPC 17183), crushed and eroded.

Diagnosis: Large, broadly ovate valve with subterminal umbo and 18+ growth bands. Growth band spacing decreases after first 10 bands. Dorsal margin straight; anterior margin, curved; posterior margin, gently arcuate. Ornamentation punctate.

Measurements:

Specimen	L	H	H/L	Ldm	Ldm/L
CPC 17183	5.34	2.85	0.53	2.50	0.47

Occurrence: BMR locality A 27, 2.4 km SSW of Taurus homestead, Duaringa 1:250 000 Sheet Bowen Basin; base of Rewan Group (Lower Triassic).

Remarks: Obviously a cyzicid, but from its state of preservation, specific identification is precluded. It is unlike Canning and Bowen Basin cyzicids, but has dimensions close to *Cyzicus ipsviciensis* (Mitchell) from the Upper Triassic Blackstone Formation of Denmark Hill, Ipswich, yet lacks reticulate ornamentation (Mitchell, 1927).

Cyzicus (Lioestheria) sp. undet. 2

(Pl. 6, fig. 5)

Material: One left valve (CPC 17184).

Diagnosis: A 'pseudoestheriid' type of valve (i.e., ovate with umbo closer to anterior end; cf. Raymond, 1946, p. 243), with a tighter spacing of growth bands posteriorly. The missing dorso-anterior-ventral sector prevents further description.

Occurrence: BHP Blackwater No. 2 bore, 2 km SE of Blackwater, Duaringa 1:250 000 Sheet, Bowen Basin. Core slice taken at 647.9 feet (?base of Rewan Group; Lower Triassic).

Remarks: Raymond's genus *Pseudoestheria* was reassigned to *Lioestheria* by Kobayashi (1954), and the last named genus made a subgenus of *Cyzicus* by Tasch (1969). This is probably a distinct new species unlike any described by Mitchell and others, and unlike any from the Canning Basin, or *Cyzicus (Lioestheria)* sp. undet. 1 from the Bowen Basin. The white diagonal ridges on the valve are due to deformation by crumpling.

Cyzicus (Lioestheria) sp. undet. 3

(Pl. 6, fig. 6)

Material: Coquina of right and left valves.

Diagnosis: A crushed left valve with umbo and portions of dorsal margin eroded. Robust, oval shape; umbonal area subterminal. Ornamentation obscure on figured specimen, but other valves in a coquina of valves show punctae.

Measurements:

Specimen	L	H	H/L
CPC 17185 (unfigured)	3.55	2.41	0.68
CPC 17186	3.07	2.38	0.77

Occurrence: BHP Blackwater No. 2 bore, 2 km SE of Blackwater, Duaringa 1:250 000 Sheet, Bowen Basin. Core slice from 338 feet level (Rewan Group; Lower Triassic).

Remarks: This species occurs on same or opposite face of split core, along with palaeolimnadid species. Specimen CPC 17185 shows growth bands on the umbo very close to apex.

Superfamily **LIMNADIOIDEA** Baird, 1849

Family **LIMNADIIDAE** Baird, 1849

Subfamily **ESTHERIININAE** Kobayashi, 1954

Genus **Palaeolimnadia** Raymond, 1946

Subgenus **Palaeolimnadia** Raymond, 1946

Type species: Palaeolimnadia (Palaeolimnadia) wianamattensis (Mitchell, 1927), p. 108, pl. 2, fig. 8 (*non* fig. 7 = *Palaeolimnadia (Grandilimnadia) mitchelli* Tasch, this volume, p. 18).

Palaeolimnadia (Palaeolimnadia) wianamattensis (Mitchell, 1927)

(Pl. 6, figs. 7, 8)

1927 *Estheria wianamattensis* Mitchell, p. 108, pl. 2, fig. 8 (*non* fig. 7).

1946 *Palaeolimnadia wianamattensis* (Mitchell); Raymond, pp. 263-64, pl. 3, fig. 8 (*non* fig. 7).

1954 *Estherites wianamattensis* (Mitchell); Kobayashi (in part), pp. 30, 110.

1958 *Kontikia wianamattensis* (Mitchell); Novozhilov, pp. 87-88, fig. 2, p. 91.

1979 *Palaeolimnadia (Palaeolimnadia) wianamattensis* (Mitchell), Tasch, this volume, p. 18.

Material: Fragments and eroded specimens (CPC 17177, 17178) from BMR locality A 27, 2.4 km SSW of Taurus homestead, from the base of the

Rewan Group (Lower Triassic); specimens (CPC 17175, 17176) from a coquina on opposite faces of a split core from 338 feet in BHP Blackwater No. 2 bore, 2 km SE of Blackwater, Rewan Group. Both localities in Duaringa 1:250 000 Sheet, Bowen Basin.

Diagnosis: Ovate to subovate valves, with umbo in naupliid stage, very large compared to rest of valve; growth bands 4+.

Measurements:

Specimen	L	H	H/L	lu	hu	hu/lu
CPC 17175	1.50	1.05	0.70*	0.65	0.40	0.61
CPC 17176	1.59	1.20	0.75	0.73	0.36	0.49

* In the naupliid stage, the value of the H/L ratio is close to that for the length of the umbo.

Subgenus **Grandilimnadia** Tasch (this volume, Paper 1)

Type species: Palaeolimnadia (Grandilimnadia) mitchelli sp. nov. (=*Estheria wianamattensis* Mitchell, 1927, p. 108, pl. 2, fig. 7, *non* fig. 8); Tasch, this volume, p. 18.

