

BYTHOCYPRIDIDAE (OSTRACODA) FROM THE MIOCENE OF THE PORT PHILLIP AND WESTERN PORT BASINS, VICTORIA

MARK THOMAS WARNE

Department of Geology, University of Melbourne, Parkville, Victoria 3052

Present address: Department of Geology, La Trobe University, Bundoora, Victoria 3083

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Six bythocypridid species have been identified from the Lower to Middle Miocene of the Port Phillip and Western Port Basins. They are *Bythocypris* (*Bythocypris*) *subrectangulata* sp. nov., *Bythocypris* (*Bythocypris*) cf. *affinis* (Brady), *B. (B.)* sp. A, *B. (B.)* sp. B, *Anchistrocheles praebensoni* sp. nov. and *Orlovibairdia mooraboolensis* sp. nov. In a review of the Bythocyprididae, the new subgenus *Bythocypris* (*Bythotriangularia*) and the new genus *Bythopussella* are named for species occurring outside the Port Phillip and Western Port Basins.

THE BYTHOCYPRIDIDAE is a family of ostracods that is well represented in late Tertiary rocks of the Port Phillip and Western Port Basins, Victoria. In this paper, material of bythocypridids recently recovered from the Batesford Limestone and from the Fyansford and Sherwood Formations is described. A general review of the family is integrated within the systematic taxonomy and includes the description of a new subgenus and a new genus for forms occurring outside the region. The lithostratigraphy of the study area and sample localities are outlined by Warne (1987, 1988, 1989).

Within the Port Phillip and Western Port Basins, bythocypridids reached their maximum abundance during the late Early to early Middle Miocene. This abundance is considered to be due to the relatively warm aquatic temperatures and the wide range of palaeoenvironments that existed at that time (Warne, 1987, 1988, 1990). These conditions coincided with generally high global sea levels (Haq et al. 1987). The maximum extent of the marine incursion in the Port Phillip and Western Port Basins, as indicated by Mallett & Holdgate (1985), Carter (1985) and Warne (1987), presumably led to greater ranges in palaeodepths than at other times in the late Tertiary, generating a comparatively large number of depth-related palaeoecological niches.

SYSTEMATIC PALAEOONTOLOGY

Type and figured specimens are housed in the invertebrate palaeontological collection of the Museum of Victoria (NMV P122202–P122212). Other specimens are housed on

assemblage slides under the registered numbers NMV P122682–P122763. Locality details for assemblage slides are recorded in Warne (1989) and at the Museum of Victoria. Outcrop samples were approximately 0.5 kg. dry weight. The abbreviations RV = right valve, LV = left valve, L = length, H = height are used throughout the text.

Subclass OSTRACODA Latreille, 1806
Order PODOCOPIDA G. W. Müller, 1894
Suborder PODOCOPA Sars, 1866
Superfamily BAIRDIACEA Sars, 1866
Family BYTHOCYPRIDIDAE Maddocks, 1969

Remarks. Cainozoic Bythocyprididae are here distinguished from the Bairdiidae by their adductor muscle scar pattern, which usually includes four scars when undivided, and by the generally compressed nature of their carapace in dorsal view. I assign eight Cainozoic genera and subgenera to the Bythocyprididae, namely *Bythocypris* (*Bythocypris*) Brady, 1880, *Bythocypris* (*Bythotriangularia*) subgen. nov., *Anchistrocheles* Brady & Norman, 1889, *Bythopussella* gen. nov., *Danipussella* Wouters, 1988, *Orlovibairdia* McKenzie, 1978, *Pussella* Danielopol in Maddocks, 1976 and *Zabythocypris* Maddocks, 1969. Danielopol (1976), Maddocks (1976) and Wouters (1988) arranged some of these genera into the subfamilies Bythocypridinae Maddocks, 1969 and Pussellinae Danielopol, 1976, mainly on the basis of differences in the shape of the brushlike organ and the number of limb bristles.

As in the Bairdiidae (Warne 1988), gradational and mosaic relationships abound within the Bythocyprididae. In this paper I attempt to refine the definitions of many bythocypridid genera. This is possible because members of the Bythocyprididae display a slightly greater degree of non-gradational species-group clustering than do the Bairdiidae. These bythocypridid species groups also have a more uniform environmental distribution than do presently recognised bairdiid genera.

The Bairdiidae and the Bythocyprididae are not distinguished by consistent or simple morphological differences. A number of forms, in particular those belonging to *Bythopussella* gen. nov., have carapace and soft part characters that are either intermediate in structure between the two families, or are unusually combined in the one form. For example, species such as *Bythopussella aculeata* (Müller, 1908), *B.* aff. *aculeata* of Maddocks (1969) and *B.* sp. A (Cronin, 1983) have muscle scar patterns and compressed carapaces typical of adult bythocypridids, but have lateral carapace outlines and anatomical features akin to juvenile bairdiids (Maddocks 1969, 1976).

The late Tertiary bythocypridids of the Port Phillip and Western Port Basins have undivided or only weakly divided primary adductor muscle scars. This feature distinguishes these forms from the reniform bairdiids belonging to *Papillatabairdia*, adults of which possess eight primary adductor muscle scars (Bentley 1981, Warne, 1986, 1989). *Orlovibairdia mooraboolensis* sp. nov. is the only species described here that possesses both rimmed and unrimmed open normal pore canals. The other species have only unrimmed open normal pore canals.

