

# Non-marine ostracods from two Quaternary profiles at Pulbeena and Mowbray Swamps, Tasmania

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Two spring-fed swamp deposits in northwestern Tasmania which contain non-marine ostracods are characterized by an alternation of marl, peaty marl and peaty layers: the Pulbeena Swamp deposit (4.80 m thick) was formed over approximately the last 80,000 years, and Mowbray Swamp (2 m thick) over about the last 110,000 years. Fifteen ostracod species have been recovered from 179 samples: three are new, three are in open nomenclature and the others have living representatives.

The ostracod data compared with pollen curves for both sites demonstrate, for most levels, a good correlation between the abundance of ostracods and that of Cyperaceae and *Potamogeton-Triglochin* pollen. This implies that ostracods can be successfully used as indicators of different water regimes for spring-fed swamps. Comparison of the ostracod fauna from the two Tasmanian sites is also made with that of other known Australian and New Zealand swamp deposits.

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THE STUDY of ostracods recovered from two sites in northwestern Tasmania was undertaken for two main reasons. Firstly, both sites represent a continuous sedimentary record over a long period of time; Pulbeena Swamp covers about the last 80,000 years and Mowbray Swamp about the last 110,000 years. Such long and continuous records are rare. Secondly, as the pollen sequence at both sites is known (Colhoun *et al.*, in press; van de Geer *et al.*, in prep.), palaeoclimatic information can be compared against the fossil ostracod data and, in turn, the palynological information should improve our knowledge of the use of ostracods as palaeoecological indicators.

## Description of the sites

### *Pulbeena Swamp*

At the Pulbeena limeworks, located between Smithton and Irishtown in northwestern Tasmania and about 30 m in altitude, a deposit of interbedded marl and swamp peat occurs over an area of about 1.7 km<sup>2</sup> (Fig. 1). An L-shaped area called Pulbeena Swamp at the limeworks exposes a 5 m thick section consisting of chemically precipitated algal marl, peat (some with standing tree

stumps) and peaty marl which overlie thin alluvial sand and gravel of Quaternary age. In turn, these rest on Precambrian dolomite (Colhoun *et al.*, in press). The site is characterized by low spring mounds scattered throughout the deposit. As the spring pipes are seen to penetrate the entire sequence on most occasions, it is likely that these springs fed the swamp continuously until it was drained early this century. At the base of the deposit near the quarry section, highly mineralized water of a fairly constant temperature (around 17°C) flows freely throughout the year from a number of springs (E. A. Colhoun & C. van de Geer, pers. comm.). Amphipods and the ostracod *Candonocypris incosta* De Deckker 1981 are common in these waters. The latter is also found as a fossil in the swamp deposits.

The alternating layers of peat and marl can be followed laterally along the quarry face but they vary locally in thickness and in places some peat layers divide and interfinger with marl bands. The lateral variation probably arose from subsidence of areas between the low mounds and was dependent on water depth. This is particularly the case at the studied site where an extensive peat bed, usually found over the entire swamp between 50 and 100 cm in depth, is divided into three layers separated by marl and peaty marl (Colhoun *et al.*, in press). In other places, where spring mounds have collapsed, the sequence is often

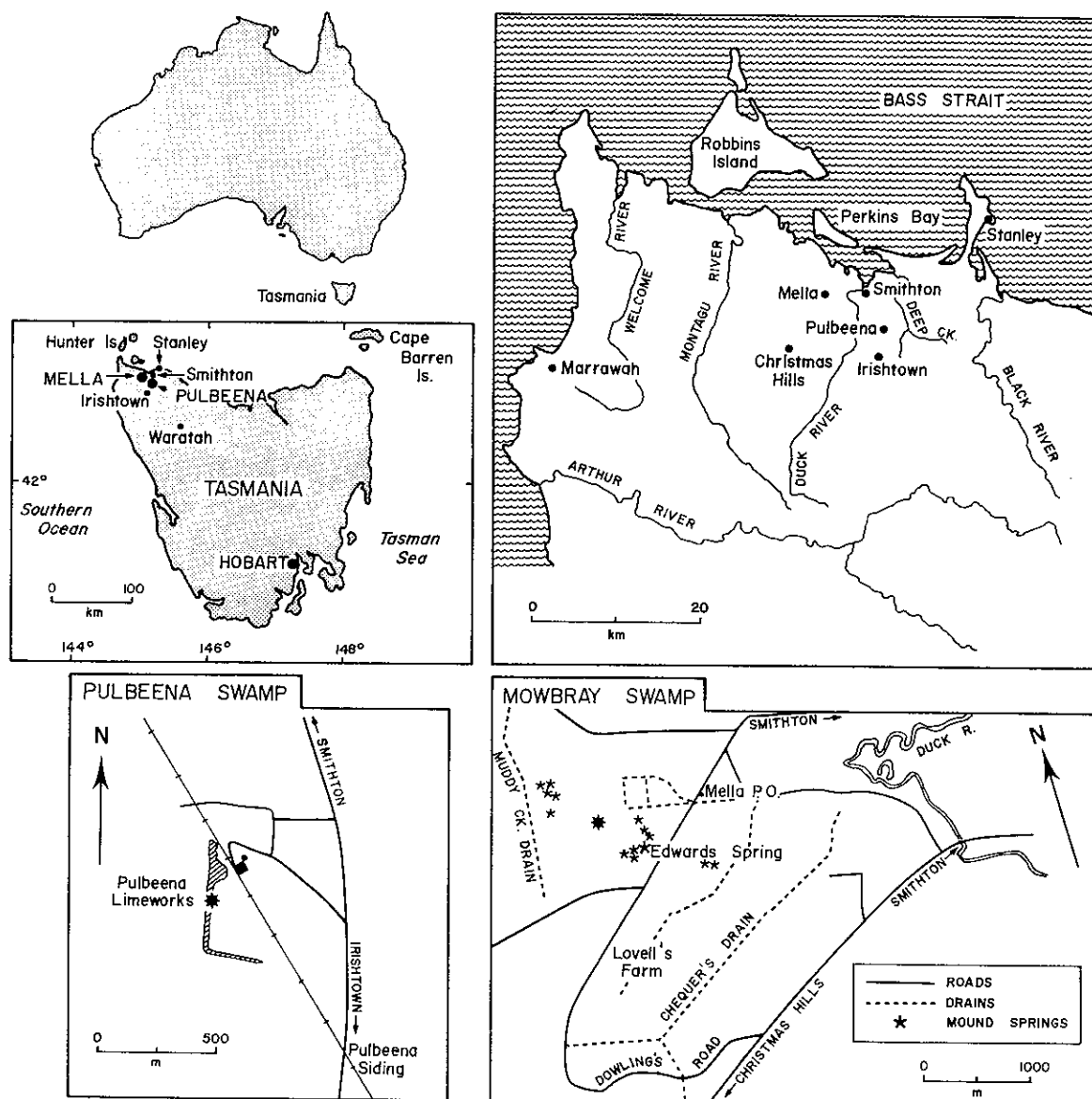


Fig. 1. Map showing location of Pulbeena and Mowbray Swamps. Large asterisks indicate the position of the two profiles studied.

compressed and the adjacent beds are usually steeply inclined towards the subsided mounds.

Further information on local climate, geomorphology, soils, ground water and lithological description of the 4.80 m thick section are given by Colhoun *et al.* (in press); they also provided a detailed palynological diagram accompanied by  $^{14}\text{C}$  dates and duplicate lithological samples for the Pulbeena Swamp deposit.

Prior to the work of Colhoun *et al.* little

had been written on Pulbeena Swamp. Banks *et al.* (1976) described from the site a right incisor and a mandible of the extinct marsupial *Palorchestes azael*. Twenty years earlier, Gill & Banks (1956) also paid some attention to the site in their review of the Cainozoic history of Mowbray Swamp and adjacent areas, and mentioned the record of three fossil ostracods which had been identified by Hornibrook (1953, 1955). These were *Candona lutea*, *Ilyodromus stanleyanus* and *Limnocythere mowbrayensis*.

### Mowbray Swamp

The Mowbray Swamp deposit, located south and southwest of Smithton at an altitude of 15 m (Fig. 1) covers a much larger area than Pulbeena Swamp. It is approximately 10 km wide and extends 20 km inland (Gill & Banks, 1956). The swamp deposits overlie interglacial marine sand which rests on Precambrian dolomite. The site studied here occurs about 500 m west of Mella (Fig. 1), where spring mounds are common. These are larger and taller than at Pulbeena Swamp, reaching up to 7 m in height and having low angle slope profiles between 5° and 10°. (Colhoun, 1979). Few springs have flowing water since the swamp has been artificially drained. Water originating from the mounds is mineralized (when compared with fresh water, TDS is less than 3‰) and has a constant temperature of 19°C (G. van de Geer, pers. comm.). The swamp and sides of the mounds consist generally of alternating layers of marl, peat and peaty marl. For further data on the site refer to van de Geer *et al.* (in prep.).

In a review of Mowbray Swamp, Gill & Banks (1956) recorded the existence of extinct marsupials, including two species of *Nototherium* and one of *Palorchestes*, as well as ostracods; one of these, *Limnocythere mowbrayensis*, was originally described from the site by Chapman (1914).

A <sup>14</sup>C dated 2 m thick section, dug in an inter-mound depression (for location see Fig. 1), was studied for pollen by van de Geer *et al.* (in prep.). Duplicate samples are analyzed here for ostracods. A lithological log is given in Fig. 15, but more detailed stratigraphical and lithological descriptions of the section are available in van de Geer *et al.* (in prep.)

### Method

Samples used from Pulbeena Swamp were mainly 10g in weight, whereas those from Mowbray Swamp weighed 5g. In the case of the smaller samples, data on ostracod abundance have been proportionately adjusted to permit adequate comparison between all samples from both deposits. The samples from which ostracods were recovered were left in a sealed 200 ml jar in 10% hydrogen peroxide solution for up to 6 weeks to disaggregate the often indurated marl. The content of the jar was then gently washed with a water jet over a 200 µm sieve

(a finer sieve would have retained the often unidentifiable valves of juvenile ostracods). The coarse residue was then dried in a low temperature oven and finally picked under a binocular microscope. Every adult ostracod was examined and later counted.

### Systematics and ecological information

All the ostracods illustrated in the present paper as well as representatives of all species found at the two sites are deposited in the Tasmanian Museum and Art Gallery under the register numbers Z 2073-2118. Samples collected at Pulbeena and Mowbray Swamps are labelled PS and MS respectively and followed by the appropriate depth in cm from the top of the section.

Subclass OSTRACODA Latreille 1806

Order PODOCOPIDA Müller 1894

Superfamily DARWINULACEA Brady & Norman 1889

Family DARWINULIDAE Brady & Norman 1889

DARWINULA Brady & Robertson 1885

*Type species. Polychaetes stevensoni* Brady & Robertson 1870.

DARWINULA sp. (Fig. 2)

1914 *Candona lutea* King; Chapman, p. 59, pl. 2, fig. 7 only.

*Description.* Flattened oval shell, smooth externally, with anterior pointed and posterior broadly rounded. Greatest height and greatest width of the shell at about four-fifths from the anterior and length-height ratio averaging 2. Left valve larger all along its periphery. Central muscle field consisting of a rosette of radially arranged scars; three to four each in front and behind and one smaller triangular scar positioned between the two lowest ones. Shell faintly reticulated internally, especially in the posterior area. Range of lengths: 620-800 µm.

*Remarks.* Little direct information is available for this species as it has not been identified, with certainty, among the living species (see remarks below). Most *Darwinula*

species are found only in freshwater, and because their eggs cannot withstand desiccation, they are found in permanent waters. However, it is not known whether the sometimes semi-terrestrial *D. sphagna*, which can live in damp moss of a sphagnum swamp, requires permanent water to reproduce — this might not be necessary as brooding occurs in this species (Barclay, 1968). No *Darwinula* species have so far been described from Australia, although the genus has been reported by Chapman (1967). Two species have been described from New Zealand: *D. repoa* Chapman 1963 from swamps and particularly peaty areas, and *D. sphagna* Barclay 1968 from damp moss of a sphagnum swamp and the interstitial waters of the Rotorua lakes (Chapman & Lewis, 1976). Although type specimens of these species have not been examined, it appears that *D. repoa* resembles the fossil specimens

studied here. However, Hornibrook (1955) pointed out that the fossil *Darwinula* sp. (= *D. repoa* of Chapman, 1963) found by him in the Pyramid Valley Swamp deposits occurs only in the blue-green mud immediately overlying the lower peat layer. The environment of deposition of the mud is different from the one described for living specimens of *D. repoa* by Chapman (1963). This is further complicated by Deevey's (1955) work which stated that, after comparison of fossil *Darwinula* from Mowbray Swamp and Pyramid Valley Swamp, the specimens appeared identical. No specific determination will be provided until living specimens of *D. repoa* are compared side by side with the fossil *Darwinula* sp. as so few diagnostic features of the shell useful in taxonomy are known for darwinulids. The pattern of the adductor scars of the specimens studied here (see Fig. 2I), so