Palaeolimnadia (Grandilimnadia) cf. **glenleensis** (Mitchell)

(Pl. 7, fig. 1)

cf. 1927 *Estheria glenleensis* Mitchell, 1927, p. 108, pl. 2, fig. 6.

Material: An incomplete right valve (CPC 17179).

Diagnosis: A convex carapace, ovate; umbo large; valve with 9 growth bands.

Measurements:

Specimen	L	H	H/L
CPC 17179	4.5	3.7	0.82
F 25482*	4.0	3.0	0.75

* Holotype of *Estheria glenleensis* Mitchell (with 9-10 growth bands); dimensions included for comparison with those of the specimen described here.

Occurrence: BMR locality CL 314/6, 4.2 km SSW of Winchester homestead, Clermont 1:250 000 Sheet, Bowen Basin; Upper Permian Blackwater Group.

Remarks: The specimen closely resembles the holotype of Mitchell's Triassic species (Wianamatta Group), deposited in the Australian Museum.

Palaeolimnadia (Grandilimnadia) sp. undet. 1

(Pl. 7, figs. 2-4)

Material: One right (CPC 17180), and two left valves (CPC 17181, 17182).

Diagnosis: Ovate valves with prominent, smooth, subterminal, elliptical umbo. Numerous vari-spaced growth bands.

Measurements: The three specimens are fragmented, eroded, covered and/or crushed, preventing meaningful measurements.

Occurrence: BHP Blackwater No. 2 bore, 2 km SE of Blackwater. All specimens from opposite faces of the same split core at 338 feet; Rewan Group (Lower Triassic).

Remarks: These fossils occur in the same core, associated with *Palaeolimnadia (Palaeolimnadia) wianamattensis* (Mitchell). The specimens are unlike those from the Bonaparte Gulf and Canning Basins.

Genus **Estheriina** Jones, 1897

Subgenus **Nudusia** Tasch (this volume, Paper 1)

Type species: Estheriina (Nudusia) blina Tasch (this volume, p. 19).

Estheriina (Nudusia) circula sp. nov.

(Pl. 7, figs. 5, 6)

Derivation of name: L. *circulus*, a circle.

Holotype: Right valve (CPC 17187) from BMR locality B 63, 4.8 km WNW of Taurus homestead, Duaringa 1:250 000 Sheet, base of Rewan Group, Lower Triassic, Bowen Basin.

Paratype: Left valve (CPC 17188) from same locality as the holotype.

Diagnosis: Circular valves with conspicuous elliptical umbo raised above dorsal margin; umbo submedial to subterminal. Growth band spacing variable, narrows ventrally. Anterior margin rounded; postero-dorsal margin eroded; valve narrows markedly at dorsal margin.

Measurements:

Specimen	L	H	H/L	lu	hu	hu/lu	GB
Holotype CPC 17187	2.64	2.13	0.81	0.70	0.30	0.43	19
Paratype CPC 17188	2.61	2.05	0.78	0.63	0.30	0.48	20+

Remarks: A distinctive species, unlike Canning Basin estheriinids. Differs from known estheriinids in general configuration, and shape and size of umbo. Occurs at same locality (B 63) as *Estheriina (Nudusia) rewanensis* Tasch, an ovate species described below. CPC 17188 has a series of spots on the valve that reflect conchostracan egg impressions.

Estheriina (Nudusia) rewanensis sp. nov.

(Pl. 7, figs. 7-9)

Derivation of name: After the Rewan Group.

Holotype: Right valve (CPC 17189) from BMR locality B 63, 4.8 km WNW of Taurus homestead; Duaringa 1:250 000 Sheet, base of Rewan Group, Lower Triassic, Bowen Basin.

Paratype: Right valve (CPC 17190) on same slab as holotype but 12.5 mm below it.

Diagnosis: Ovate valves, with comparatively large submedial umbo, slightly raised above dorsal margin that is oblique to the rounded posterior edge; ventral margin slightly rounded.

Measurements:

Specimen	L	H	H/L	lu	hu	hu/lu	GB
Holotype CPC 17189	2.26	1.48	0.65	0.74	0.41	0.55	11
Paratype CPC 17190	1.89	1.52	0.80	0.64	0.35	0.55	14

Remarks: The types occur in a coquina of equivalent valves, many of which display the typical umbo, but are otherwise crushed and incomplete.

An incomplete specimen (CPC 17191)—with nine growth bands and a smooth large umbo (see Pl. 7, fig. 9)—from the Canning Basin (WAPET Meda No. 1 Well, cuttings from 700-10 feet), seems to fit this species description. At first glance, this specimen appears to have the subterminal umbo and subovate outline which characterises *Estheriina (Nudusia) blina.* However, when the antero-ventral sector is restored, and the growth bands are brought to their original extent, it is clear that the specimen has a submedial umbo, and should be referred to *Estheriina (Nudusia) rewanensis.*

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PLATE 1

Leaia (Leaia) andersonae sp. nov.
(p. 11)

Fig. 1. Holotype, CPC 17135, left valve, x10; WAPET Grant Range No. 1 well, core 62 (8530-8536 feet). Anderson Formation.

Leaia (Hemicycloleaia) rectangellipta sp. nov.
(p. 12)

Figs. 2-4. Holotype, CPC 17136, left valve; fig. 2 x10; fig. 3 is detail of dorso-anterior curvature, x17.5; fig. 4 is detail of dorsal margin, x12; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation.

Leaia (Hemicycloleaia) grantrangicus sp. nov.
(p. 12)

Figs. 5, 6. Holotype, CPC 17137, right valve; fig. 5 x10; fig. 6 is detail of anterior rib curvature, x14.5; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation.