Subfamily BYTHOCYPRIDINAE Maddocks,
1969

Genus *Bythocypris* Brady, 1880
Subgenus *Bythocypris (Bythocypris)* Brady,
1880

Type species. Bythocypris reniformis Brady, 1880.

Remarks. The four species here assigned to *Bythocypris (Bythocypris)* have smooth, reniform to subreniform or subrectangular carapaces of varying thickness, inner lamellae of moderate size, adductor muscle scars that are usually undivided, and no marginal denticula-

tion. Their carapaces are narrow in dorsal view but, unlike species of *Anchistrocheles* s.s., are not strongly differentially compressed or flattened along a narrow zone adjacent to the anteroventral and posteroventral margins. The reniform carapace of the type species, *B. (B.) reniformis*, is intermediate in shape between the subrectangular carapace of *B. (B.) subrectangulata* sp. nov. and the subtriangular carapace of *B. (Bythotriangularia)* subgen. nov. Thus, *B. (B.) reniformis* is not indicative of the maximum divergence in lateral outline between *B. (Bythocypris)* and *B. (Bythotriangularia)* but is closer to the subrectangular forms than to the subtriangular forms. Based on Maddocks' (1969, 1973) drawings of *B. (Bythotriangularia)* species, forms assigned to this new subgenus may also have a greater propensity for secondary adductor muscle scar division than species of *Bythocypris* s.s.

Species such as *Anchistrocheles antemacella* Maddocks, 1969, *A. barnharti* Maddocks, 1976, *A. bradyi* Scott, 1905, *A. hartmanni* Maddocks, 1976, *A. mcquadei* Maddocks, 1976, *Anchistrocheles* sp. Whatley & Downing, 1983 and *Cythere acerosa* Brady, 1868 more closely resemble *Bythocypris* s.s. than *Anchistrocheles* s.s. in lateral outline. For example, *A. bradyi* is closer in overall carapace morphology to *Bythocypris (Bythocypris) subrectangulata* sp. nov. than it is to any species of *Anchistrocheles*, as the latter is here defined. Consequently, the seven species listed above are tentatively transferred to *Bythocypris (Bythocypris)*, even though they may ultimately warrant new generic or subgeneric status. These species possess slightly more compressed carapaces than many *Bythocypris (Bythocypris)* species. Unlike *Anchistrocheles*, however, this compression is not restricted to a narrow zone adjacent to the anteroventral and posteroventral margins but extends over a broader area of the carapace, frequently giving the entire anterior region a flattened, slightly extended appearance. It is not known whether this difference in the type of surface compression corresponds to any consistent differences in soft part anatomy.

Forms such as *Bythocypris (Bythocypris?) bradyi* appear to be transitional in carapace morphology towards deeper water species belonging to *Zabythocypris*, which have very compressed carapaces in dorsal view. This inferred relationship is supported by the tendency of some anteriorly flattened *Bythocypris (Bythocypris?)* species to develop increased dorsal overlap. In *Zabythocypris*, greatly increased dorsal overlap

has resulted in left and right valves with markedly different length/height ratios.

Of the bythocypridid species in the late Tertiary of the Port Phillip and Western Port Basins, *Bythocypris* (*Bythocypris*) *subrectangulata* is mainly a shallow water species, although it is rare in near-shore facies. *B.* (*Bythocypris*) *cf. affinis*, *B.* (*Bythocypris*) sp. A and *B.* (*Bythocypris*) sp. B occur mainly in deeper water facies (Warne 1987).

Bythocypris* (*Bythocypris*) *subrectangulata
sp. nov.

Figs 1A, 2A–B

Bythocypris sp.—Whatley & Downing 1983: 352, pl. 1, fig. 9.

Bythocypris sp. 1.—Warne 1987: 441.

Etymology. A reference to the subrectangular lateral outline of the carapace.

Holotype. Adult LV, female, NMV P122202, from 1 m above the base of the Fyansford Formation (Early Miocene, late Batesfordian) in the south-west face of Batesford Limestone Quarry, near Fyansford, Victoria (below the upper limit of *Lepidocyclina*); 38°06'S, 144°17'E.

Paratype. Adult RV, male, NMV P122203.

Additional material. Fifty-five mainly disarticulated valves from the Fyansford and Sherwood Formations.

Dimensions. Holotype, LV, female, NMV P122202: L = 1.11 mm, H = 0.59 mm. Paratype, RV, male, NMV P122203: L = 1.09 mm, H = 0.45 mm.

Diagnosis. Carapace moderately large, narrow and subrectangular, of medium shell thickness.

Description. Carapace smooth, moderately robust for family, narrow in dorsal view but without differential compression along marginal regions of lateral surface. Margins of both valves gently rounded and convex, except ventral margins which are concave. Maximum length well below mid-height; maximum height at mid-length; maximum width at mid-length and slightly below mid-height. Posterior slightly more produced and narrower than anterior in RV, less so in LV. Normal pore canals simple, scattered and without rims. Inner lamellae moderately wide; vestibula larger in anterior than posterior; marginal pore canals numerous and straight. Hinge long, simple and adont. Adductor muscle scar pattern consisting of three generally undivided, elongate anterior scars plus one posteroventral scar; middle one of the three

anterior scars sometimes sutured. Mandibular muscle scar pattern consisting of two very narrow scars. Frontal muscle scar pattern consisting of one scar above and slightly anterior to mandibular muscle scar pattern. Various dorsal muscle scars also visible. Sexual dimorphism pronounced, males being more elongate than females.