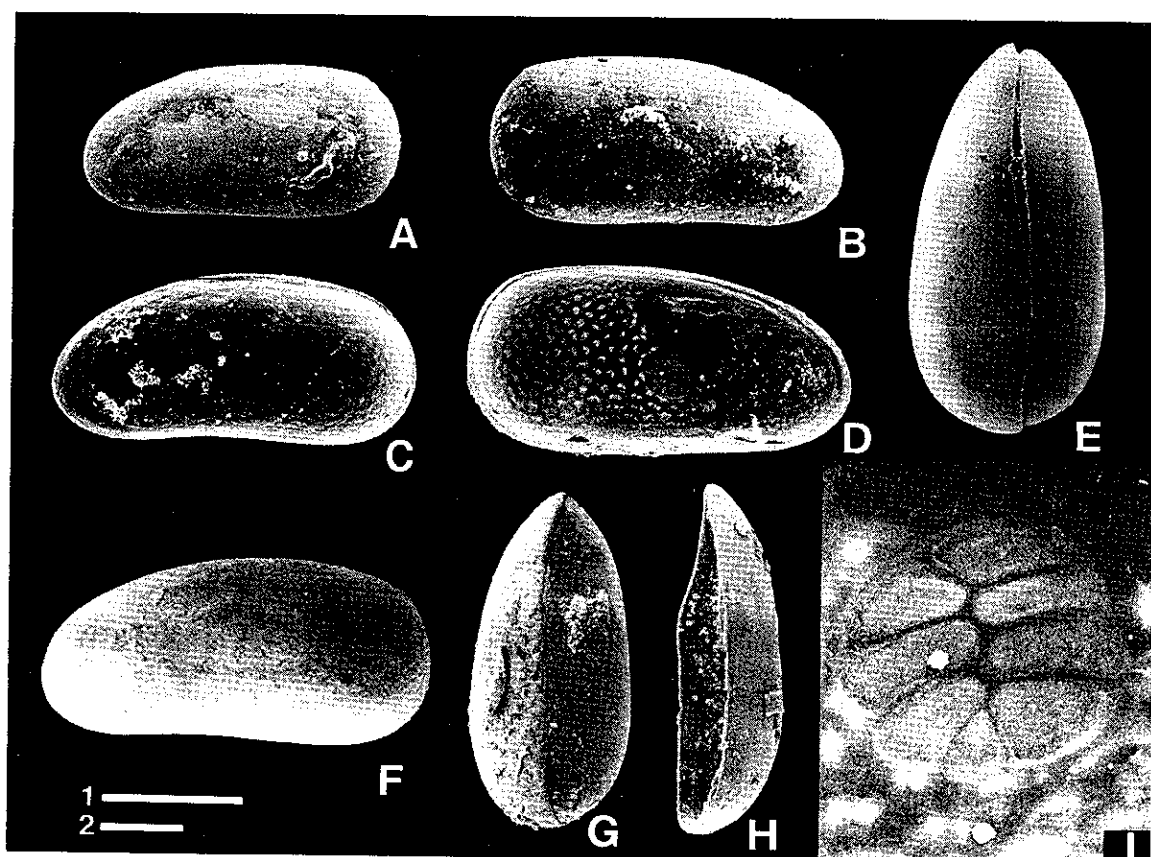


Fig. 2. *Darwinula* sp. A, LV external, PS270-Z2110. B, RV external, PS270-Z2110. C, RV internal, PS270-Z2110. D, LV internal, PS270-Z2110. E, C dorsal, PS405-Z2108. F, LV external, PS390-Z2107. G, C dorsal, PS390-Z2107. H, RV dorsal, PS270-Z2110. I, LV internal, central muscle field, detail of D. Scales: 1-200  $\mu$ m for A-H; 2-20  $\mu$ m for I. C - carapace; LV, RV - left, right valve; PS - Pulbeena Swamp, MS - Mowbray Swamp followed by depth in cm from top of section.

different from the elongated ones found in *D. stvensoni* (Brady & Robertson 1870) as illustrated by Sohn (1976), might help in specific identification. *Darwinula* sp. illustrated by Hornibrook (1955) from the Pyramid Valley deposit bears nine adductor scars.

Superfamily CYTHERACEA Baird 1850

Family LIMNOCYTHERIDAE Sars 1925

Subfamily LIMNOCYTHERINAE Sars 1925

LIMNOCYTHERE Brady 1867

*Type species. Cythere inopinata* Baird 1843.

LIMNOCYTHERE sp. (Fig. 3)

*Description.* Rectangular shell, elongated in male and compressed in female, with the dorsum slightly arched and the ventrum concave. Ornamentation of shell faint, with normal pores more obvious posteriorly and two narrow dorsal bosses, when viewed from above. There is a deep indentation above and in front of the anterior boss and of a horizontal groove just below and parallel with the hinge posteriorly. Inner lamellae broader anteriorly. Range of lengths: male, 540  $\mu$ m; female, 480-520  $\mu$ m.

*Remarks.* Only a few specimens of this species, which is likely to be new, have been found at level PS 250 in the Pulbeena Swamp deposit. Because of the paucity of material, no further description is provided.

GOMPHODELLA De Deckker 1981

*Type species. Gomphodella maia* De Deckker 1981c.

GOMPHODELLA AUSTRALICA (Hussainy 1969) (Fig. 4)

1969 *Gomphocythere australica* Hussainy, p. 299.

1981c *Gomphodella australica* (Hussainy), De Deckker, p. 132.

*Description.* See Hussainy (1969) and De Deckker (1981c).

*Remarks.* *G. australica* is a freshwater species and, like *G. maia*, has been found once in water of 2.3‰ salinity. It also requires permanent water to live in and is found on filamentous algae. Only 3 valves of

this species, which is much larger than *G. maia*, have been recovered from the Pulbeena Swamp deposit (levels PS120, 150).

Superfamily CYPRIDACEA Baird 1845

Family CANDONIDAE Kaufmann 1900

Subfamily CANDONINAE Kaufmann 1900

CANDONA Baird 1845

*Type species. Cypris reptans* Baird 1835.

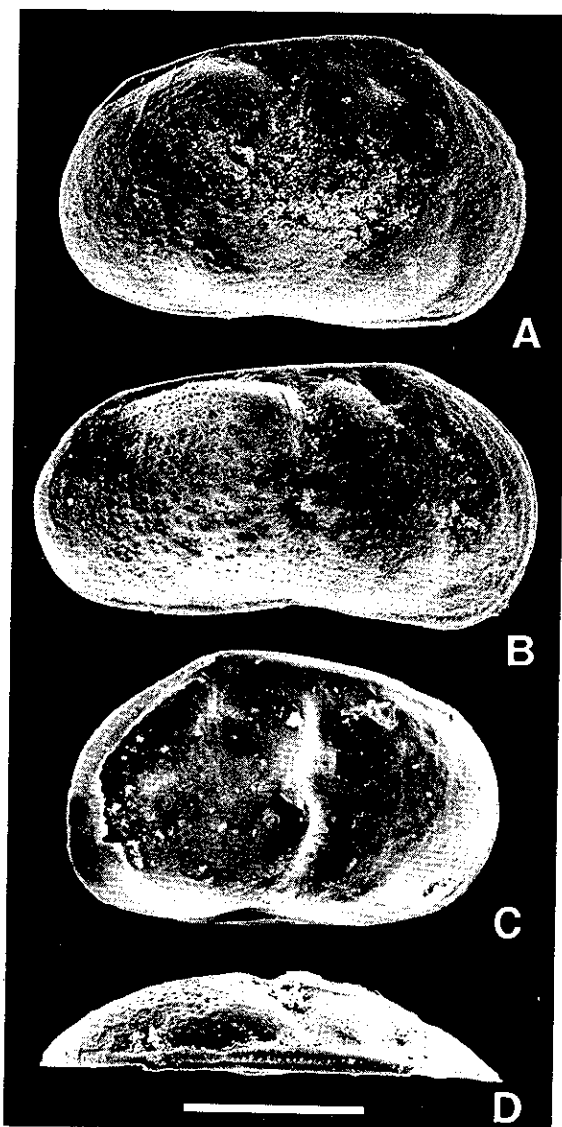


Fig. 3. *Limnocythere* sp. A, RV external, female, PS250-Z2105. B, RV external, male, PS250-Z2105. C, RV internal, female, PS250-Z2105. D, LV dorsal, female, PS250-Z2105. Scale - 200  $\mu$ m.

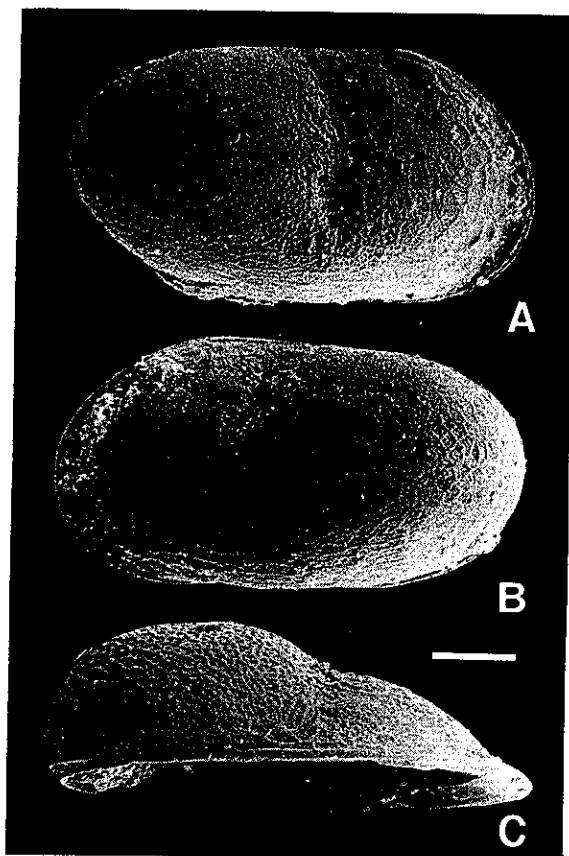


Fig. 4. *Gomphodella australica* (Hussainy 1969). A, RV external, female, PS150-Z2074. B, LV external, female, PS150-Z2074. C, LV dorsal, female, PS120-Z2074. Scale - 200  $\mu$ m.

#### CANDONA TECTA sp. nov. (Fig. 5)

**Description.** Smooth oval shell with the ventrum nearly flat and slightly concave in the middle; greatest height at about two-thirds from anterior. Length height-ratio about 2. Shell narrow in dorsal view. Anterior broadly rounded and posterior more tapered. Posterodorsal area more steeply inclined than the anterodorsal one. Internally, inner lamellae similar in both valves and almost three times broader anteriorly than posteroventrally. Central muscle field consisting of six closely arranged scars of almost equal size. Holotype (Z 2091) 615  $\mu$ m long and 280  $\mu$ m high; paratypes (Z 2092) range in length from 530-520  $\mu$ m.

**Type locality.** Pulbeena Swamp deposit, level PS 180 — pollen zone 3 of Colhoun *et al.* (in press).

**Derivation of name.** From Latin *tectus*

meaning hidden because this species is uncommon at both sites.

**Remarks.** No ecological data are available because living representatives are unknown. This species is different from the misidentified *Candona lutea* King 1855 illustrated by Chapman (1914) from Mowbray Swamp. After examination of Chapman's material kept at the National Museum of Victoria, it is possible to say that Chapman's (1914) fig. 6 represents *Candonocypris incosta* and fig. 7, labelled as *C. lutea* juvenile, is *Darwinula* sp. Valves of *Ilyodromus smaragdinus* are also present in Chapman's collection from the same site, but they are too small to fit his description and illustration of *C. lutea*.

CANDONOPSIS Vavra 1891

**Type species.** *Candona kingsleyi* Brady & Robertson 1870.

CANDONOPSIS TENUIS (Brady 1886) (Fig. 6)

1886 *Candona tenuis* Brady, p. 92.

1896 *Candonopsis tenuis* (Brady); Sars, p. 62.

**Description.** Smooth, flattened ellipsoid shell with anterior end more tapered. Greatest height at about two-thirds from the anterior. Dorsum more arched in male which is also larger. Concave part of the ventrum at about two-fifths from the anterior. Shell narrow in dorsal view. Internally, inner lamellae similar in both valves; broadest anteriorly and about twice as wide posteroventrally. Selvage faint and peripheral. Central muscle field placed at

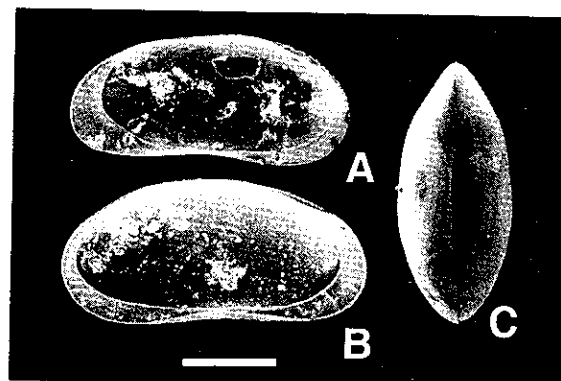


Fig. 5. *Candona tecta* sp. nov. A, RV internal, paratype, PS400-Z2092. B, LV internal, holotype, PS400-Z2091. C, C dorsal, PS430-Z2092. Scale - 200  $\mu$ m.

about one-third in height from the dorsum and above the convex area of the ventrum. Adductor scars consisting of six scars; the much larger one is above a row of three in front and two behind. Range of length 700-1,200  $\mu\text{m}$ .

**Remarks.** This species is only known to be a freshwater form. It is a true *Candonopsis* species, possessing the typical broad scar at the top of the adductor scars in females (Fig. 6G) as illustrated by Krstic (1976) for *C. kingslei pliocenica* Krstic 1976. In males, the scar is much smaller. The original illustration of *Candona lutea* King 1855 strongly resembles the fossil material studied here but King's (1855) description is insufficient to engage in further discussion because there seems to be no type material for the species.

