Aquatic Macroinvertebrates of the Murray River

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This article is dedicated to the memory of Prof WD (Bill) Williams (1936-2002) whose early books on the aquatic invertebrates of Australian inland waters stimulated interest and research on the ecology of these important groups.

Abstract
The aquatic macroinvertebrate fauna of the Murray River is presented based on surveys and scientific literature. Insects dominate the aquatic macroinvertebrate fauna but the non-insect groups such as the crustaceans, molluscs, worms and other primitive classes are also well represented. The distribution of the fauna is discussed in relation to the four physical and biological zones of the river; the Headwater, Riverine, Mallee and Lower Murray tracts. The biology and ecology of many groups is documented and, where possible, the impacts of human influences on the invertebrates of the Murray River are given. (The Victorian Naturalist 119 (4), 2002, 188-200)

Introduction
The aquatic invertebrates are to a certain extent the forgotten fauna of the Murray River. With the exception of the Murray River crayfish and of course the nuisance insects such as mosquitoes the aquatic invertebrates come a distant second to the more obvious aquatic icons such as Murray Cod, Golden Perch, Macquarie Perch and other native fish. However, the aquatic invertebrate fauna are an important component of a healthy functioning river and should not be viewed as just a part of the food supply for fish. The aquatic macroinvertebrates are an essential component of a functioning aquatic ecosystem. They are primarily decomposers with herbivores and predators making up the functioning feeding groups (Bolton and Brock 1999). Their feeding activities mobilise carbon and energy from plants through to the higher aquatic orders. In addition the aquatic macroinvertebrates have been used successfully as indicators of water quality and river condition (Norris et al. 2001).

The aquatic macroinvertebrate fauna of the Murray River as a whole were not examined scientifically until 1980 when the then River Murray Commission commenced their biological monitoring programme which is still ongoing today. Over 430 macroinvertebrate taxa were recorded from the Murray River between Jingellic and Lake Alexandrina during 1980-1985 (Bennison et al. 1989). Insects dominated the aquatic invertebrates with crustaceans, molluscs and worms also well represented. Sources of information for this paper include (Bennison et al. 1989; Boulton and Lloyd 1991; Suter et al. 1993) and personal observations by the authors. Throughout the paper reference will be made to the highly modified flow regimes caused by the consumptive use of water from the river. This has undoubtedly influenced the macroinvertebrate composition and distribution (Geddes 1990; Walker 1990), but detailed discussion of these effects is beyond the scope of this paper. An excellent presentation of the hydrological and geomorphological structural changes to the river can be found in Thoms et al. (2000).

The Murray River physically and biologically can be divided into four major zones or tracts (Bennison et al. 1989; Thoms et al 2000) (Fig. 1):

- the Headwaters tract reaches from the Murray’s source to Albury. The gradient of the river is steep and the streams are dominated by cobble, boulder and sand substrates with little organic material. This zone includes the alpine areas down to the foothills (Fig. 2);
- the Riverine tract reaches from Albury to the junction of the Edwards River. The gradient is low, the substrate is dominated by sand and silt with moderate levels of organic material and the river flows across...
Fig. 1. The four physical and biological tracts of the Murray River.

- a broad floodplain and is multi-channelled with extensive floodplain wetlands;
- the Mallee tract reaches from the Edwards junction to the Darling junction. The low gradient continues, and the substrate is sand and silt with moderate levels of organic material. Throughout this tract the river flows along a single narrow watercourse; and
- the Lower Murray tract reaches downstream of the Darling junction to the Murray mouth (Fig. 3). The river gradient is the lowest in this tract, the substrate is dominated by sand and silt with moderate levels of organic material, and the river is now highly regulated with locks and weirs which have altered the characteristics of the river from lotic to lentic.

This paper provides an overview of the aquatic macroinvertebrate fauna of the Murray River, including both the main channel and the floodplain wetlands that together constitute the ecological component and integrity of the river, and relates their distribution to these zones.

**Cnidaria**

The Cnidaria is represented in the Murray River by at least three genera, two hydrozoans (Hydra and Cordylophora) and the freshwater jellyfish Craspedacusta sowerbyi. The solitary hydroid Hydra is found in the Riverine, Mallee and Lower Murray Tracts but the colonial hydroid Cordylophora appears restricted to the Lower Murray Tract (Bennison et al.)
1989). Both these genera occur on logs and other such stable substrates. Their distribution may be greater than the artificial substrate data suggests but other sampling methods used in rivers may limit the adequacy of collections.