Remarks. This species is similar in lateral outline to *Bythocypris* (*Bythocypris*?) *bradyi* (Scott, 1905). Although Maddocks (1969) recorded a range of sizes for *B.* (*B.*) *bradyi*, *B.* (*B.*) *subrectangulata* is distinctly larger and not as flattened or produced in the anterior region. In addition, *B.* (*B.*) *bradyi* has slightly broader inner lamellae, a more symmetrically rounded posterior margin, a higher position of maximum length, and a thinner shell. *B.* (*B.*) *reniformis* Brady, 1880 is not as elongated as *B.* (*B.*) *subrectangulata* and has more acutely rounded anterior and posterior margins. The new species is assigned to *Bythocypris* s.s. on the basis of its subrectangular lateral outline and lack of differential compression adjacent to the anteroventral and posteroventral margins.

Age and stratigraphical range. Late Early to early Middle Miocene (Batesfordian to early Bairnsdalian, foraminiferal zones N8–N10/11), in clays and marls of the Fyansford and Sherwood Formations, as well as in calcilutites of the Sherwood Formation.

Bythocypris* (*Bythocypris*) *cf. affinis
(Brady, 1886)

Figs 1B, 2C–D

Bythocypris sp. 3.—Warne 1987: 441.

Anchistrocheles sp. 1.—Warne 1987: 441.

Material. Eight disarticulated adult and juvenile valves from the Fyansford and Sherwood Formations.

Dimensions. LV, female, NMV P122204: L = 1.09 mm, H = 0.55 mm. RV, male, NMV P122205: L = 1.07 mm, H = 0.47 mm.

Description. Carapace elongate, of medium size and thickness for family; LV larger than RV. Overlap greatest in mid-ventral and antero-dorsal regions. Anterior margins of both valves symmetrically rounded, with extremities at mid-height; posterior margins more acutely and asymmetrically rounded, with extremities well below mid-height. Dorsal margins of both valves gently arched, becoming straight anterodorsally;