Family CYPRIDIDAE Baird 1845

Subfamily SCOTTIINAE Bronstein 1947

MESOCYPRIS Daday 1910

*Type species. Mesocypris pubescens* Daday 1910.

MESOCYPRIS sp. (Fig. 7)

**Description.** Smooth oviform shell, arched dorsally and with a flat ventrum which is slightly concave in the mouth region. Anterior of the shell more pointed than the posterior which is broadly rounded. Greatest height at about the middle. Left valve overlaps the other all along its periphery, with the largest overlap at both extremities of the hinge. Internally, inner lamellae broader anteriorly in both valves. Selvage

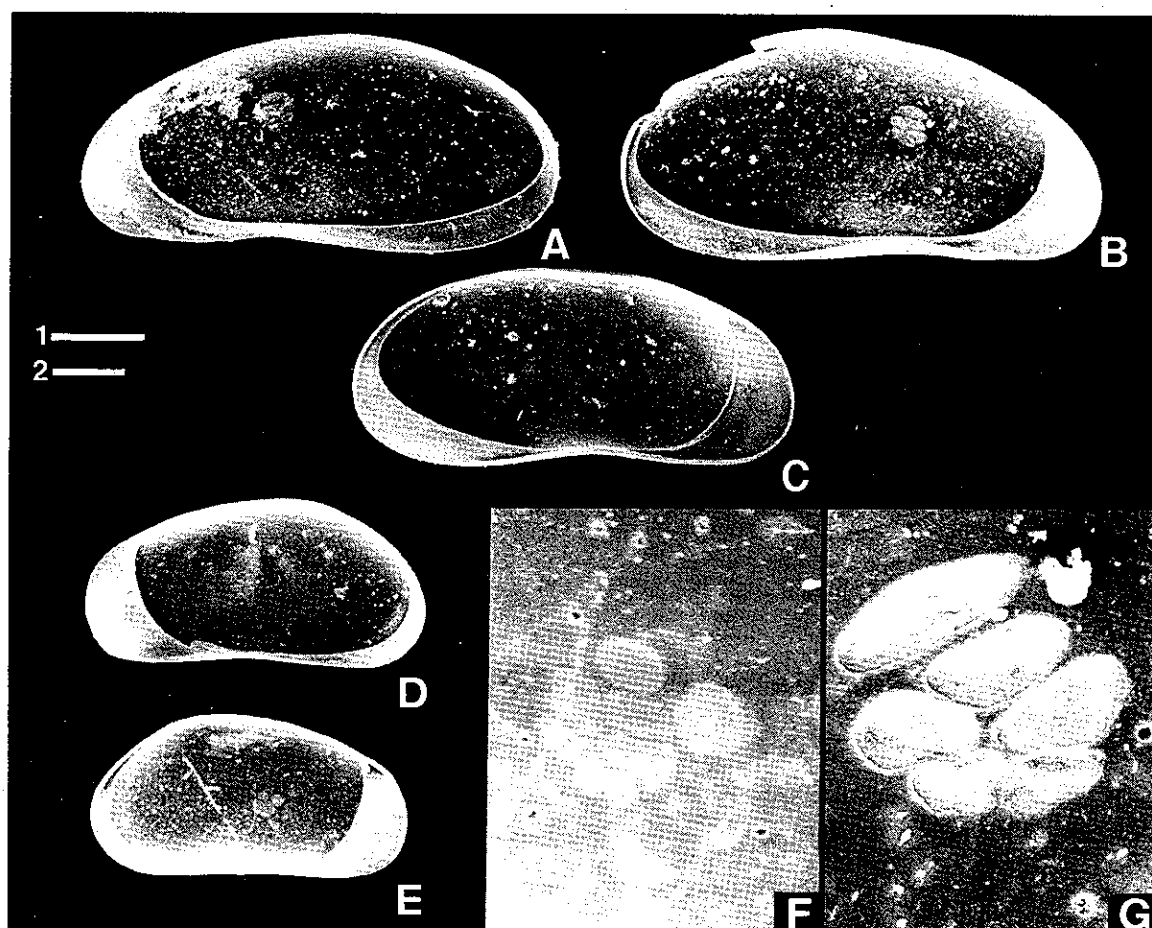
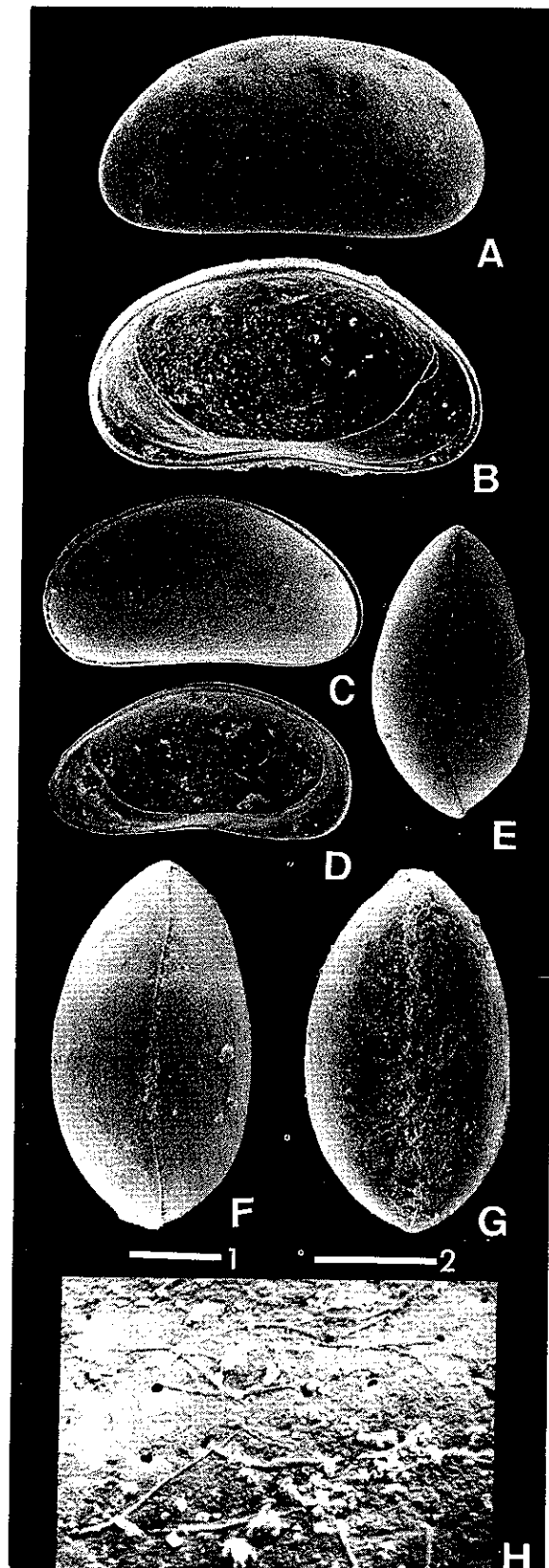


Fig. 6. *Candonopsis tenuis* (Brady 1886). A, RV internal, female, PS365-Z2089. B, LV internal, female, PS365-Z2089, partly broken. C, LV internal, female, PS400-Z2089. D, RV internal, male, PS180-Z2090. E, LV internal, male, PS180-Z2090. F, LV internal, central muscle field, detail of E. G, LV internal, central muscle field, detail of B. Scales: 1 - 200  $\mu\text{m}$  for A-E; 2 - 25  $\mu\text{m}$  for F-G.



broad anteriorly and posteriorly in the left valve but faint and more distant from the edge of the shell in the right valve. There is a deep groove between the edge of the shell and the selvage in the left valve, especially posteroventrally. Range of greatest length 650-850  $\mu\text{m}$ .

**Remarks.** Little is known about the ecology of *Mesocypris* sp. because no living representatives have been identified with certainty. Members of the Scottiinae (*sensu* De Deckker, 1979, 1980), which groups all *Mesocypris* and *Scottia* species, are found either in fresh waters and swampy areas (e.g. *S. pseudobrowniana* Kempf 1967) or are terrestrial and require little moisture (for a review see De Deckker, in press). The overall shape and size of adult specimens of *Mesocypris* sp. vary extensively (see Fig. 7). The specimens identified here as *Mesocypris* sp. probably belong to *M. insularis* (Chapman 1963) of De Deckker (1980), a species found today in New Zealand in peaty swamps and the bed of a Wellington stream (Chapman, in Chapman & Lewis, 1976). These environments are similar to those postulated for Pulbeena and Mowbray Swamps (peaty swamps and slow flowing springs) where *Mesocypris* sp. is common. Eagar's (1969) description of a Pleistocene mummified specimen of *M. insularis* from the Wairarapa Valley in New Zealand is of interest because specimens of *Mesocypris* sp., from both sites studied here, have many sensory hairs still attached to the shell and protruding from the normal pores, especially in the ventral area (Fig. 8H). For a revision of living Australian *Mesocypris* species, see De Deckker (in press).

Subfamily HERPETOCYPRIDINAE  
Kaufmann 1900

ILYODROMUS Sars 1894

Type species. *Candona stanleyana* King 1855.

Fig. 7. *Mesocypris* sp. A, LV external, MS265-Z2078. B, LV internal, MS265-Z2078. C, C showing RV, MS355-Z2080. D, RV internal, MS265-Z2078. E, C dorsal, MS355-Z2080. F, C dorsal, MS305-Z2079. G, C ventral, MS305-Z2079. H, C ventral, detail of G. Scales: 1 - 200  $\mu\text{m}$  for A-G; 2 - 20  $\mu\text{m}$  for H.



*ILYODROMUS MULTIFARIUS* sp. nov. (Fig. 8)

**Description.** Smooth shell, oval in shape, and with a flat ventrum. Greatest height at about middle. Dorsal area more steeply inclined than the anterior area but both ends are rounded. Length-height ratio greater in female. Inner lamellae very broad anteriorly and characterized by inner margin forming a straight line in the hinge area, at least in females. Ventrally and posteroventrally, the width of the inner lamellae can vary but it is narrower than anteriorly. Selvage faint and peripheral in both valves. Central muscle field with a vertical row of three scars and one behind plus two large mandibular ones below and partly in front. Holotype (Z 2093) 800  $\mu$ m long and 400  $\mu$ m high; paratypes (Z 2094-2095) range in length from 600-815  $\mu$ m.

**Type locality.** Pulbeena Swamp deposit, level PS 455 — pollen zone 10 of Colhoun *et al.* (in press).

**Derivation of name.** From Latin referring to the various shapes of the shell.

**Remarks.** As this species has only been recorded from the Pulbeena Swamp deposit, no ecological information is available. It is likely to be a freshwater species which favours organic-rich sediments to crawl upon, similar to most *Ilyodromus* species in Australia.

*ILYODROMUS SMARAGDINUS* Sars 1894 (Fig. 9)

1894 *Ilyodromus smaragdinus* Sars, p. 43.

**Description.** Adult shell flattened, ellipsoidal and smooth externally. Dorsum arched. Left valve slightly larger than the right valve. Overlap of left valve dorsally at both extremities of the hinge area. In dorsal view, it is compressed and both ends are pointed. Inner lamellae very broad in both valves, but broadest anteriorly; ventrally they are half of anterior width. Selvage faint and close to the edge in both valves. Length ranges from 1,000 — 1,200  $\mu$ m. Juvenile valves are similar in shape to adults but more flattened and with a faint notch in front of the hinge area anteriorly. Most valves possess fine longitudinal striations externally.

**Remarks.** This is a freshwater species not yet found living in Australia. It was originally described by Sars (1894) who raised the species from a sample of dried mud from lagoons near Dunedin in New Zealand. The species has not been collected since. The basic vertical row of three (sometimes two) large adductor muscle scars with one behind and two broad mandibular ones in front and below is typical of *Ilyodromus*. The specific identification relies on Sars's (1894) illustrations and description of *I. smaragdinus*.

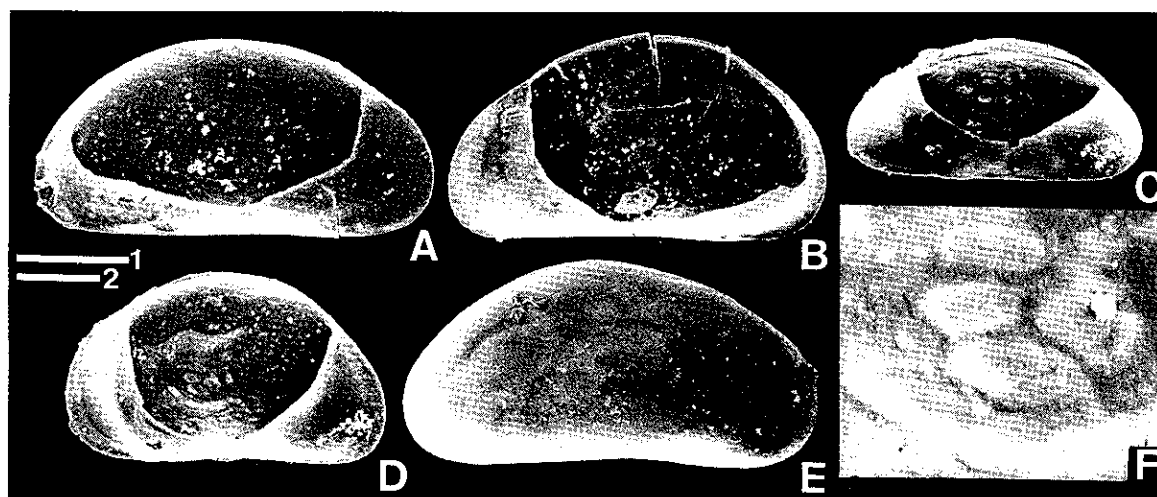


Fig. 8. *Ilyodromus multifarius* sp. nov. A, LV internal, holotype, PS455-Z2093. B, RV internal, paratype, PS455-Z2094. C, LV internal, dorso-lateral view of D, PS180-Z2095. D, LV internal, PS180-Z2095. E, RV external, paratype, PS455-Z2094. F, LV internal, central muscle field, detail of D. Scales: 1 - 200  $\mu$ m for A-E; 2 - 25  $\mu$ m for F.