The freshwater jellyfish *Craspedacusta sowerbyi* has been recorded in the Hume reservoir but it is rarely seen because it is small (25 mm diameter) and almost transparent. This limited distribution in the Murray system may be a product of sampling effort. Little is known about this species although Williams (1980) recorded that it is usually found floating near the surface of large freshwater lakes and reservoirs.

**Turbellaria (Flatworms)**

Flatworms are recorded throughout the river from the headwaters to Lake Alexandrina. In the headwaters *Spathula* sp., a very dark animal, is commonly found on rocks. Ball (1977) recorded that all species of *Spathula* are found in cool, well oxygenated mountain water. *Curvula pinguis* is a lowland species and has been recorded from above Lake Hume to the end of the Murray River. The taxonomy of this group is limited and formal identification requires serial sectioning of properly preserved animals (St Clair et al. 1999). It is highly likely that there are more species than these two in the Murray, particularly in the Headwater tract (St Clair et al. 1999).

**Tennococephalidae**

The tennococephalans are small oval-shaped animals with 2-6 apical tentacles. The tennococephalans are ectosymbionts on freshwater crayfish. Some species live on the carapace of these large crustaceans and others in the gill chamber where they feed on small insect larvae, rotifers and nematodes, and algae (Williams 1980). An individual crayfish can often have multiple species on its body. A study by Cannon and Sewell (1994) suggested that each crayfish species had a distinct tennococephalan fauna associated with it. The taxonomy of this group is currently being revised. At least nine species have been recorded from the Murray River with *Tennococephalus coecus* in the Headwater tract and *Tennococephalus chaeroplosis* mainly from the Mallee and Lower River tracts.

**Nematomorpha (Horsehair worms)**

Adult horsehair worms, genus *Gordius*, have been recorded in pools in the Headwater and Riverine tracts of the Murray River down to Corowa. The larvae and juveniles are parasitic in terrestrial invertebrates (insects) where they encyst after being eaten and later break out of the host as an adult when the host is near water (Williams 1980).

**Annelida (Worms and leeches)**

The oligochaetes (segmented worms) are common throughout the Riverine, Mallee and Lower Murray tracts. Worms do occur in the Headwater tract, but numbers are generally low. Bennison et al. (1989) only identified the worms as non-tubifids and tubificids. The non-tubificid worms were abundant in the Riverine and Mallee tracts particularly in the depositional zones where organic material accumulates. The tubificid worms were low in abundance along the length of the river suggesting very low levels of organic pollution. One of the most noticeable tubificid worms is *Branchiura sowerbyi*, a distinctive hairy-gilled worm recognised by the posterior half having conspicuous gills (Fig. 4). It is common but not abundant in all tracts downstream of Albury occurring in depositional zones where there is a build up of fine organic material.

The leeches were represented by two families, Glossiphoniidae and Richardsoniidae. The Glossiphoniidae are small translucent leeches that prey on invertebrates particularly freshwater gastropods (Williams 1980) and are low in abundance in the Headwater, Mallee and Lower Murray tracts. The larger Richardsoniidae were rare in the river and were only recorded in the Lower Murray tract.
Mollusca (Snails and mussels)

The molluscs are well represented in the Murray River with 5-10% of the community composition in the main channel of the Headwater tract, but they decline to less than 5% in the Riverine, Mallee and Lower Murray tracts (Bennison et al. 1989). The distribution of many species may have changed since regulation of the Murray began in the early 1900s (Sheldon and Walker 1993).

Bivalvia (Mussels, pea-clams)

The small bivalves *Sphaerium* sp., *Pisidium* sp. and *Corbiculina australis* occur in the main channel of the river with *Sphaerium* most abundant above Lake Hume, *Pisidium* in the headwater streams and *C. australis* along the length of the river from the headwaters to Lake Alexandrina.