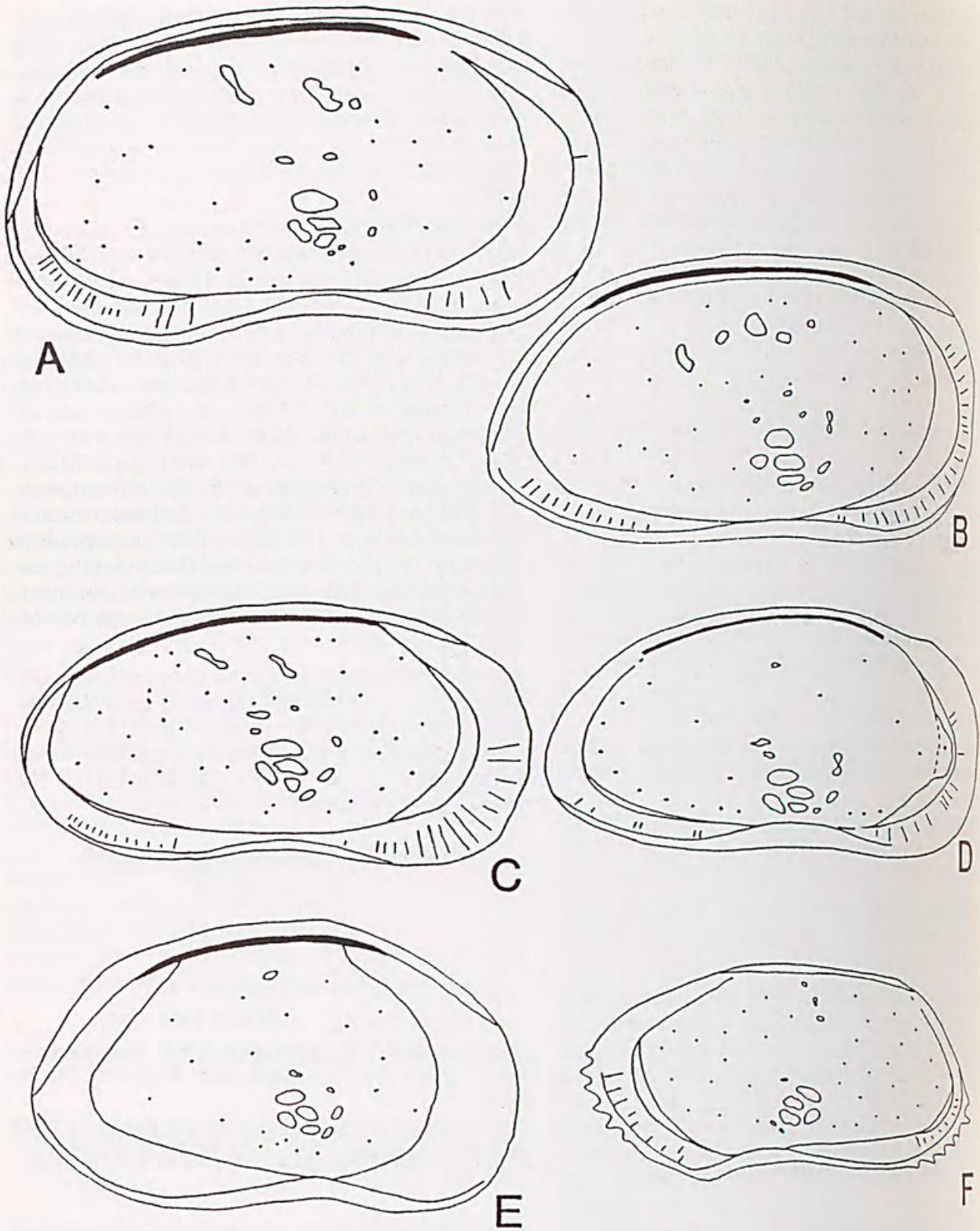


Fig 1. A, *Bythocypris (Bythocypris) subrectangulata* sp. nov., LV internal, NMV P122202, holotype, female, $\times 71$. B, *Bythocypris (Bythocypris)* cf. *affinis* (Brady, 1886), LV internal, NMV P122204, female, $\times 68$. C, *Bythocypris (Bythocypris)* sp. A, LV internal, NMV P122206, female?, $\times 85$. D, *Bythocypris (Bythocypris)* sp. B, LV internal, NMV P122208, $\times 79$. E, *Anchistrocheles praebensoni* sp. nov., LV internal, NMV P122209, holotype, female, $\times 88$. F, *Orlovibairdia mooraboolensis* sp. nov., RV internal, NMV P122212, paratype, male, $\times 92$. A from Fyansford Formation (late Batesfordian), Batesford Limestone Quarry; B, D-F from Fyansford Formation (Balcombian), Batesford Limestone Quarry; C from Fyansford Formation (Balcombian), Fossil Beach, Morningson.

ventral margins gently concave. Maximum length below mid-height, maximum height at mid-length, and maximum width below mid-height and approximately at mid-length. Valves slightly narrower anteriorly than posteriorly in dorsal view. Normal pore canals simple, scattered and without rims. Inner lamellae wide anteriorly and narrow posteriorly, both with vestibula developed. Marginal pore canals (as seen in anterior part of carapace) scattered and straight. Hinge long, simple and adont. Adductor muscle scar pattern consisting of three generally undivided, irregularly rounded anterior scars plus one similarly shaped posteroventral scar. Mandibular muscle scar pattern consisting of two elongate scars. Frontal muscle scar pattern consisting of two semi-detached oval scars. Dorsal scars visible. Sexual dimorphism evident, males being more elongate than females.

Remarks. This species is similar in size, shape and muscle scar arrangement to various subspecies and variants of *Bythocypris affinis* illustrated by Maddocks (1969), but they all have less acutely rounded posterior margins. *Bythocypris* (*Bythocypris*?) sp. (Whatley & Downing, 1983) [= *Anchistrocheles* sp. Whatley & Downing, 1983] and *B. (B?) antemacella* Maddocks, 1969 are also similar but are smaller, thinner shelled, more asymmetrically and less acutely rounded posteriorly, and slightly more flattened and produced anteriorly. The possibility that the form illustrated here is an intraspecific variant of *B. (B?)* sp. (Whatley & Downing, 1983) is not excluded. Previously (Warne 1987), I assigned specimens of the present form to two different genera on account of the unusually pronounced sexual dimorphism.

Age and stratigraphical range. Early Middle Miocene (Balcombian to early Bairnsdalian, foraminiferal zones N8/9–N10/11), in clays and marls of the Fyansford and Sherwood Formations.

Bythocypris (*Bythocypris*) sp. A

Figs 1C, 2G–H

Bythocypris sp. 2.—Warne 1987: 441.

Material. Thirty-six disarticulated adult(?) and juvenile valves from the Fyansford and Sherwood Formations.

Dimensions. LV, female?, NMV P122206: L = 0.79 mm, H = 0.44 mm. RV, male?, NMV P122207: L = 0.80 mm, H = 0.35 mm.

Remarks. This form is very similar to *Bythocypris* (*Bythocypris*) *subrectangulata* in the shape and clustering of the muscle scars but is smaller, more acutely rounded posteriorly, and has a higher posterior extremity and a greater height to length ratio. The differences in shape are approximately the same if *B. (B.)* sp. A. is compared with similar sized juvenile specimens of *B. (B.) subrectangulata*. Furthermore, the inner lamellae in juveniles of *B. (B.) subrectangulata* are narrower and are usually uncalcified. *B. (B.)* sp. A is most abundant in deeper water units of the Fyansford Formation at Mornington, whereas autochthonous occurrences of *B. (B.) subrectangulata* are restricted to the shallow water units of the Fyansford Formation at the Batesford Limestone Quarry (Warne 1987).

Maddocks (1969) noted that some bairdiacean species have the capacity to develop calcified inner lamellae in juvenile stages. It is possible, therefore, that the differences in carapace features between *Bythocypris* (*Bythocypris*) *subrectangulata* and *B. (B.)* sp. A merely reflect ecophenotypic variation within a single species.

Age and stratigraphical range. Early Middle Miocene (Balcombian to early Bairnsdalian, foraminiferal zones N8/9–N10/11), in clays and marls of the Fyansford and Sherwood Formations.