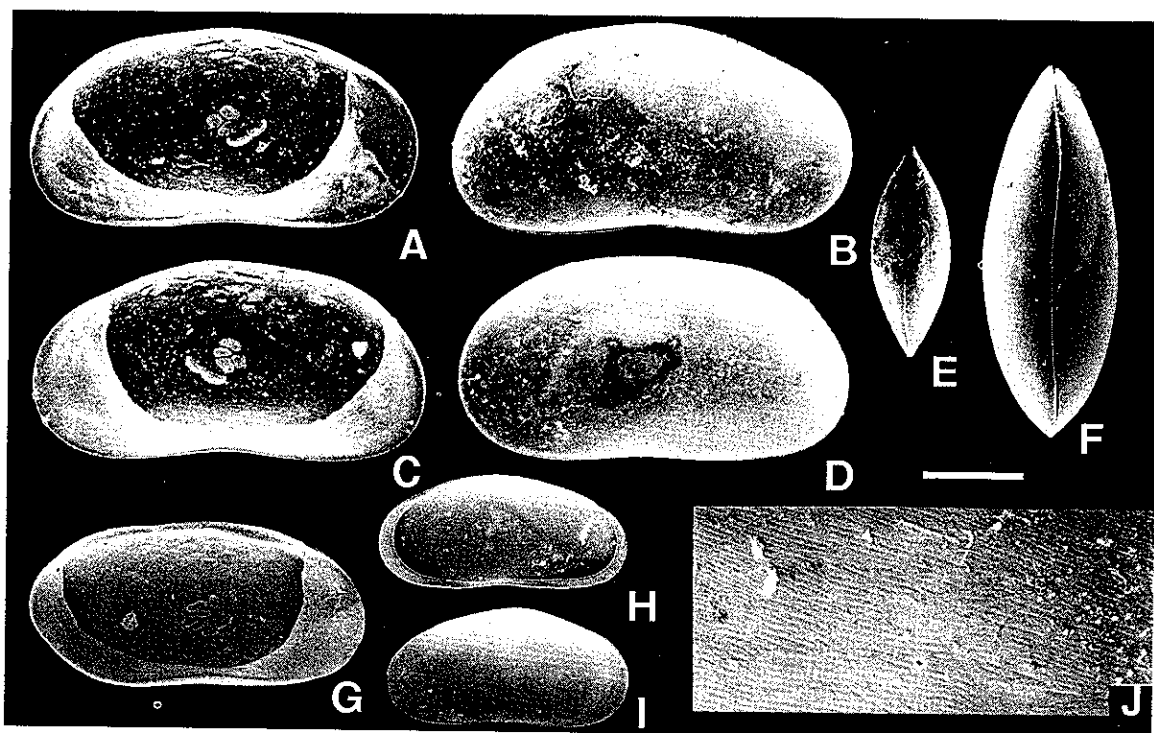


Fig. 9. *Ilyodromus smaragdinus* Sars 1894. A, LV internal, PS350-Z2085. B, RV external, PS3502-Z2085. C, RV internal, PS350-Z2085. D, LV external, PS350-Z2085. E, C dorsal, juvenile, PS350-Z2085. F, C dorsal, PS405-Z2087. G, LV internal, PS355-Z2086. H, RV internal, juvenile, PS405-Z2087. I, RV external, juvenile, PS405-Z2087. J, RV external, detail of I. Scale - 300  $\mu$ m for A-J, 30  $\mu$ m for I.

which indicate that the inner lamellae are broad at both ends of the valves. This is different from *I. viridulus* (Brady 1886) which possesses broad inner lamellae only at the anterior. Unlike most *Ilyodromus* species described by Sars (1894), the shell of *I. smaragdinus* is smooth in adults; juvenile specimens are faintly striated longitudinally (Fig. 9J), a common feature for the genus. Juveniles of this species differ from those belonging to *Candonocypris* by the greater length-height ratio of the shell. Note that the overall shape of the shell can be quite variable (cf. Fig. 9A-D and 9G).

#### Subfamily CYPRETTINAE Hartmann 1963

##### CYPRETTA Vavra 1895

*Type species.* *Cypridopsis* (*Cypretta*) *tenuicaudata* Vavra 1895.

##### CYPRETTA VIRIDIS (Thomson 1878) (Fig. 10)

1878 *Cypris viridis* Thomson, p. 253.

1894 *Cypridopsis viridis* (Thomson); Sars, p. 32.

1912 *Cypretta viridis* (Thomson); Müller, p. 206.

1955 *Cypridopsis viridis* (Thomson); Hornibrook, p. 273.

*Description.* Adult shell pseudopunctate, globular in shape with flatter ventrum which is concave in the mouth region. Pseudopunctuation more obvious anteriorly and posteriorly. Greatest height and greatest width at about middle. In dorsal view, anterior of shell narrower. Length-height ratio of both valves about 1.45. Right valve larger anteriorly; there is a strong overlap of both valves in the mouth region with the right valve placed on the outside. Posteriorly, valves are almost equal. Internally, right valve with broad selvage all along and with a deep narrow groove adjacent to it on the inner edge of the shell. The selvage is tuberculate posteroventrally and curved inward in the middle of the ventrum. In the left valve, selvage is faint and near the edge of the shell anteriorly and slightly away from the edge posteriorly. Inner lamellae at least twice as broad anteriorly where radial septa are also visible through the shell. Length of adults ranges from 920-960  $\mu$ m. Juvenile shells are globular in shape and highest at about two-thirds from the anterior.

**Remarks.** *C. viridis*, as with other *Cypretta* species, is a good swimmer which is found in a variety of freshwater bodies and even in slowly flowing rivers. It is uncommon in temporary pools and is usually found swimming near the water's edge especially in among aquatic vegetation.

This species is distinguishable from *C. minna* (King 1855), *C. turgida* (Sars 1896) and *C. globula* (Sars 1889) on the basis of the following features: *C. minna* has a smaller length-height ratio of the valves (~1.1-1.2); *C. turgida* is rounder in dorsal view; and *C. globula* has small tubercles (*sic* Sars, 1896) on the posteroventral edge of the valve. All three species have a length-height ratio of both valves similar to that of *C. viridis*. Further anatomical work is necessary in order to determine whether or not *C. turgida* is a juvenile of *C. viridis*.

Subfamily CYPRIDOPSINAE Kaufmann 1900

SARSCYPRIDOPSIS McKenzie 1977

**Type species.** *Potamocypris gregaria* Sars 1895.

SARSCYPRIDOPSIS PROXILA sp. nov. (Fig. 11)

**Description.** Subtriangular shell, pseudopunctate except in the dorsal area; greatest height at about two-fifths from the anterior and anterior part of the dorsum steeply inclined. Posterodorsally, the shell is almost straight. In dorsal view, the shell is narrow with both ends pointed. Right valve larger anteriorly, posteriorly with a small overlap in front of the hinge area dorsally, and with a larger overlap ventrally at mid-length. Selvage narrow and placed far away from outer margin in the right valve antero- and posteroventrally and curved inward ventrally where both valves overlap. Selvage faint and peripheral in the left valve. Holotype (Z 2111) 690  $\mu$ m long and 390  $\mu$ m high; range of length of adult paratypes (Z 2112-2114) 640-700  $\mu$ m.

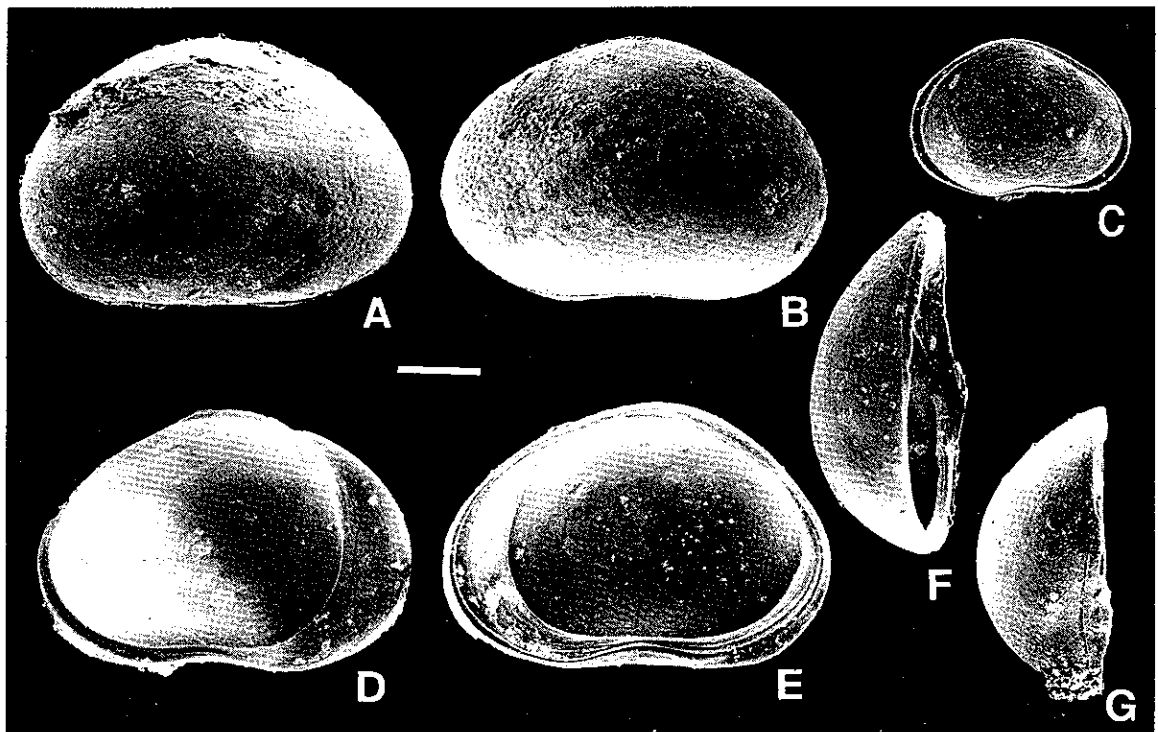


Fig. 10. *Cypretta viridis* (Thomson 1878). A, RV external, PS360-Z2099. B, LV external, PS360-Z2099. C, RV internal, juvenile, PS390-Z2098. D, LV internal, PS390-Z2098. E, RV internal, PS390-Z2098. F, LV dorsal, PS360-Z2099. G, RV ventral, PS360-Z2099. Scale - 200  $\mu$ m.

*Type locality.* Pulbeena Swamp deposit, level PS 390 — pollen zone 8 of Colhoun *et al.* (in press).

*Derivation of name.* From Latin *proxilus* meaning elongated.

*Remarks.* No accurate ecological information is yet available. Other *Sarscypridopsis* species are good swimmers, and therefore indicative of open water conditions. On shell morphology alone, *S. proxila* appears to be closely related to *S. aculeata* (Costa 1847) (see De Deckker, 1981b). The latter species is found in temporary pools and can withstand slightly saline waters up to 20‰ (De Deckker, 1981e). *S. proxila* differs by its more elongated shell (length-height ratio 1.7 for *S.*

*proxila* and 1.5 for *S. aculeata*). Additionally, the selvage in *S. aculeata* is placed much farther away from the edge of the shell at both ends of the left valve and is broader in both valves; the inner lamellae are broader posteriorly in both valves of *S. proxila*. The outline of *S. proxila* resembles that of the South African species *S. striolata* (Sars 1924) illustrated by McKenzie (1977); the latter species differs from *S. proxila* by the diagnostic longitudinal striations on its shell.

#### *Other species*

Since the following five species have either been recently described or re-examined, only information relevant to the interpretation of the fossil material is presented here.