Leaia (Hemicycloleaia) tonsa sp. nov.
(p. 13)

Figs. 7, 8. Holotype, CPC 17138; fig. 7 shows left valve on right side, and interior view of right valve on left side, x8; fig. 8 shows left valve x10; WAPET Grant Range No. 1 well, core 62 (8530-8536 feet). Anderson Formation.

PLATE 1

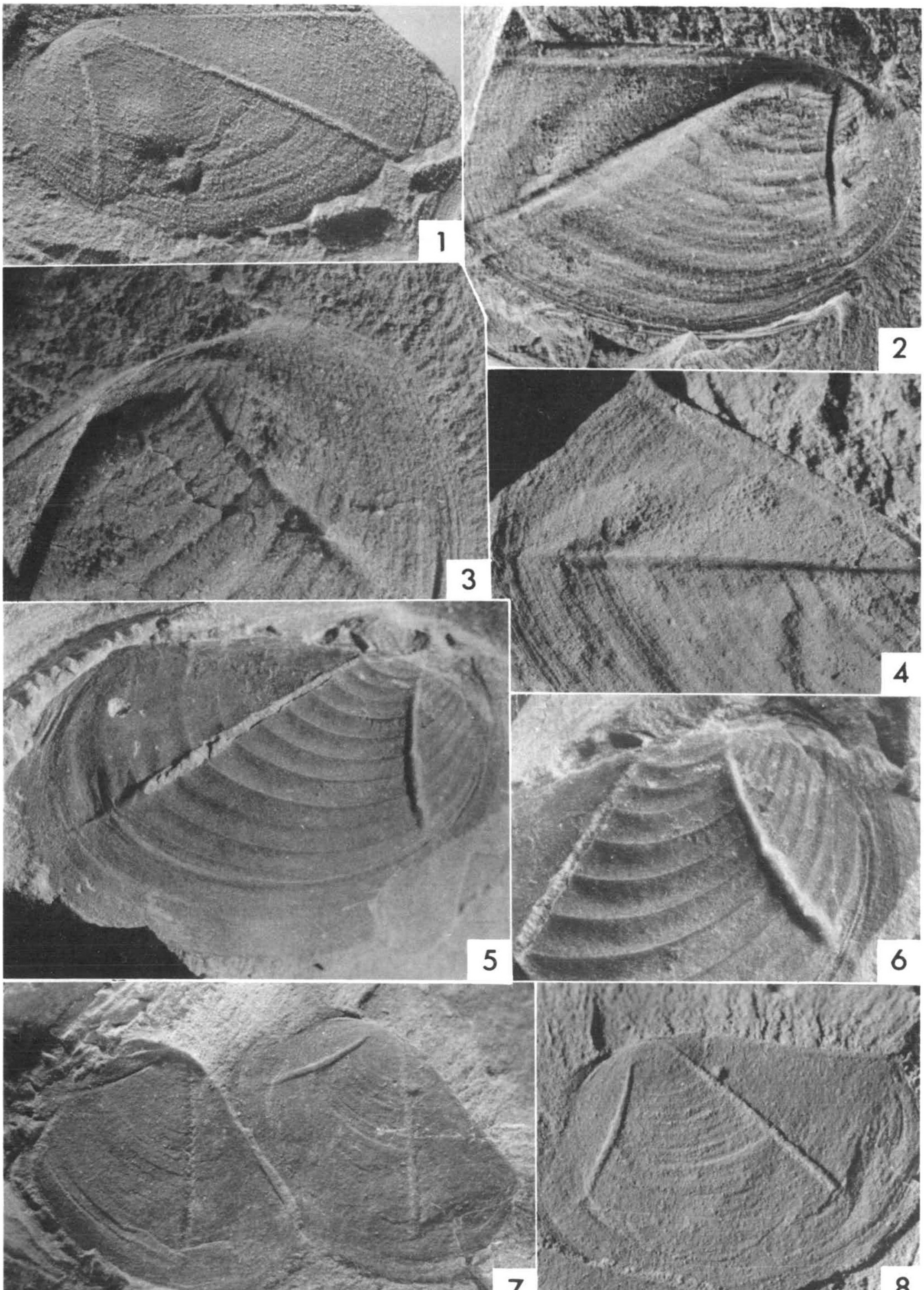

PLATE 2

Leaia (Hemicycloleaia) longicosta sp. nov.
(p. 13)

Figs. 1, 2. Holotype, CPC 17139, right valve; fig. 1 is internal mould, x12.5; fig. 2 is rubber cast of holotype, x12.5; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation.

Leaiid coquina
(p. 7)

Fig. 3. CPC 17134, x3; WAPET Grant Range No. 1 well, core 62 (8530-8536 feet). Anderson Formation.

Monoleaia australiata sp. nov.
(p. 13)

Fig. 4. Holotype, CPC 17140, right valve, x20; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation.

Rostroleaia sp.
(p. 14)

Fig. 5. Specimen destroyed, left valve, x20; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation. Arrow indicates deflection of dorsal margin.

Limnadiopsileaia carboniferae sp. nov.
(p. 14)

Figs. 6-8. Holotype, CPC 17141, left valve; fig. 6—arrow points to the single rib, a posterior rib, x12.5; fig. 7—arrow points to the recurved posterodorsal margin, x30; fig. 8—arrow indicates sector showing shell repair along the ventral margin, x44; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation.