Bythocypris (*Bythocypris*) sp. B

Figs 1D, 2I

Bythocypris sp. 4.—Warne 1987: 441.

Material. One LV from the Fyansford Formation.

Dimensions. LV, NMV P122208: L = 0.87 mm, H = 0.41 mm.

Remarks. This specimen is similar in shape and height/length ratio to *Bythocypris* (*Bythocypris*) *prolata* Maddocks, 1969 but is smaller than adults of that species.

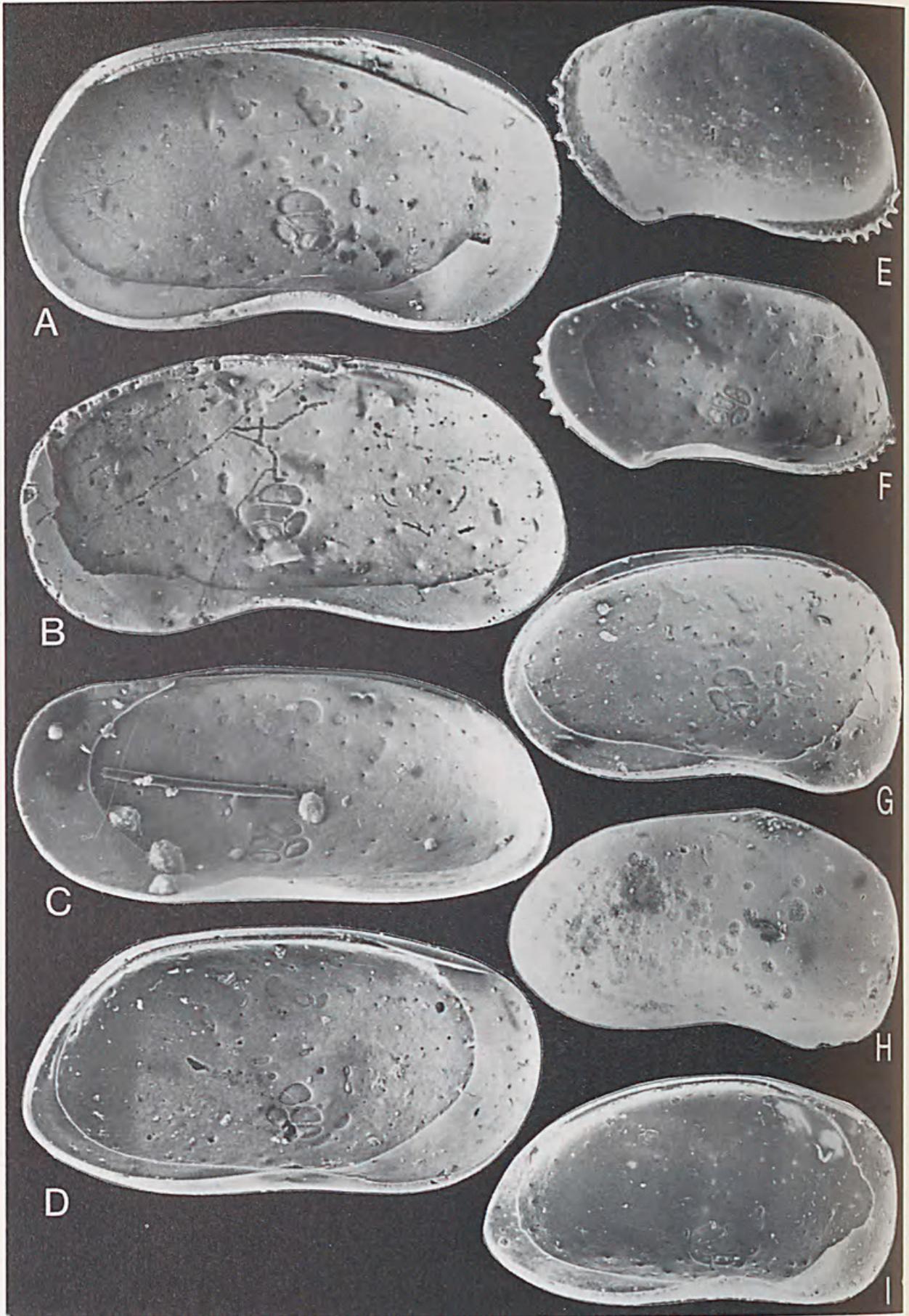
Age and stratigraphical range. Early Middle Miocene (Balcombian, foraminiferal zones N8/9), in clays of the Fyansford Formation.

Subgenus *Bythocypris* (*Bythotriangularia*) subgen. nov.

Etymology. A reference to the family Bythocyprididae and to the subtriangular carapace.

Type species. *Bythocypris spiriscutica* Maddocks, 1969: 96–99, figs 49E–I, 50A–D, 51A–E.

Other species. *B. (Bythotriangularia) eltanina* (Maddocks, 1969); *B. (Bythotriangularia) mozambiquensis*



(Maddocks, 1969); *B. (Bythotriangularia) promoza* (Maddocks, 1973).

Diagnosis. Carapace of medium size, inflated in dorsal view, subtriangular to oval in lateral view and with a strong anterior-posterior asymmetry. Inner lamellae moderately broad; adductor muscle scar pattern typically bythocypridid except that individual scars are commonly divided.