*Limnocythere mowbrayensis* Chapman 1914 (see De Deckker, 1981a) is a benthic species

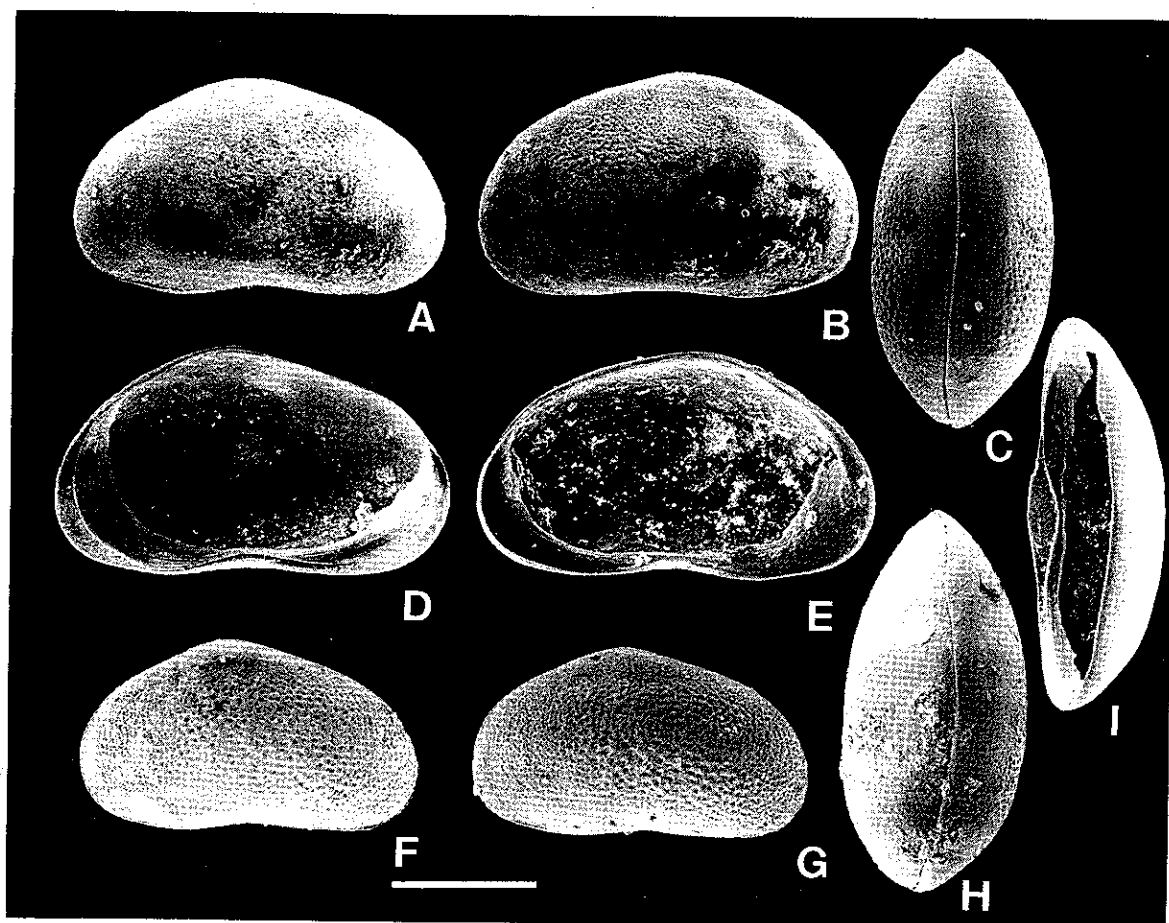


Fig. 11. *Sarscypridopsis proxila* sp. nov. A, LV external, paratype, PS390-Z2112. B, RV external, paratype, PS390-Z2112. C, C dorsal, PS270-Z2114. D, RV internal, holotype, PS390-Z2111. E, LV internal, paratype, PS390-Z2112. F, LV external, juvenile, PS280-Z2113. G, LV external, juvenile, PS280-Z2113. H, C dorsal, PS280-Z2113. I, RV dorsal, paratype, PS390-Z2112. Scale - 250  $\mu$ m.

usually found among filamentous algae. It occurs in permanent fresh waters but can tolerate waters up to 6‰ salinity, such as an ephemeral locality near the Coorong Lagoon, South Australia (De Deckker & Geddes, 1980; De Deckker 1981b).

Until De Deckker (1981a) recorded *L. mowbrayensis* from two South Australian

localities, no living representatives of this species had been found. As a fossil, it was originally described from Mowbray Swamp by Chapman (1914) and later found by the same author (Chapman, 1919) from Boneo Swamp in Victoria (as *L. sicula*, later synonymized by Hornibrook, 1955). It was also recorded from Pyramid Valley Swamp

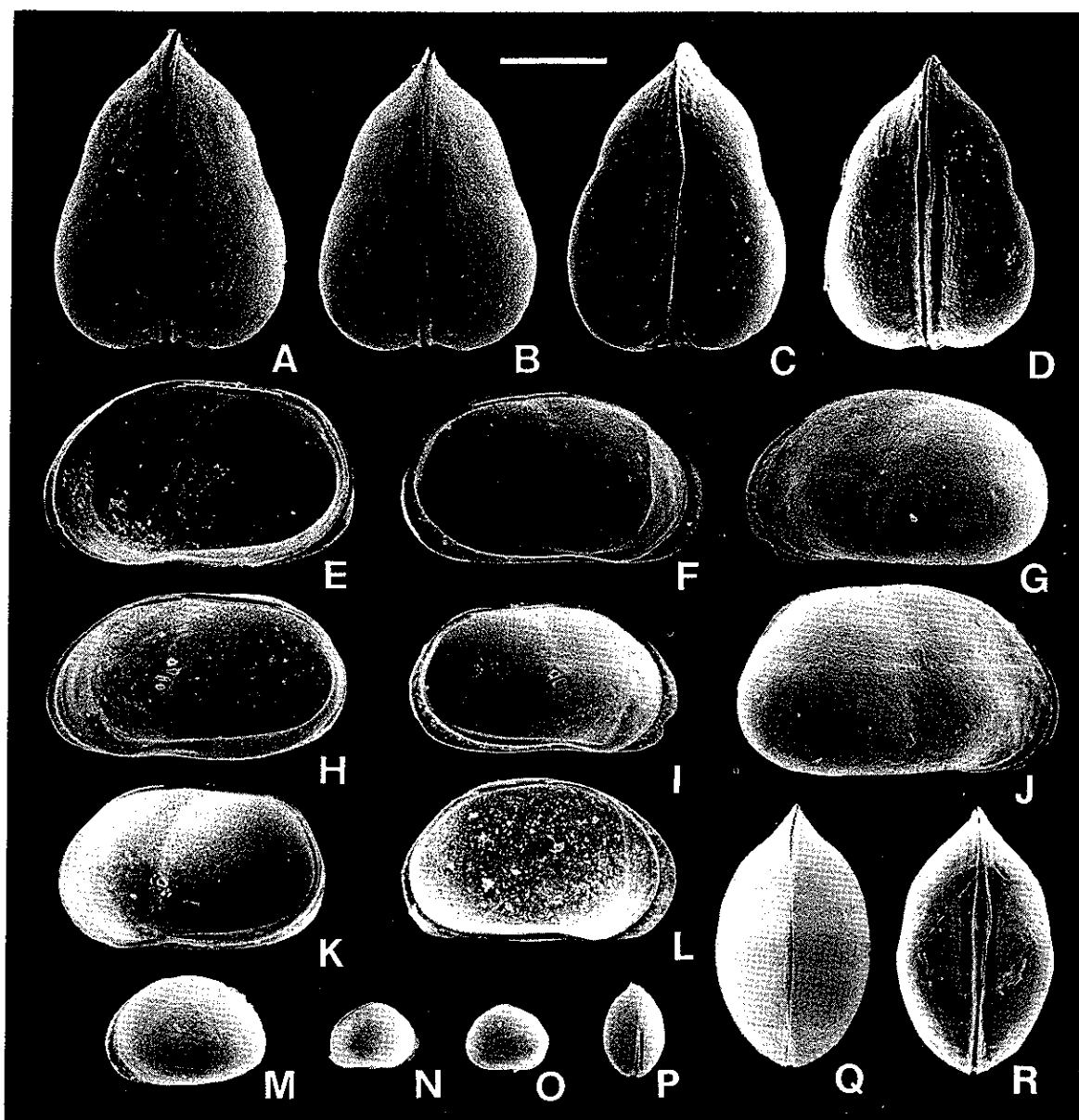


Fig. 12. *Gomphodella maia* De Deckker 1981. A, C dorsal, female, PS315-Z2075. B, C dorsal, female, PS315-Z2075. C, C ventral, female, PS370-Z2076. D, C ventral, female, PS315-Z2075. E, RV internal, female, PS405-Z2077. F, LV internal, male, PS370-Z2076. G, LV external, female, PS315-Z2075. H, RV internal, male, PS370-Z2076. I, LV internal, male, PS405-Z2077. J, RV external, female, PS315-Z2075. K, RV internal, male, PS405-Z2077. L, LV internal, male, PS370-Z2076. M, LV external, juvenile, PS315-Z2075. N, LV internal, juvenile, PS315-Z2075. O, RV external, juvenile, PS315-Z2075. P, C dorsal, juvenile, PS405-Z2077. Q, C dorsal, male, PS405-Z2077. R, C ventral, male PS405-Z2077. Scale — 200  $\mu$ m.

in New Zealand by Hornibrook (1955) who placed it in synonymy with the junior *L. percivali* Brehm 1939. Deevey (1955), who also studied the Pyramid Valley Swamp deposit, provided illustrations of *L. percivali* which are different from those of Hornibrook: *L. percivali* of Deevey (1955, figs. 5, 6, 8, 9) does not seem to have a broad lateral process and is characterized by a row of 3-4 spines on the posteroventral edge of the right valve. Such spines have only been found once on a fossil juvenile of *L. mowbrayensis* from a short core at Pillie Lake in South Australia (De Deckker, 1981d).

*Gomphodella maia* De Deckker 1981c (Fig. 12) lives in permanent waters: its eggs cannot withstand desiccation and brood care is known to occur in this species. Juveniles have been found in closed carapaces of *G. maia* in the two sites studied here. The presence of *G. maia* is considered to indicate permanent water conditions bearing in mind that this is a generalization because De Deckker (1981c) interpreted the occurrence of numerous carapaces of this species as a possible indication of burrowing in sediment during periods of desiccation; the latter has not been observed in living specimens. However, as all *Gomphodella* species, and most likely *Darwinula* sp., require permanent water to reproduce, it seems plausible to suggest that water must have been permanent somewhere at Pulbeena for the species to survive (? short) periods of dessication. *G. maia* occurs in fresh waters but has been collected once at 2.3‰ (see De Deckker, 1981c).

*Leptocythere lacustris* De Deckker 1981c is a benthic ostracod which occurs in permanent waters characterized by only slight salinity fluctuations. Its salinity range is 19-28‰, but it has been found also at 2.8‰ salinity.

Few valves of *L. lacustris* are present in samples from the Pulbeena Swamp deposit, possibly indicating that highly saline waters rarely flowed from the springs. *L. lacustris* was not found in the samples from the profile at Mowbray Swamp, in which many Mg-Fe sulphate crystals abound, but the species was present in the dark grey mud sampled at the bottom side of one of the drains in the swamp near Mella.

*Candonocypris novaezelandiae* (Baird 1843), described by De Deckker (1981b), is a freshwater species commonly found in farm

dams and eutrophic waters. It usually lives in among decaying vegetal matter and in black organic mud. Bisexual populations are found in permanent water, whereas parthenogenic ones occur in ephemeral or small waterbodies.

This species has already been recovered as fossil from Boneo Swamp in Victoria by Chapman (1919) and from Pyramid Valley Swamps by Hornibrook (1955), although on each occasion under the specific name of *C. assimilis*, now synonymized to *C. novaezelandiae* (see De Deckker, 1981b). Signs of gnawing by organisms, mainly on the external area of valves, are common. This phenomenon occurs after death of the ostracods as the inner lamellae of the shells are also gnawed. The organism causing these gnawing 'tracks', best observed under a scanning electron microscope, is unknown.

*Candonocypris incosta* De Deckker 1981b is a freshwater species that has been collected only twice; once at Pulbeena Swamp (see note below) and in New Guinea, in Lake Peunde (altitude 3,750 m).

A number of valves of juveniles and some left valves of *Candonocypris* remain unidentified at the species level and are designated as *Candonocypris* sp. in the ostracod distribution diagram for Pulbeena Swamp (Fig. 13). *C. incosta* is the only ostracod species found living today at the base of the quarry at Pulbeena in water flowing slowly from some of the springs. There it was found crawling above and within the topmost one cm of sediment.

## Ostracods from Pulbeena Swamp

All ostracods larger than 200 µm and picked from the 97 samples collected at Pulbeena Swamp were counted and their numbers are represented in Fig. 13. When samples yielded less than 10 g of sediment, the numbers of ostracods were proportionately adjusted. In nearly all samples which yielded more than 50 valves, adults and juveniles of each species were found together and both left and right valves were present in about equal numbers, indicating that there has been no selective sorting of ostracods. As most fragile shells belonging to species such as *Ilyodromus multifarius*, *Candona tecta*, *Candonopsis tenuis* and *Darwinula* sp., were found intact, it seems likely that there was

little or no reworking of the sediments or ostracods. With the exception of *Gomphodella maia* and *Mesocypris* sp. all species at Pulbeena are usually poorly represented. In nearly all samples these two are the most common species and are often found in similar proportions; their abundance appears to be significant. When conditions were favourable, such as the presence of permanent water, their numbers were high, as confirmed in samples which yield a more diversified ostracod fauna. High numbers of species may result from the greater availability of niches in the water body resulting from an increase in aquatic plants because of deepening of the permanent water body and, perhaps, warmer conditions. Correspondingly, when species numbers were low, conditions were less favourable and there was little permanent water and little or no aquatic vegetation. All this is substantiated by a comparison between the pollen diagram and the ostracod diagram. No inference concerning temperatures can be made as it is not known whether dry conditions are associated with either cold or warm temperatures. Thus the interpretation of the presence of the ostracod species in the samples is attempted below on the basis that the ecological information obtained on living species today refers equally to fossil material.