PLATE 2

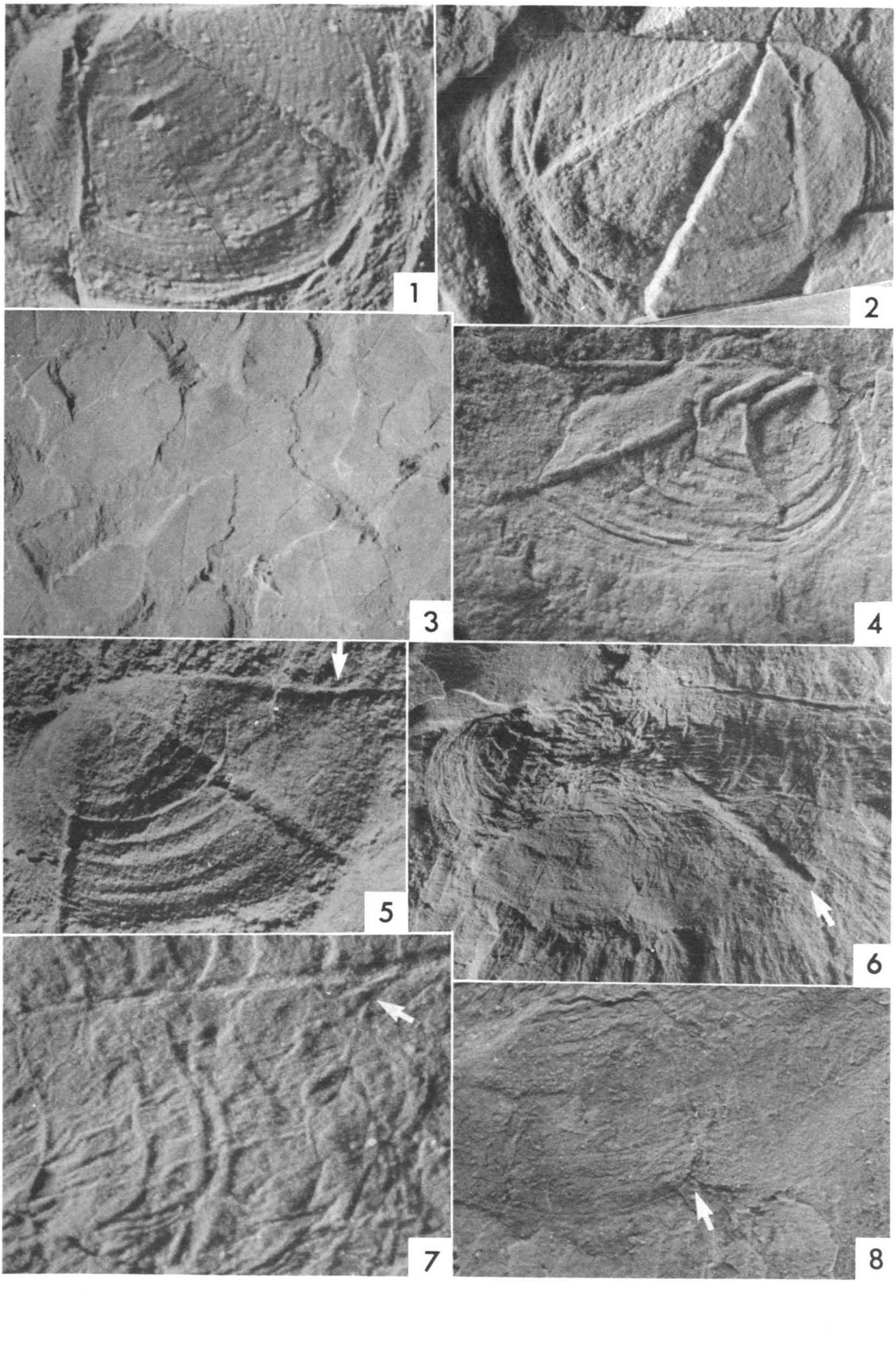

PLATE 3

Cyzicus (Lioestheria) sp. undet. 1
(p. 15)

Fig. 1. CPC 17142, right valve x15; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation.

Ellipsograpta? sp.
(p. 14)

Fig. 2. Specimen destroyed, right? valve, x30; WAPET Grant Range No. 1 well, core 59 (8164-8168 feet). Anderson Formation.

Cyzicus (Lioestheria) erskinehillensis sp. nov.
(p. 15)

Fig. 3. Holotype, CPC 17144, right valve, x20; Erskine Hill. Blina Shale.

Cyzicus (Lioestheria) sp. undet. 2
(p. 15)

Fig. 4. CPC 17143, left valve, x15; WAPET Grant Range No. 1 well, core 52 (7907-7912 feet). Anderson Formation.

Cyzicus (Lioestheria) australensis (Novozhilov, 1958)
(p. 16)

Fig. 5. CPC 17150, fragment of right valve, x20; note hachure-type ornamentation in umbonal area; Bells Ridge. Blina Shale.

Cyzicus (Lioestheria) sp. undet. 3
(p. 16)

Fig. 6. CPC 17151, left valve, x15; BMR locality M29, Chilpada Chara, Minnie Range. Blina Shale.

Cyzicus (Lioestheria) sp. undet. 4
(p. 17)

Fig. 7. CPC 17152, right valve, x15; BMR locality M29, Chilpada Chara, Minnie Range. Blina Shale.