Remarks. The subtriangular to oval carapace distinguishes *B. (Bythotriangularia)* from the more elongated, reniform to subreniform or subrectangular carapace of *B. (Bythocypris)*. Although differences in soft part anatomy are unknown, the shape of the carapace is sufficiently distinct to warrant the recognition of *B. (Bythotriangularia)* as a separate taxon, especially given the small differences in lateral carapace outline between other closely allied bythocypridid genera, such as *Anchistrocheles* s.s. and *Orlovibairdia* s.s. The lateral outline of *B. (Bythotriangularia)* is similar to that of some pontocypridids but they can be easily distinguished by their markedly different adductor muscle scar patterns.

Bythocypris elongata Brady, 1880 may also belong to *B. (Bythotriangularia)* but it is more elongated than the other species included in the new subgenus and has a very narrow inner margin. Teeter (1975) placed *B. elongata* in his new genus *Triangulocypris*, which he regarded as a bythocypridid. His description and illustrations of the adductor muscle scar pattern suggest, however, that *Triangulocypris* belongs to the Paracyprididae, and the genus was assigned to that family by van den Bold (1988). Consequently, *B. elongata* probably does not belong to *Triangulocypris*.

Subfamily PUSSELLINAE Danielopol in Maddocks, 1976

Remarks. The subfamily name dates from Maddocks (1976), the earlier name Pussellidae Danielopol, 1973 being unavailable because the type genus was a *nomen nudum*.

Genus *Anchistrocheles* Brady & Norman, 1889

Type species. Anchistrocheles fumata Brady, 1890.

Remarks. *Anchistrocheles* s.s. is here considered to include forms with a reniform to subreniform lateral outline, conspicuous differential compression along a narrow zone adjacent to the anterior, posterior and ventral margins of the lateral surface, and a very broad inner lamella evident except in a relatively small region adjacent to the middle portion of the dorsal margin. *Anchistrocheles* s.s. differs from the deep water *Zabythocypris* in being larger, more robust and significantly less compressed in the middle of the carapace. It differs from *Orlovibairdia* s.s. in lacking marginal spinosity and in having slightly broader inner lamellae.

A variety of forms with differing carapace features have been included in *Anchistrocheles*. One such group includes *A. aculeata* Müller, 1908, *A. aff. aculeata* of Maddocks (1969) and *A. sp. A* Cronin, 1983. These forms, which are here assigned to the new genus *Bythopussella*, may be more closely related to the Caribbean interstitial genus *Pussella* Danielopol, 1976 than to *Anchistrocheles* s.s. Another species group that was erroneously included in *Anchistrocheles* has already been discussed in the remarks on *Bythocypris (Bythocypris)*.

Anchistrocheles praebensoni sp. nov.

Figs 1E, 3A–B

Anchistrocheles sp. 2.—Warne 1987: 441.

Etymology. A reference to the similarity of this species to *Anchistrocheles bensoni* Maddocks, 1969.

Holotype. Adult LV, female, NMV P122209 from near the top of the Fyansford Formation (Middle Miocene, Balcombian) in the south-west face of Batesford Limestone Quarry near Fyansford, Victoria (base of upper quarry bench well above the upper limit of *Lepidocyclusina* sp., approximately 25 m above boundary with Batesford Limestone); 38°06'S, 144°17'E.

Paratype. Adult RV, male, NMV P122210.

- ◀ Fig 2. A, B, *Bythocypris (Bythocypris) subrectangulata* sp. nov. A, LV internal, NMV P122202, holotype, female, × 71. B, RV internal, NMV P122203, paratype, male, × 76. C, D, *Bythocypris (Bythocypris) cf. affinis* (Brady, 1886). C, RV internal, NMV P122205, male, × 71. D, LV internal, NMV P122204, female, × 78. E, F, *Orlovibairdia mooraboolensis* sp. nov. E, LV external, NMV P122211, holotype, female, × 89. F, RV internal, NMV P122212, paratype, male, × 90. G, H, *Bythocypris (Bythocypris) sp. A*. G, LV internal, NMV P122206, female?, × 85. H, RV external, NMV P122207, male?, × 81. I, *Bythocypris (Bythocypris) sp. B*, LV internal, NMV P122208, × 78. A, B from Fyansford Formation (late Batesfordian), Batesford Limestone Quarry; C–F, I from Fyansford Formation (Balcombian), Batesford Limestone Quarry; G, H from Fyansford Formation (Balcombian), Fossil Beach, Mornington.