Because the vertical distribution of many ostracod species corresponds almost exactly to the distribution of some of the aquatic plants for the section studied at Pulbeena Swamp (Fig. 14), the biostratigraphic zonation based on pollen abundance and the distribution of Colhoun *et al.* (in press) is kept here for the ostracods. This should also facilitate comparison between the present work and that of Colhoun *et al.* (in press). Ten zones have been recognized by these authors and they are examined in a descending order. All pollen data and dates mentioned here are taken from Colhoun *et al.* (in press).

**Zone 1 (20-65 cm).** (The upper 20 cm is not considered because it has been disturbed by human activity). This zone covers most of the last 11,000 years. Marl was precipitated during this period and conditions for ostracods were unfavourable except within the bottom 15 cm (= earliest part of Holocene). There, at samples PS 50 and PS 60 especially, the presence of *Mesocypris* sp. and *G. maia* in substantial numbers for this

zone (and in lower numbers at level PS 65) indicates that water was permanent and plentiful (see comments on *G. maia* for details on the significance of permanent water). This is further substantiated by the presence of *C. viridis* at levels PS 50 and PS 60. At the other levels, water was probably ephemeral, as shown by the absence or paucity of *G. maia* and the presence of rare specimens belonging to species other than *Mesocypris* sp. The occurrence of three individuals of *L. lacustris* at level PS 50 probably indicates mineral-rich water.

**Zone 2 (65-150 cm) (11,000-35,000 yBP).** Ostracods are rare or absent and therefore there was little water at most times between PS 65 and PS 115. There are two exceptions at PS 75 (15,000 yBP) and PS 95 (19,000 yBP), where water was permanent but not as plentiful as for levels PS 50 and 60, *C. viridis* being absent and members of the Cyperaceae poorly represented. Level PS 95 could have been deposited under more open water because *S. proxima* is recorded in association with a few pollen of *Potamogeton-Triglochin*. Between PS 115 (22,000 yBP) and PS 150 (35,000 yBP), ostracods are more numerous than at levels PS 50 and PS 60. Water was permanent but rarely deep. The high numbers of *Mesocypris* sp. and *G. maia* coincide with moderate percentages of Cyperaceae and low values of *Potamogeton-Triglochin*. The significance of high percentages of Portulacaceae pollen (cf. *Claytonia australasica* sic Colhoun *et al.*, in press), from a plant of terrestrial to aquatic habit, is not understood with regard to the ostracod abundance.

**Zone 3 (150-200 cm) and Zone 4 (200-225 cm) (35,000-50,000 yBP).** These zones based on pollen are considered together as there is little difference in their ostracod faunas. The top of this zone is characterized by a layer of marl poor in ostracods. Apart from two valves of *G. maia* found in sample PS 155, there is no indication that water was permanent. Below level PS 160, water was permanent at most times except perhaps at level PS 215 where *Darwinula* sp. was absent and *G. maia* poorly represented. The high percentages of Cyperaceae and *Potamogeton-Triglochin* pollen between levels PS 160 and PS 185 do not coincide with high numbers of ostracods when compared with the sequence below zone 5 where the opposite occurs. Only once, at level PS 165 (43,000 yBP), where *C. viridis* is found and consequently

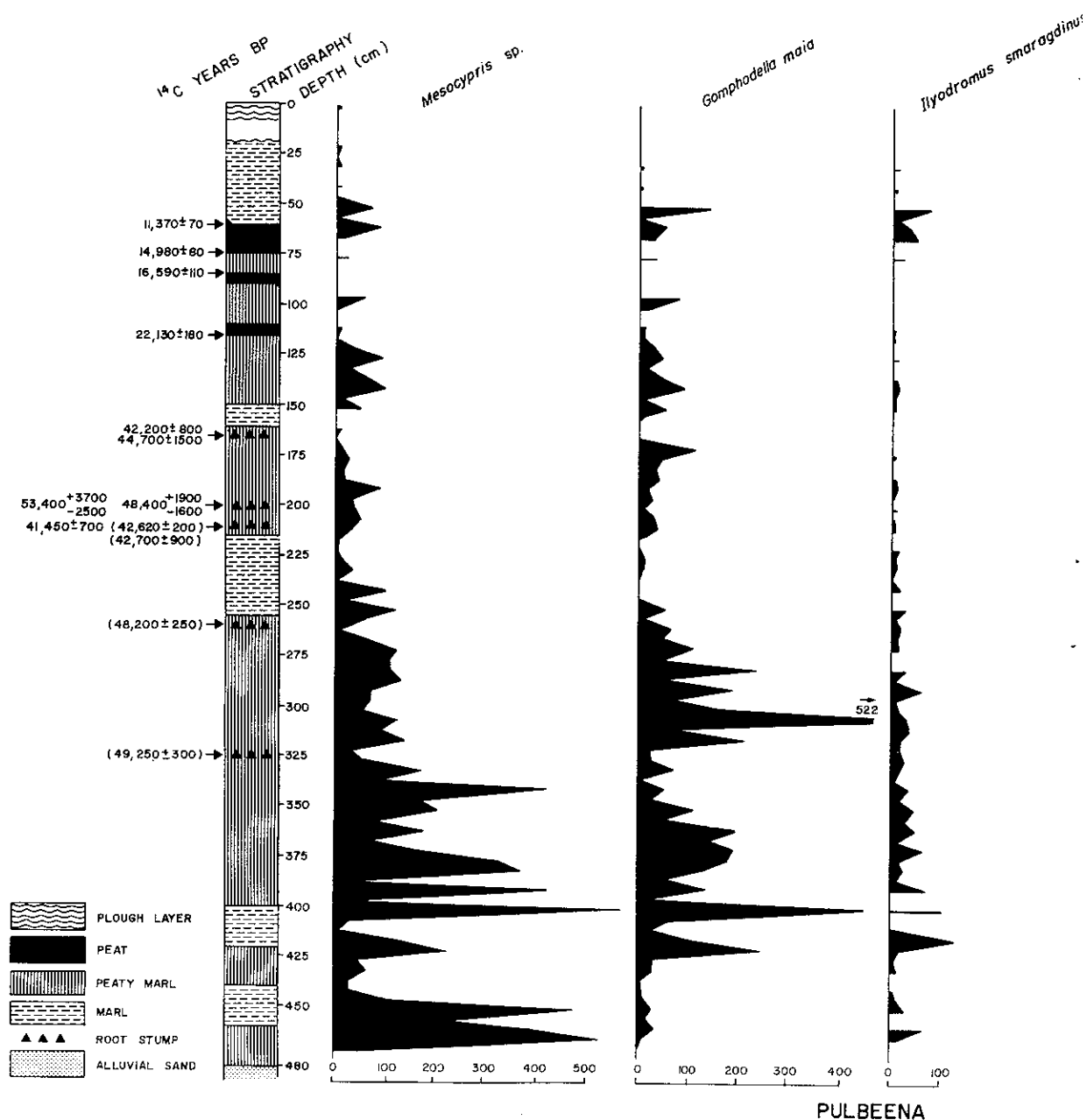


Fig. 13.  $^{14}\text{C}$  dates, stratigraphy and distribution of fossil ostracods and total pollen, plus pollen zonation of the Pulbeena Swamp profile. Numbers of ostracods represent the quantity of valves per 10 g of sediment; dots indicate the presence of 1 valve only. Data on  $^{14}\text{C}$  dates, stratigraphy and pollen zonation from Colhoun *et al.* (in press).

open water postulated, is the percentage for aquatic pollen highest for zones 3 and 4. At the same level, Colhoun *et al.* (in press) recognized charred root stumps in positions of growth meaning that fire had burnt across part of the swamp.

Dates have not been postulated for zones

5-10, as explained in Colhoun *et al.* (in press).

**Zone 5 (225-255 cm).** Zone 5 is characterized by a moderate percentage of Cyperaceae and low numbers of *Potamogeton-Triglochin* and the ostracods *Mesocypris* sp. and *G. maia*. The difference in the pollen diagram



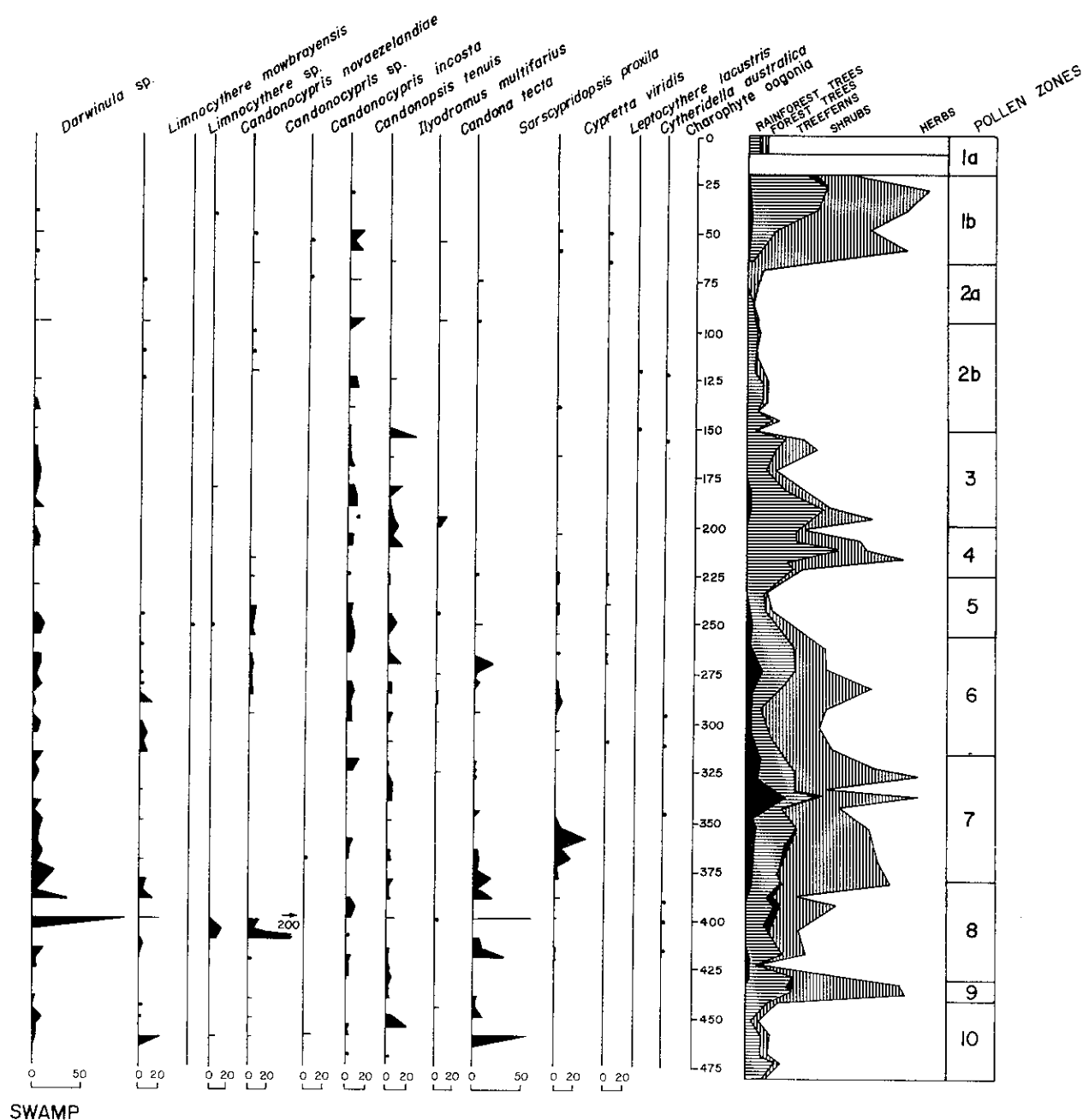


Fig. 13 continued.

between this zone and others is the high percentage of Cyperaceae coinciding with even higher values of Gramineae. This phenomenon, particular to zone 5, was probably caused by dry conditions; water level, although probably still permanent at all times (except for level PS 240), fluctuated and is interpreted as being high for levels PS 225-230, PS 240-245 and PS 255. The presence of *L. lacustris* could indicate a high

mineral content in the water at levels PS 225-230, PS 240 and PS 255. Marl was deposited during the entire duration of zone 5. The low number of ostracods is comparable with those of higher marls (levels PS 150-160 and PS 20-60), although water depth is considered to have been lower for the latter two layers.