PLATE 3

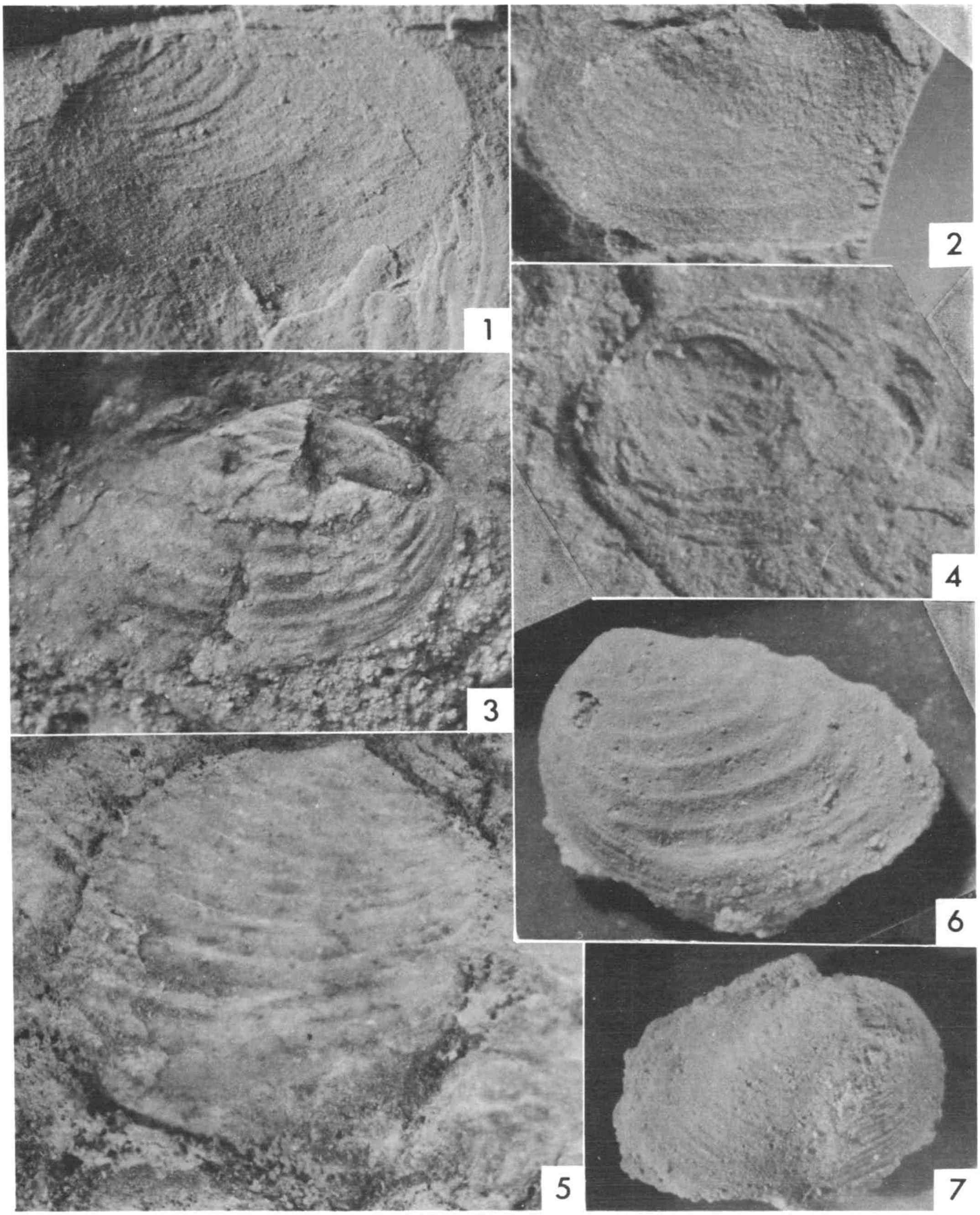

PLATE 4

Cyzicus (Lioestheria) sp. undet. 5
(p. 17)

Fig. 1. CPC 17153, left valve, x25; BMR locality M52, Lake Jones. Blina Shale.

Fig. 2. CPC 17154, right valve, x25; WAPET Meda No. 1 well, cuttings from 500-510 feet. Blina Shale.

Palaeolimnadia (Palaeolimnadia) wianamattensis (Mitchell, 1927)
(p. 18)

Fig. 3. CPC 17156, right valve, x25; Wongil Ridge. Blina Shale.

Palaeolimnadia (Grandilimnadia) medaensis sp. nov.
(p. 18)

Fig. 4. Holotype, CPC 17158, left valve, x20; WAPET Meda No. 1 well, cuttings 590-600 feet. Blina Shale.

Palaeolimnadia (Grandilimnadia) sp. undet. 1
(p. 19)

Fig. 5. CPC 17159, left valve, x25; WAPET Meda No. 1 well, cuttings 630-640 feet. Blina Shale.

Estheriina (Nudusia) blina sp. nov.
(p. 19)

Fig. 6. Holotype, CPC 17160, left valve, x20; WAPET Meda No. 1 well cuttings 590-600 feet. Blina Shale.

Fig. 7. Paratype, CPC 17161, right valve, x20; Bells Ridge, locality B146; (originally a paratype of *'Carbonicola' minutissima* Chapman & Parr, 1937; compare with fig. 8).

'Carbonicola' minutissima Chapman & Parr, 1937
(p. 20)

Fig. 8. Holotype, CPC 2310, right valve, x20; (not conspecific with CPC 17161—see text); Bells Ridge, locality B146. Blina Shale.