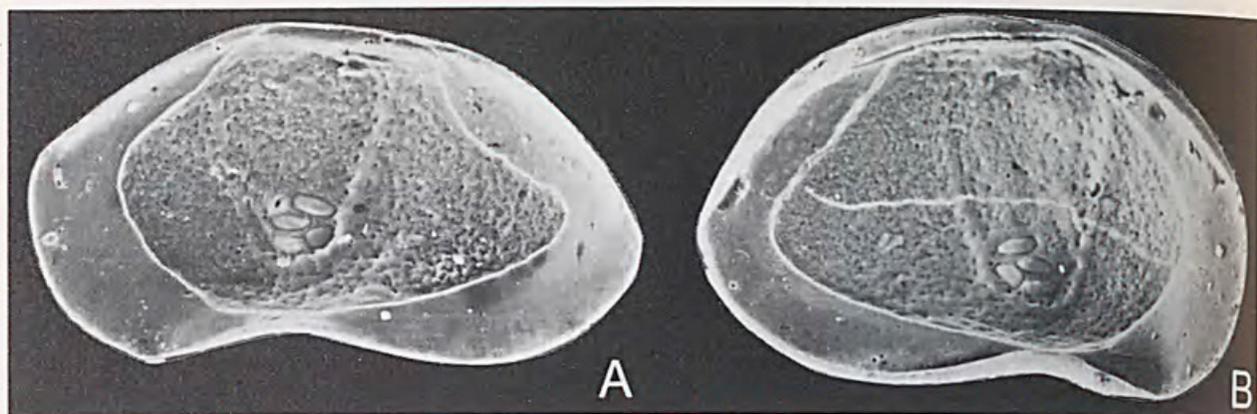


Fig 3. A, B, *Anchistrocheles praebensoni* sp. nov., Fyansford Formation (Balcombian), Batesford Limestone Quarry. A, RV internal, NMV P122210, paratype, male, $\times 86$. B, LV internal, NMV P122209, holotype, female, $\times 90$.

Additional material. Fifty-one articulated and disarticulated adult and juvenile valves from the Batesford Limestone and Fyansford and Sherwood Formations.

Dimensions. Holotype, LV, female, NMV P122209: L = 0.73 mm, H = 0.41 mm. Paratype, RV, male, NMV P122210: L = 0.74 mm, H = 0.34 mm.

Diagnosis. Carapace of varying shell thickness, with narrow, differentially compressed zone adjacent to anteroventral and posteroventral margins; very broad inner lamella evident in all but a relatively small region adjacent to mid-dorsal margin.

Description. Carapace of moderate size, smooth. Most adult specimens of medium shell thickness (opaque), but rare adults and most juveniles with thinner shells (translucent). LV larger than RV and strongly overlapping it. LV asymmetrically rounded anteriorly, with convex anterodorsal and anteroventral margins; extremity at mid-height. Posteriorly, LV more acutely rounded with convex posterodorsal and posteroventral margins; extremity below mid-height. RV similar to LV anteriorly and posteriorly but with straight anterodorsal margin and anterior extremity slightly above mid-height. Ventral margins of both valves strongly incurved. Dorsal margin gently arched in LV, straight in RV. Maximum length below mid-height; maximum height slightly anterior to mid-length. Normal pore canals simple, without rims. Inner lamellae with inner and outer margins not parallel. Inner margin sinuosity as follows. 1. Anterodorsal part of inner margin more or less straight in both valves except near its dorsal margin terminus where it arches slightly towards valve perimeter.

2. Anteroventral part of inner margin gently and evenly arching towards valve perimeter. 3. Anterior section of inner margin approximately parallel to outer margin. 4. Ventral and posteroventral parts of inner margin with no distinct change in curvature between them; they are straight in LV and slightly arched towards ventral perimeter in RV, except posteriorly where they become more strongly arched as part of the acutely rounded posterior extremity of the inner margin. 5. Posterodorsal part of inner margin more or less straight in LV, broadly arched towards centre of carapace in RV. 6. Ventral and posterior sections of inner margin not parallel to outer margin. Vestibula distinct but relatively small. Marginal pore canals abundant and straight. Hinge short and adont. Adductor muscle scar pattern comprising four undivided and unsutured elliptical scars in a loosely packed aggregate. Outer lamellae granular internally in thicker-shelled adults, smooth in thinner-shelled adults and in juveniles. Sexual dimorphism evident, males more elongate than females.

Remarks. *Anchistrocheles praebensoni* sp. nov., *A. bensoni* Maddocks, 1969 and *A. fumata* Brady, 1890 are very similar morphologically, and are here considered to define the morphological limits of *Anchistrocheles* s.s. The three species can be distinguished from each other by their different lateral outlines and by the size and sinuosity of the inner margin.

Specimens identified by Yassini & Jones (1987) as *Bythocypris reniformis* Brady, 1880 are very similar in shape to that species but differ in being differentially compressed along a narrow zone adjacent to the anteroventral and postero-

ventral margins. These specimens may belong to *Anchistrocheles*, a view that is supported by the shape and areal extent of the inner lamella which, although less extensive than that of *A. praebensoni*, is similar in size to that of *A. fumata*.

Anchistrocheles praebensoni is restricted to shallow water facies of the Port Phillip and Western Port Basins.

Age and stratigraphical range. Late Early to early Middle Miocene (Batesfordian to Balcombian; foraminiferal zones N7/8–N8/9), in calcarenites, calcilitites and marls of the Batesford Limestone, Fyansford Formation and Sherwood Formation.

Genus *Orlovibairdia* McKenzie, 1978

Type species. *Bythocypris angulata* Brady, 1870.

Remarks. *Orlovibairdia* is very similar to *Anchistrocheles* in carapace morphology, and both genera include forms with a reniform lateral outline. *Orlovibairdia* species tend to be more elongate, however, and the genus as a whole encompasses forms with a broader range in lateral outline, from reniform to subrectangular. *Orlovibairdia* also differs from *Anchistrocheles* in possessing less extensive inner lamellae, strong anteroventral and posteroventral denticulation, and, in some species, coarse punctate ornament.