The section below zone 5 is characterized by much richer ostracod faunas at most

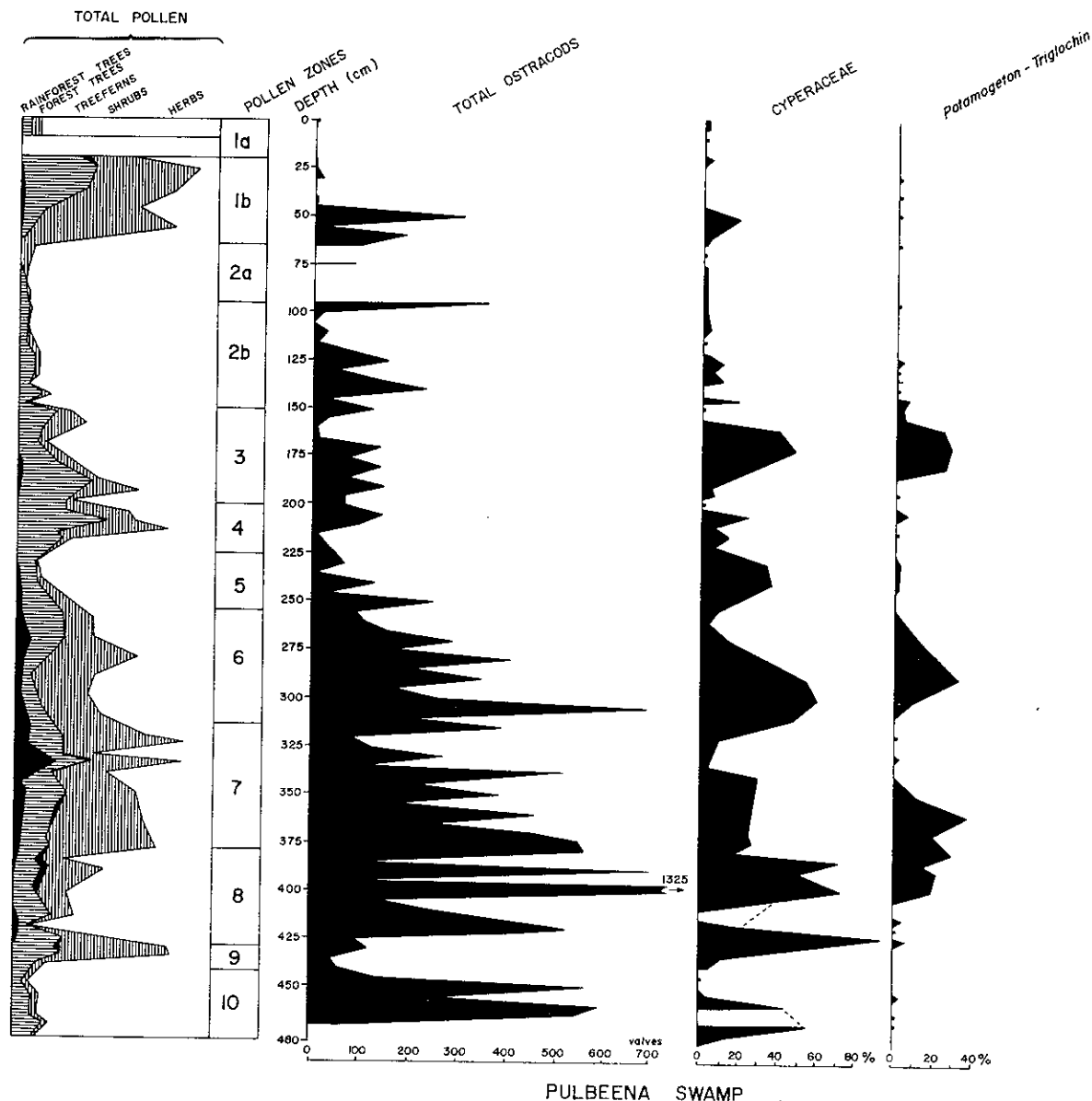


Fig. 14. Distribution of all ostracod valves in 10 g samples matched against the total pollen, Cyperaceae, *Potamogeton-Triglochin* curves from Colhoun *et al.* (in press) for the Pulbeena Swamp profile.

levels. The richer faunas are attributed to more favourable conditions such as an increased supply of water and more aquatic vegetation rather than to the slower sedimentation rates demonstrated by  $^{14}\text{C}$  data (see Colhoun *et al.*, in press).

**Zone 6 (255-315 cm).** This zone, based on ostracod data only, probably should be extended to level PS 320 where there is a noticeable drop in numbers of *Mesocypris* sp. and *G. maia*. Numbers of these two species fluctuate greatly throughout the zone

but remain generally high. Diversity is also high. The presence of *C. viridis* and *S. proxila* is significant at a number of levels because both species indicate open water conditions. This is confirmed by the abundance of Cyperaceae (up to 26 per cent of the total pollen in Colhoun *et al.*, in press) and *Potamogeton-Triglochin*. One of the highest percentages for these aquatic plants corresponds with the small peak of *C. viridis* at level PS 290. Charophyte oogonia have been recovered from two levels within the zone.

**Zone 7 (315-380 cm).** Low numbers of *G. maia* and slightly higher values for *Mesocypris* sp. between levels PS 320-335 are accompanied by low percentages of Cyperaceae and increasing percentages of *Potamogeton-Triglochin*. These indications of unfavourable conditions are further substantiated by high numbers of Gramineae (indicating drier conditions) which reach a peak at level PS 330. The highest values recorded for the open water ostracod *C. viridis* between levels PS 355-370 correspond with an abundance of aquatic plants (Cyperaceae and *Potamogeton-Triglochin*); the highest percentages recorded for these plants at level PS 365 coincide with the maximum abundance of *C. viridis*. The area at Pulbeena could have been a shallow lake during the interval PS 355-370. At other times, conditions were of permanent water with frequent high levels to allow aquatic plants to grow and accommodate a diversified ostracod fauna.

**Zone 8 (380-430 cm).** Numbers of *Mesocypris* sp. and *G. maia* fluctuate extensively during this period. The rest of the ostracod fauna is diversified within most samples. The environment postulated is similar to that prevailing during zone 7 except that the water level must have been lower for zone 8. Cyperaceae values are very high and *Potamogeton-Triglochin* are present in large numbers in only the top 25 cm of the zone. At level PS 400 especially, ostracod diversity and numbers are extremely high and conditions must have been at their optimum. Within the interval PS 400 and PS 420, marl formed at levels PS 405-410. The presence of *C. novaezealandiae* (and probably some of the *Candonocypris* sp., particularly at level PS 410) indicate that decaying vegetation was present at the bottom of the 'lake' floor. Eutrophic water during this time may explain the rarity of other ostracods. At level PS 420 ostracod numbers are high and the fauna is diverse, although to a lesser extent than at level PS 400. This coincides with the highest peak of Cyperaceae and very few *Potamogeton-Triglochin*. *C. viridis* and *S. proxila* point to a high water level.

**Zone 9 (430-440 cm).** Ostracod numbers are low and poorly diversified, corresponding with a low percentage of Cyperaceae. The other aquatics are almost non-existent. Apart from the presence of large numbers of *Leptospermum* pollen, there is little dif-

ference in the ostracod data alone between this zone and levels such as PS 385, PS 395 in zone 8.

**Zone 10 (440-480 cm).** The bottom 10 cm of this zone contains a high amount of terrigenous sediment and is devoid of ostracods. Water was permanent at most times for levels PS 440-470, even though *G. maia* is poorly represented, because *Darwinula* sp. is found in nearly all samples. *C. novaezealandiae* hints at eutrophic conditions for level PS 460, a period when ostracod diversity was very high and open water conditions prevailed. This is indicated by the large number of *S. proxila* accompanied by substantial numbers of Cyperaceae. *C. viridis* is absent at this particular level, coinciding with the absence of *Potamogeton-Triglochin*.

### Conclusion

The most important result from this study of Pulbeena Swamp is that the curve for total numbers of ostracods matches those for the Cyperaceae and *Potamogeton-Triglochin* (Fig. 14). When the pollen are absent or in low numbers, ostracods are few, as in zone 5. There Gramineae are abundant. The ostracods, like the aquatic pollen, appear to be good indicators of water regimes. Similarly, absence of ostracods here seems to indicate either a low water level or little water, a feature reflected by low percentages or an absence of the aquatic pollen.

### Ostracods from Mowbray Swamp

The ostracod fauna recovered at this site is less diverse than at Pulbeena Swamp. Forty samples out of the 82 examined did not yield any ostracods: these correspond mainly to peaty layers in which Mg-Fe sulphate crystals (Leonhardite ( $\text{MgSO}_4 \cdot 4\text{H}_2\text{O}$ ) and Melanterite ( $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ); G. van de Geer, pers. comm.) are common. Ostracods are generally present in marls in which the above mentioned sulphate crystals are absent.

The site chosen by van de Geer *et al.* (in prep.) in an inter-mound depression was probably not the deepest depression at Mowbray, since a few samples taken at the base of the swamp at the bottom side of one of the drains near Mella yielded richer ostracod faunas than the section measured by van de Geer *et al.* This explains the absence of *L. mowbrayensis* (Fig. 15),

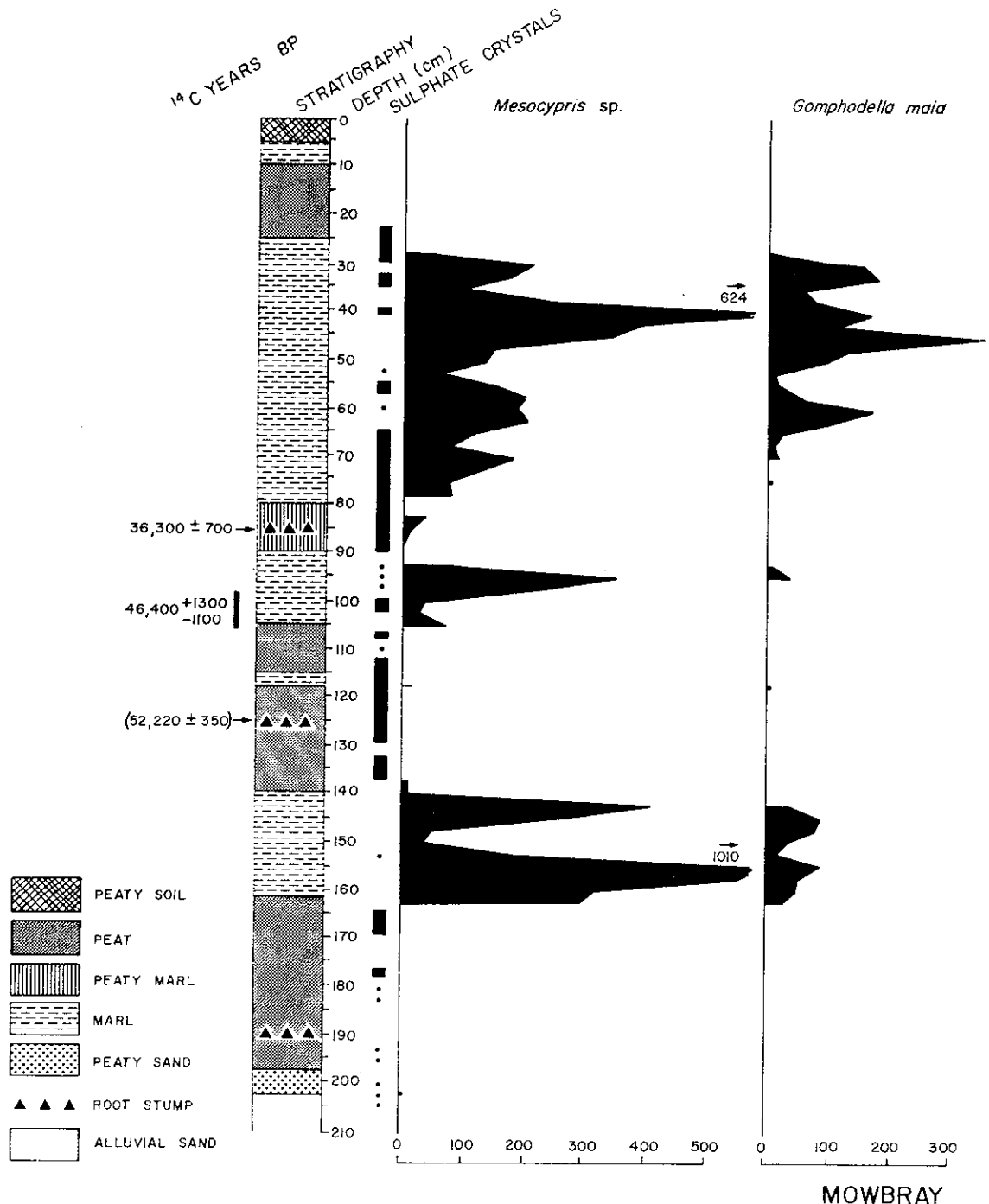


Fig. 15. <sup>14</sup>C dates, stratigraphy, distribution, Mg-Fe sulphate crystals and ostracods plus pollen zonation of the Mowbray Swamp profile. Same remarks on ostracod numbers as for Fig. 13. Data on <sup>14</sup>C dates, stratigraphy and pollen zonation from van de Geer *et al.* (in prep.).

although the species was originally collected from Mowbray Swamp. *L. mowbrayensis* is present in dark peaty marl rich in pyrite collected in a depressed area at the bottom side of one of the man-made drains. This

layer was not investigated further as no pollen and <sup>14</sup>C data are available; it is likely to be a facies equivalent to one of the bottom layers in the measured section. The absence of ostracods such as *C. viridis* and *S. proxila*