PLATE 4

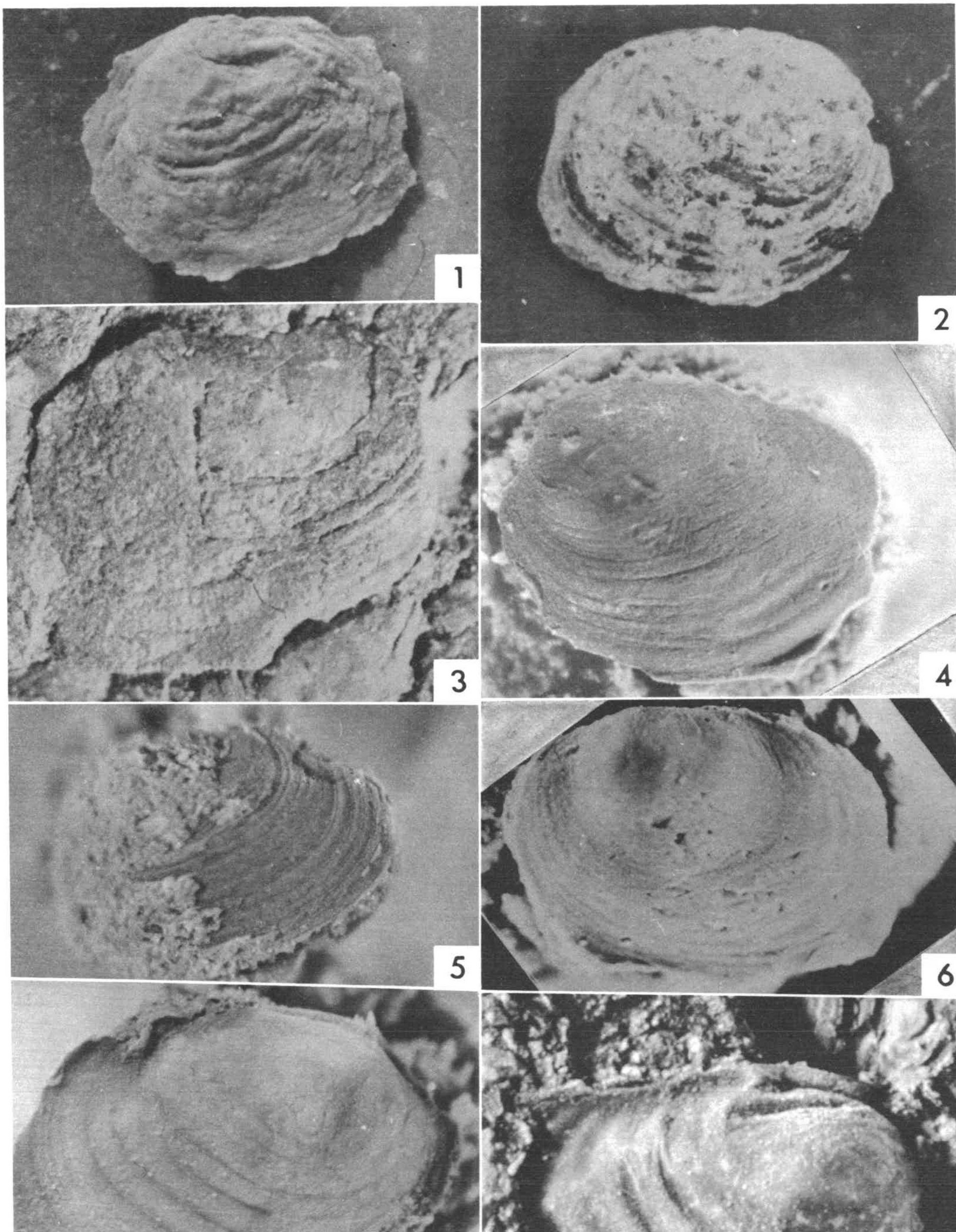

PLATE 5

(Magnification about x12.5 unless otherwise stated)

Cyzicus (Euestheria) dickinsi sp. nov.
(p. 29)

Fig. 1. Holotype, CPC 17163, right valve; note submedial umbo.

Fig. 2. Paratype, CPC 17164, right valve.

Fig. 3. Paratype, CPC 17165, right valve, one of the coquina of valves of this species, with subterminal umbo.
All specimens from BMR locality 619, south of Mount Goodwin, 6 km SE of Port Keats Mission.

Cyzicus (Euestheria) bonapartensis sp. nov.
(p. 29)

Fig. 4. Holotype, CPC 17166, carbonised external mould of right valve; ARCO-AAP Petrel No. 1 well, core 8, 10 512 feet.

Cyzicus (Euestheria) sp. undet. 1
(p. 29)

Fig. 5. CPC 17167, left valve in contact with right valve (not seen in figure); ARCO-AAP Petrel No. 1 well, cuttings, 10 550-10 600 feet.

Cyzicus (Euestheria) sp. undet. 2
(p. 29)

Fig. 6. CPC 17168, right valve; ARCO-AAP Petrel No. 1 well, cuttings, 11 000 feet.

Cyzicus sp. undet. 3
(p. 30)

Fig. 7. CPC 17169, right valve, x20; ARCO-AAP Petrel No. 1 well, cuttings, 10 550-10 600 feet.

Palaeolimnadia (Grandilimnadia) arcoensis sp. nov.
(p. 30)

Fig. 8. Holotype, CPC 17170, carbonised external mould of right valve, x15.

Fig. 9. Paratype, CPC 17171, left valve, x15. Both specimens from ARCO-AAP Petrel No. 1 well, core 8, 10 512 feet.

Palaeolimnadia (Palaeolimnadia) profunda sp. nov.
(p. 30)

Fig. 10. Holotype, CPC 17172, carbonised internal mould of right valve, x15; ARCO-AAP Petrel No. 1 well, junk basket core, 11 230 feet.