Some species of *Orlovibairdia* resemble *Pussella* and *Danipussella* in lateral outline, but members of the last two genera have significantly greater length to height ratios.

Orlovibairdia mooraboolensis sp. nov.

Figs 1F, 2E–F

Orlovibairdia sp. 1.—Warne 1987: 441.

Etymology. A reference to the type locality near the Moorabool River at Fyansford, Victoria.

Holotype. Adult LV, female, NMV P122211 from near the middle of the Fyansford Formation (Middle Miocene, Balcombian) in the south-west face of Batesford Limestone Quarry, near Fyansford, Victoria (base of middle quarry bench above the upper limit of *Lepidocyclina* sp., approximately 10 m above the boundary with Batesford Limestone); 38°06'S, 144°17'E.

Paratype. Adult RV, male, NMV P122212.

Additional material. Twenty-five disarticulated adult and juvenile valves from the Fyansford and Sherwood Formations.

Dimensions. Holotype, LV, female, NMV P122211: L = 0.67 mm, H = 0.37 mm. Paratype, RV, male, NMV P122212: L = 0.66 mm, H = 0.31 mm.

Diagnosis. Carapace relatively small, smooth and elongate, with conspicuous differential compression of anteroventral and posteroventral margins which are strongly denticulate.

Description. Carapace thin shelled; anteroventral margin with six denticles; posteroventral margin with nine denticles. LV larger than RV and overlapping it. LV asymmetrically rounded anteriorly, with convex anterodorsal and anteroventral margins; extremity below mid-height. Posteriorly, LV more acutely rounded with convex posterodorsal and posteroventral margins; extremity below mid-height. RV similar to LV anteriorly and posteriorly but with straight anterodorsal margin. Dorsal margin arched in LV, straight in RV. Ventral margins of both valves strongly incurved. Maximum length slightly below mid-height; maximum height at mid-length in LV, anterior of mid-length in RV; maximum width below mid-height and at mid-length. Normal pore canals open, scattered, some with rims. Inner lamellae relatively narrow compared with type species, wider anteriorly and anteroventrally than posteroventrally. Vestibulum evident but small. Marginal pore canals (as seen anteriorly on carapace) scattered and straight. Adductor muscle scar pattern consisting of four subrounded to elongate scars in a loose aggregate; individual scars sometimes complexly sutured but no discrete division observed. Sexual dimorphism pronounced, males being more elongate than females.

Remarks. *Orlovibairdia mooraboolensis* is similar to *O. angulata* but the latter is slightly larger and possesses a scattered punctate ornament. *O. cf. arcaforma* (Swanson, 1979) [species attributed to Swanson by McKenzie 1978 but a *nomen nudum* when cited] differs from the new species in having a subrectangular lateral outline and strong punctate ornament. *O. formosana* Hu, 1981 from the Pliocene to Pleistocene of Taiwan is smooth like *O. mooraboolensis* but has a subrectangular lateral outline and a denticulate anterodorsal margin.

The variation in lateral outline and ornament outlined above in *Orlovibairdia* species illustrates the mosaic of carapace characters within the genus.

Age and stratigraphical range. Early Middle Miocene (Balcombian to early Bairnsdalian; foraminiferal zones N8/9–N10/11), in marls and clays of the Fyansford and Sherwood Formations.

Genus *Bythopussella* gen. nov.

Etymology. A reference to the family Bythocyprididae and to the possible affinity of the new genus with *Pussella*.

Type species. *Anchistrocheles aculeata* Müller, 1908: 101–102, pl. 14, figs 4–7, pl. 15, figs 1–5.

Other species. *B. aff. aculeata* of Maddocks, 1969, *B. sp. A* (Cronin, 1983) [= *Anchistrocheles sp. A* Cronin, 1983].

Diagnosis. Carapace of moderate size for family, subtrapezoid in lateral outline and compressed in dorsal view. Posterior extremity with prominent terminal spine; anterior extremity generally denticulate and sometimes with terminal spine. Carapace smooth or weakly punctate. Dorsal margin arched in LV, slightly concave in RV. Posterodorsal margin slightly convex in RV, more or less straight in LV. Anteroventral and posteroventral margins broadly convex in both valves. Ventral margin straight in RV, slightly concave in LV. Anterior extremity above mid-height and posterior extremity below mid-height in both valves.

Remarks. The three species here assigned to *Bythopussella* were previously included in *Anchistrocheles* but they differ markedly from members of that genus in lateral outline, in the extent of the inner lamella, and in the usual presence of a terminal posterior spine. *Bythopussella* resembles *Pussella* in that species of both genera may possess a terminal posterior spine. *Bythopussella* differs from *Pussella* and *Daniopussella* in being less elongate. *Bythopussella* is easily distinguished from *Bythotriangularia*, which has a carapace that is subtriangular or oval carapace instead of subtrapezoidal, lacks a posterior terminal spine and is generally more inflated.

The lateral outline of some *Bythopussella* species is perhaps reminiscent of various juvenile bairdiids, some of which also have a posterior terminal spine. Adults of *Bythopussella* differ from juvenile bairdiids, however, in the development of broad inner lamellae and in the overall compression of the carapace.

Bythopussella species appear to inhabit relatively deep marine realms.

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