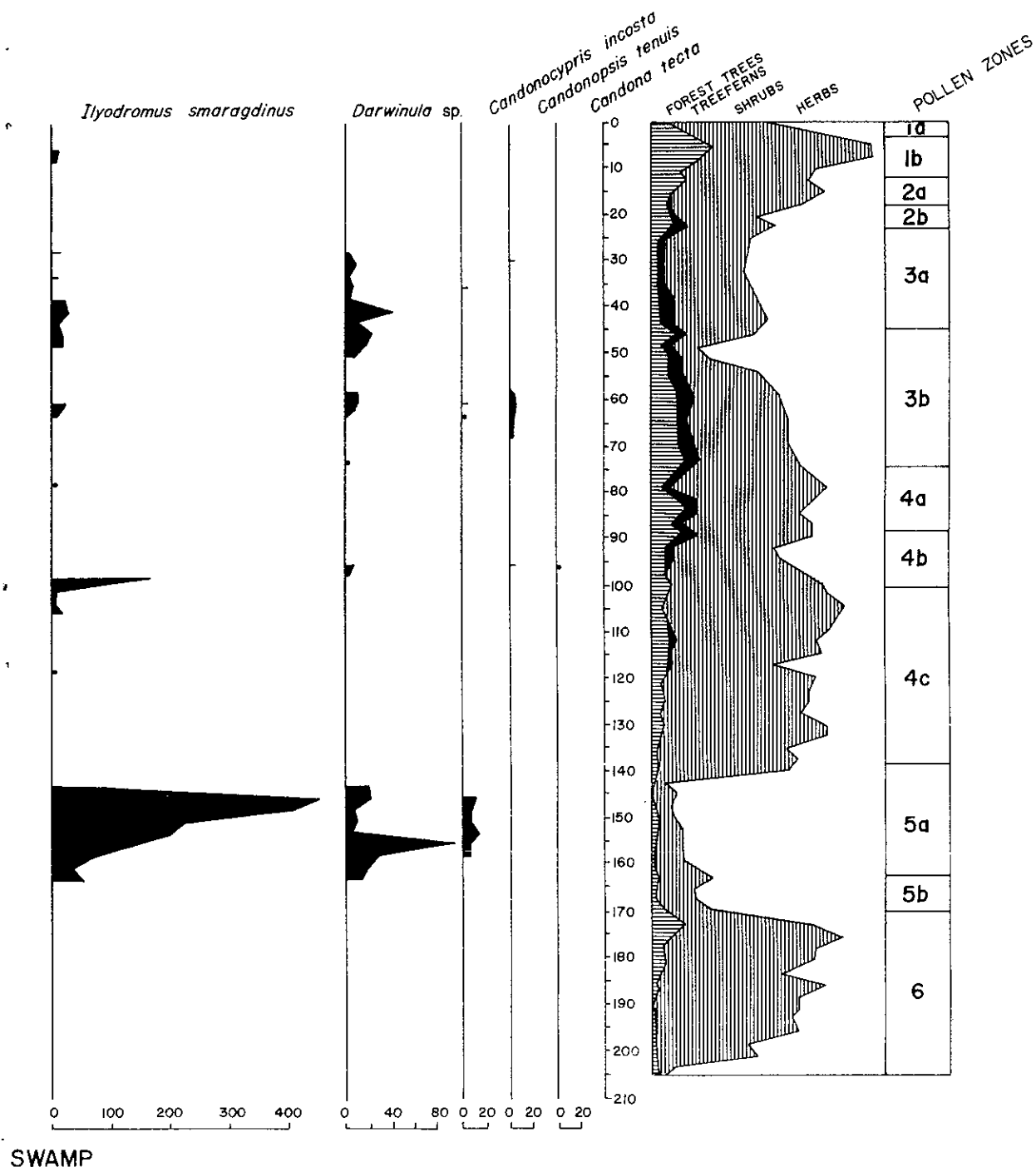


Fig. 15—(continued)

in the section indicates that water level was probably never very high at the studied site.

The pollen zonation defined by van de Geer *et al.* (in prep.) will be retained here as the basis of the various zones. Dates are also taken from van de Geer *et al.* (in prep.).

Zone 1 (0-11.2 cm) and Zone 2 (11.2-23.7 cm). These two zones are combined, ostracods being absent from nearly all samples except MS 8.5 and MS 10 where there are a few valves of *I. smaragdinus*. The poor representation of Cyperaceae and the

absence of *Potamogeton* suggest that little water was probably flowing from the spring.

**Zone 3 (23.7-76.2 cm).** Van de Geer *et al.* (in prep.) subdivided this zone into two parts mainly on the basis of the abundance of *Potamogeton*, Cyperaceae and Gramineae pollen. This subdivision can also be recognized from ostracod abundance (Fig. 15), numbers fluctuating proportionately with values of *Potamogeton* and Cyperaceae. At level MS 40, ostracod numbers are at their highest for the zone, corresponding with the highest peak for *Potamogeton* and high values of Cyperaceae.

A  $^{14}\text{C}$  date of 36,300 yBP obtained for level MS 80-87.5 indicates that zones 3a and 3b presumably predate the Holocene and that zone 3b started approximately 35,000 years ago.

In zone 3a (23.7-45 cm), ostracod numbers fluctuate in accordance with the values of aquatic pollen (Cyperaceae and *Potamogeton*). At level MS 40 water level must have been fairly high to allow abundant *Potamogeton* to grow and to provide optimum conditions for *Mesocypris* sp. and perhaps also *Darwinula* sp. Water was permanent during this entire period. The presence of Mg-Fe sulphate crystals in samples MS 32.5 and MS 35 corresponds with a general decrease in numbers of some ostracods species and the absence of others; an exception occurs at level MS 35 where there are small numbers of *C. incosta* and *C. tenuis*. This phenomenon cannot be interpreted, as sulphate crystals are also found in MS 40 which is very rich in ostracods.

In zone 3b (45-76.2 cm), ostracod numbers are lower than in zone 3a but are still substantial. Water was permanent for the period covering samples MS 50-70, except perhaps at level MS 52.5 where *G. maia* is poorly represented. The highest diversity and numbers of ostracods recorded in zone 3b do not correspond to a high level of aquatic pollen. This phenomenon remains unexplained as it appears contradictory to the conclusion drawn for most other levels at Mowbray and Pulbeena Swamps. Perhaps the water level was too low and prevented the growth of macrophytes.

**Zone 4a (76.2-88.7 cm).** At times there was no water and at others water was ephemeral as indicated respectively by the absence of ostracods in some samples and the low numbers of *Mesocypris* sp. in others (MS

82.5-87.5 = around 36,000 yBP). This corresponds with low percentages of Cyperaceae and traces of *Potamogeton*. Mg-Fe sulphate crystals are found in all samples from this zone.

**Zone 4b (88.7-101.2 cm).** *Mesocypris* sp. is found in nearly all samples except in the youngest part of this zone. This species is poorly represented in level MS 100 where Mg-Fe sulphate crystals are found. Six of the seven ostracod species found at Mowbray Swamp are represented at some stage of this zone. Water was permanent at level MS 95 and perhaps also at the two adjacent levels as shown by the presence of *G. maia* and *Darwinula* sp. The high number of *Mesocypris* sp. at level MS 95 coincides with the highest values for Cyperaceae in this zone.

**Zone 4c (101.2-138.7 cm) (> 46,000 yBP).** This zone probably had a duration of 10,000 years. A few valves of *Mesocypris* sp. and rare *G. maia* and *I. smaragdinus* are found together at level MS 117.5. This corresponds to a small percentage of *Potamogeton* and a slight increase of Cyperaceae which are generally low in number or absent throughout the zone. Thus freshwater spring activity was renewed for a short period. A few *Mesocypris* sp. valves are also found at level MS 137.5 in association with Cyperaceae. The other levels were probably formed under little spring activity or without water, or under conditions where there were sulphate rich waters. It is impossible to be more precise because the presence of the Mg-Fe sulphate crystals does not necessarily indicate contemporaneous precipitation with deposition of sediment. Crystallization may have taken place at a later time within the porous peaty layers characteristic of zones 4a, 4c and the bottom of zone 5.

**Zone 5 (138.7-171.2 cm).** Ostracods are present only down to level MS 162 where there is a change from marl to peat. Because Mg-Fe sulphate crystals are absent in the ostracod layers but are common above and below them, it is suggested here that zone 5 should be further divided into two parts: zone 5a (138.7-162 cm) and zone 5b (162-172 cm). Zone 5a is thought to end at about 56,000 yBP because there is an enriched  $^{14}\text{C}$  date of  $52,000 \pm 350$  yBP for level MS 125. The ecological significance of the unusually high numbers of *I. smaragdinus* in most samples of zone 5a is not understood. Water

Deevey (1955) by an alternative ostracod species similar in morphology to Tasmanian species. *novaezealandica* Hornibrook, p. are present in the valley. The *zona* found represented the end of the genus related to *G.* ite.

The plant *neestrata* Kinney Hornibrook. This ostracod requires open ground in lakes in Australia (1970; De De probably no Tasmanian species minerals for

The composition of two locations even though similar trophic many species others belong related ones. *Mesocypris* s. 'pyramid Vall

Although the age for the mentioned, the water regime

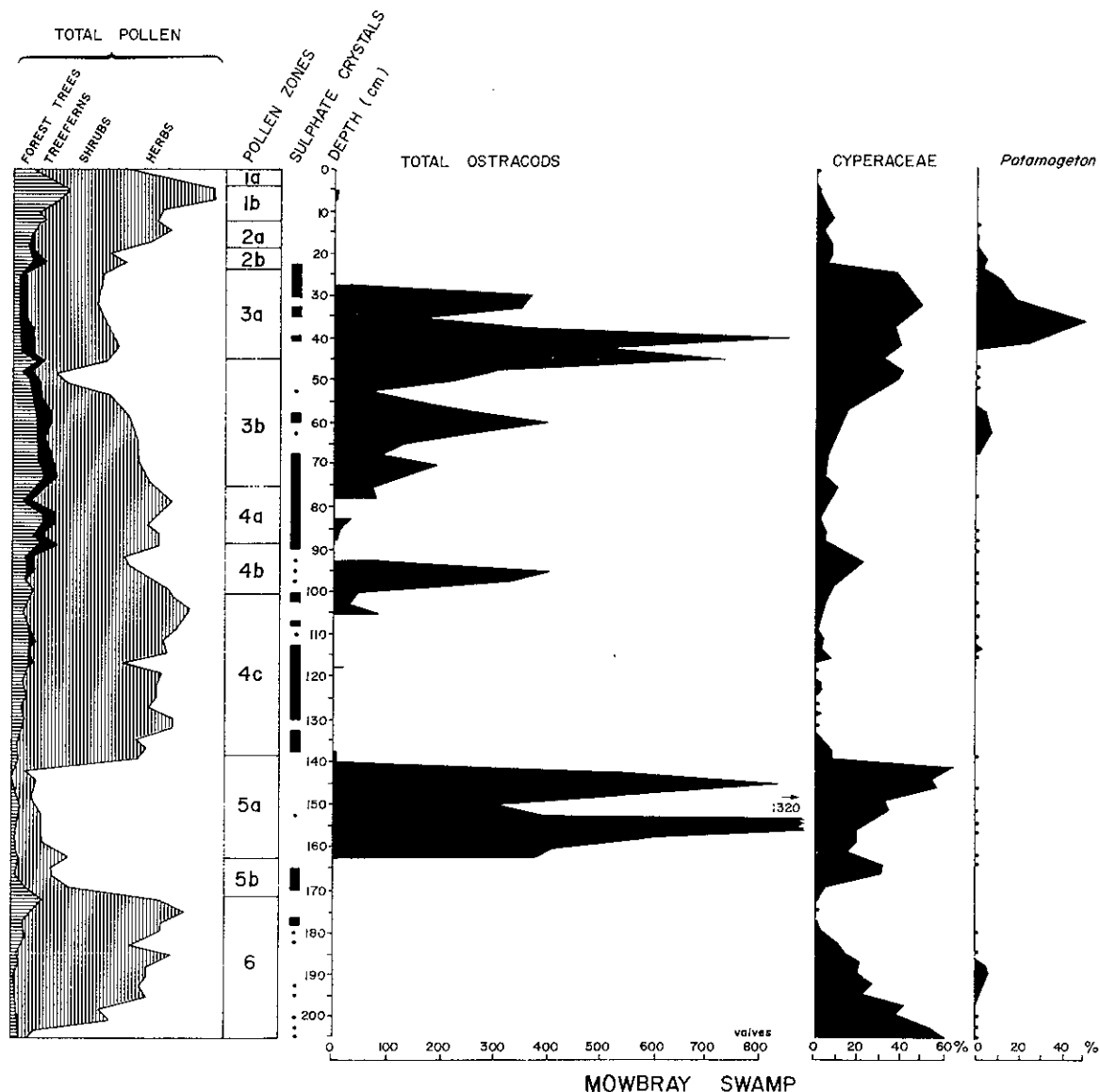


Fig. 16. Distribution of all ostracod valves in 10 g samples matched against the total pollen, Cyperaceae, *Potamogeton* curves obtained from van de Geer *et al.* (in prep.).

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was permanent for the period covering MS 152.5-162. The high numbers of *Mesocypris* sp. at level MS 155 do not correspond to an increase in Cyperaceae pollen.

**Zone 6 (171.2-205 cm).** Ostracods are absent in this zone despite high percentages of Cyperaceae and the occurrence of other aquatics.

## Conclusion

The occurrence of ostracods at Mowbray Swamp usually corresponds to levels with high percentages of carbonates. When inorganic and carbon-rich sediments peak together (see Fig. 16), the samples are devoid of carbonates. For zones 3a, 4b and 5a, the distribution of ostracods is usually paralleled by the curve for aquatic plants (Fig. 16).

## Interpretation

### *Dulbeena and*

The two sites show an alternation of deposits deposited in a permanent depression and should be interpreted as fluctuations in the uniform deposition. The Mowbray Swamp is still a depression. For a short period additional effects of Mowbray Swamp because the lowest depressions would be in Mg-F or long periods and climatic waters remain except that formed during accumulated. Fluctuate with 4, 16) at both indicators of evident at the location of appropriate environment could live.

A short period at both sites of known water level. Between Holocene and the driest period occurred between except for a 5,000 yBP. Fluctuations around the water level are available whether this water layer be there ostracod swamp. The low at the 2 BP period of C dates determine water presented to the basins at Pu 25 coincide

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