PLATE 5

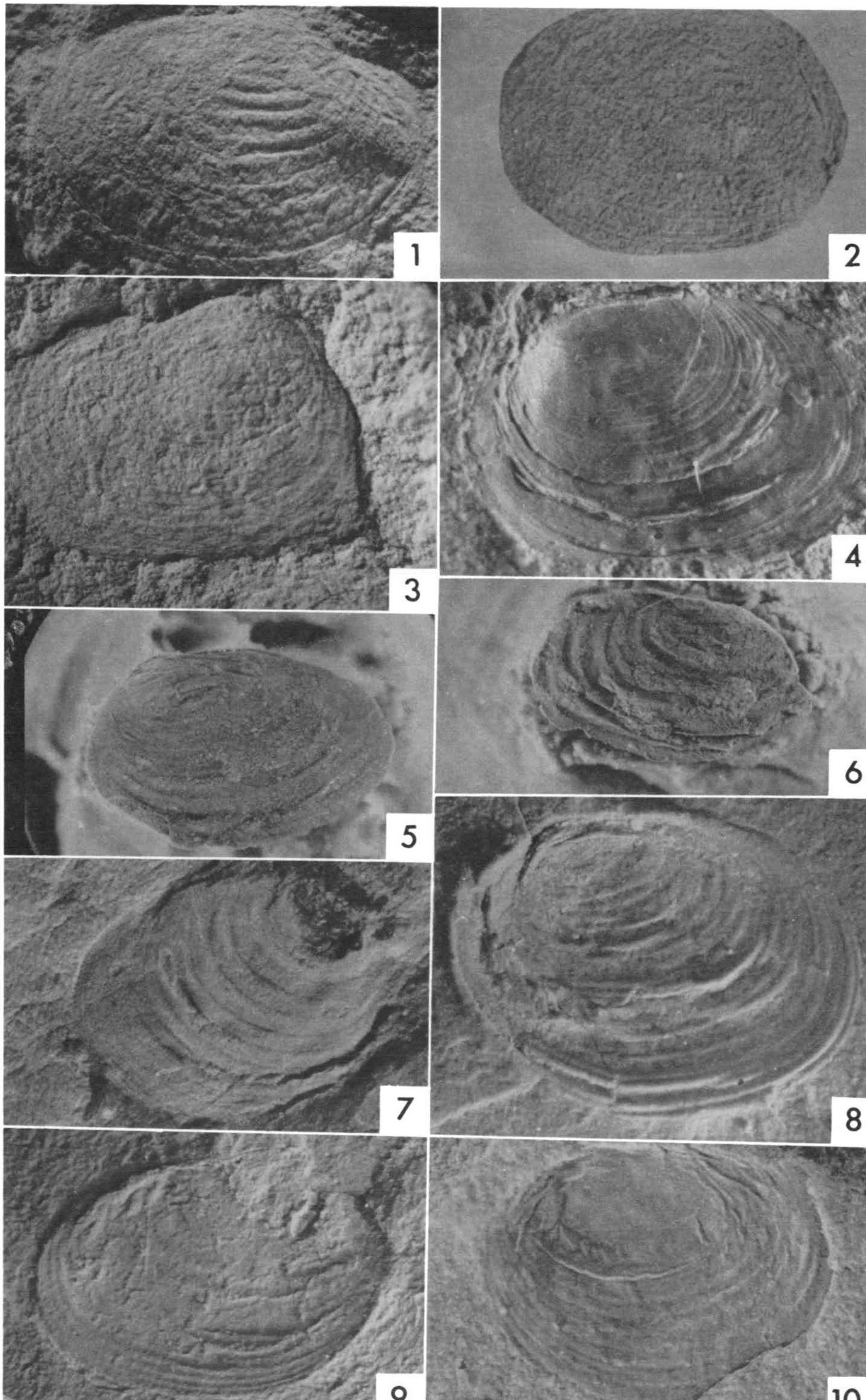

PLATE 6

(Magnification about x20 unless otherwise stated)

Leaia (Hemicycloleaia) deflectomarginis sp. nov.

(p. 40)

Fig. 2. Holotype, CPC 17173A, an incomplete left valve.

Fig. 1. Holotype, CPC 17173B, a more complete external mould.
Arrows point to slight downward flexure of the dorsal margin. BMR locality CL314/6—Upper Permian Blackwater Group (Upper Bowen Coal Measures).

Leaia (Hemicycloleaia) sp. undet. 1

(p. 40)

Fig. 3. CPC 17174, external mould of left valve, x10. Locality as for figs. 1, 2.

Cyzicus (Lioestheria) sp. undet. 1

(p. 41)

Fig. 4. CPC 17183, left valve, crushed and eroded, x10. BMR locality A27—base of Lower Triassic Rewan Group.

Cyzicus (Lioestheria) sp. undet. 2

(p. 41)

Fig. 5. CPC 17184, left valve; BHP Blackwater No. 2 bore, core from 647.9 feet—base of Lower Triassic Rewan Group.

Cyzicus (Lioestheria) sp. undet. 3

(p. 41)

Fig. 6. CPC 17186, left valve, one of a coquina of valves. Locality as for fig. 5—core from 338 feet in Lower Triassic Rewan Group.

Palaeolimnadia (Palaeolimnadia) wianamattensis (Mitchell, 1927)

(p. 41)

Fig. 7. CPC 17175, left valve; note the large volume of valve occupied by the umbo. Locality and horizon as for fig. 6.

Fig. 8. CPC 17178, right valve, eroded. Locality as for fig. 4.

PLATE 6

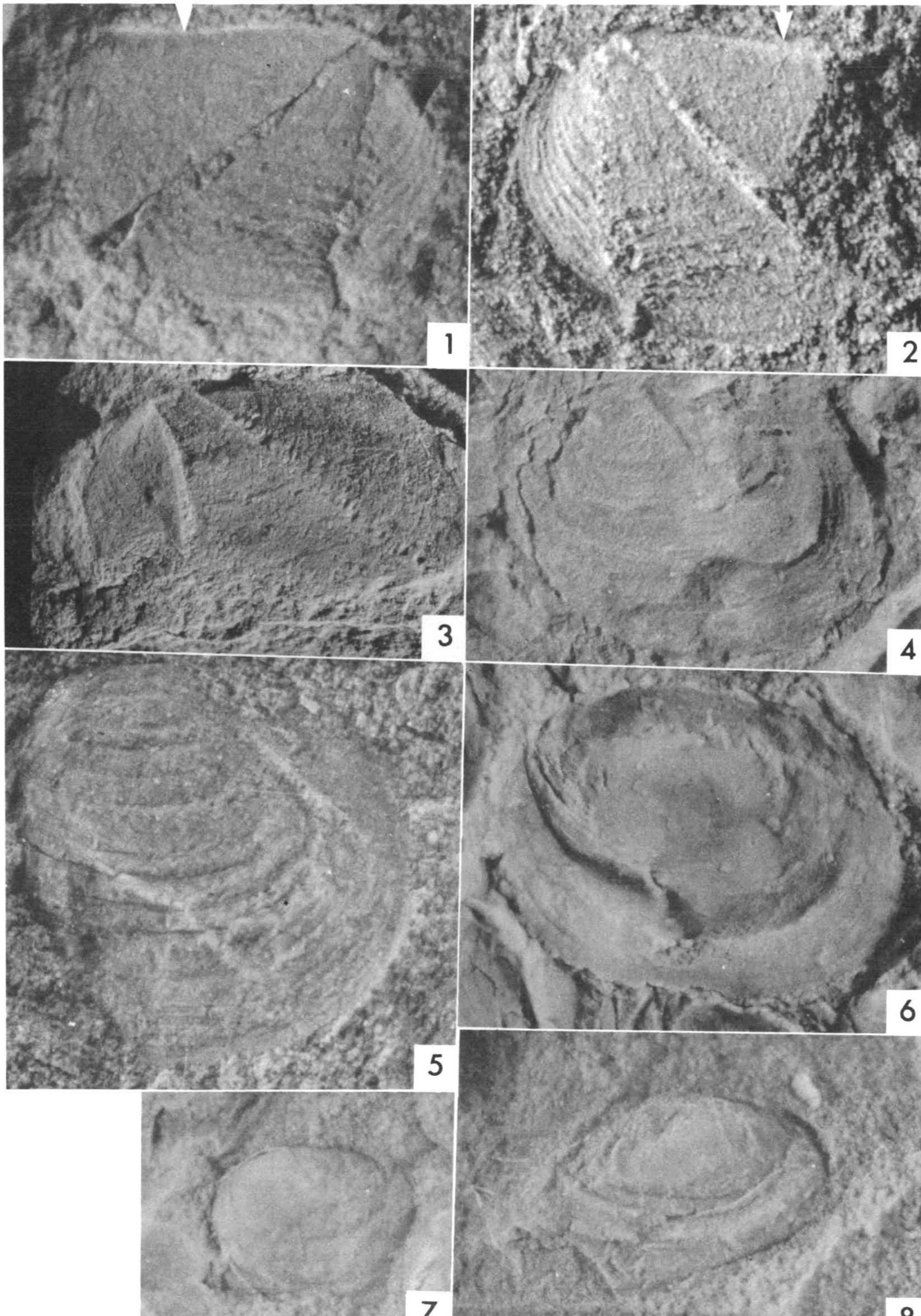

PLATE 7

(Magnification about x20 unless otherwise stated)

Palaeolimnadia (Grandilimnadia) cf. **glenleensis** (Mitchell, 1927)
(p. 42)

Fig. 1. CPC 17179, an incomplete right valve, x15; BMR locality CL314/6—Upper Permian Blackwater Group (Upper Bowen Coal Measures).

Palaeolimnadia (Grandilimnadia) sp. undet. 1
(p. 42)

Fig. 2. CPC 17180, right valve; note prominent elliptical umbo.

Fig. 3. CPC 17182, left valve.

Fig. 4. CPC 17181, left valve; oblique overview of umbo (posterior half of valve intentionally out of focus).
All three specimens occur on opposite faces of split core taken from 338 feet in BHP Blackwater No. 2 bore. Lower Triassic Rewan Group.

Estheriina (Nudusia) circula sp. nov.
(p. 42)

Fig. 5. Holotype, CPC 17187, right valve.

Fig. 6. Paratype, CPC 17188, left valve.
Both specimens from BMR locality B63—base of Lower Triassic Rewan Group.

Estheriina (Nudusia) rewanensis sp. nov.
(p. 42)

Fig. 7. Holotype, CPC 17189, right valve, coated with magnesium powder, x15. Locality as for figs. 5, 6.

Fig. 8. Paratype, CPC 17190, right valve. Locality as for figs. 5, 6.

Fig. 9. CPC 17191, right valve; WAPET Meda No. 1 well, cuttings 700-710 feet. Lower Triassic Blina Shale, Canning Basin, Western Australia (not included in Tasch & Jones, this volume, Paper 1).

PLATE 7