Two large bivalve molluscs are associated with the Murray River. The common riverine mussel *Alathryia jacksoni* (Fig. 5) occurs in the main stream channel in areas with flow, and the floodplain mussel *Velesunio ambiguus* is found in the slow or still waters of backwaters and billabongs. In the Lower Murray the hydrology has been highly modified by the presence of locks and weirs resulting in stationary/slow flowing reaches rather than a natural flowing river. Walker (1990) suggested that this change has provided the opportunity for *Velesunio ambiguus* (the floodplain species) to invade the main channel of the river at the expense of *Alathryia jacksoni* (the riverine species). *Velesunio ambiguus* lives in the calm waters behind the weirs and *A. jacksoni* in the turbulent waters below the weirs (Walker 1990).

A population of a third species of mussel *A. condola* exists below Lake Mulwala. The mussels have a larval stage (glochidia) which is parasitic on fish (Walker 1990) and it is most likely that *A. condola* has colonised the Murray on fish migrating from the Murrumbidgee River via the Mulwala Canal.

Gastropoda (Snails)

About 18 species of gastropod molluscs or snails (Fig. 6) have been recorded from the lower Murray River and were abundant in the first half of the 20th century (Sheldon and Walker 1993). Recent work along the lower reaches suggests that many species have very low abundances or no longer occur (Bennison et al. 1989; Boulton and Lloyd 1991; Sheldon and Walker 1993). One such species, *Notopala sublineata hanleyi*, is a live bearing snail that was common from the lower Murray but now appears extinct in the river. However, an extant population was reported by Sheldon and Walker (1993) taking up residence in the Kingston and Loveday irrigation pipelines near Barmera, South Australia. Sheldon and Walker (1993: 298) suggest that ‘this is possibly the last surviving population of *N. hanleyi*’. In addition a number of other species of snails have a greater abundance in pipelines than in the lower river, including *Ferrisia petterdi, Gabbia australis, Glyptophysa aliciae, Thiara balonnensis* and *‘Angobia angasi’*. All these species are detritivores feeding on organic and microbial accumulations and the inside of the pipelines provides ideal habitat compared with the highly regulated lower Murray River (Sheldon and Walker 1993). The pipelines provide the variability of wetting and drying that once occurred in the lower Murray, but does not occur now due to regulation. This refuge in the irrigation pipelines is also a nuisance for irrigators as the snails can block sprinklers.
and drip irrigation lines. The sculptured snail *Thiara balomnensis* still occurs in the river from Lake Mulwala to South Australia but is now rare in the lower reaches of the river except in the irrigation pipelines. The freshwater limpet *Ferrissia petterdi* is still common throughout the Murray and its flood plain being found in fast flowing waters as well as in billabongs and backwaters.

There are seven species of the family Planorbidae represented along the Murray, with riverine and floodplain species. *Glyptophysa gibbosa, Isidorella hainesii, Glyptophysa aliciae, Bayardella cosmet* are found mainly in the river, whereas *Gyradus meridionalis, G. tasmanicus* and *Helicorbis australiensis* are more common in the backwaters and billabongs. The riverine species have helicoidal shells (normal coiled snail) and the floodplain species have flat, ammonite-like shells. These snails all graze on aquatic plants. *Glyptophysa gibbosa, Isidorella hainesii, Gyradus meridionalis, Helicorbis australiensis, Glyptophysa aliciae* and *Bayardella cosmet* occur along the length of the Murray whereas *G. tasmanicus* only occurs in streams of the upper Headwater tract. Regulation has been implicated in the loss of aquatic plants in the Murray River (Thoms et al. 2000) particularly where there is raised turbidity reducing light availability (Lower Murray tract) and river bank erosion (Riverine, Mallac and Lower Murray tracts). This reduction of aquatic plants in the main channel may also have affected the distribution of the planorbid snails. In floodplain wetlands where the aquatic plants are still abundant the planorbid snails still can be found.

A number of introduced gastropod snails have successfully colonised the Murray River. *Physa acuta*, a snail introduced from Europe or North America, was known from only the lower Murray prior to 1970 (Smith and Kershaw 1979). However, this species has spread the length of which Murray and now competes with the planorbid snails and in many cases has replaced the native species. Bennison et al. (1989) recorded the planorbid snail *Isidorella sp.* and *Physastra gibbosa downstream of the Hume weir until 1980 after which it was replaced by *Physa acuta.* *Potamopyrgus niger* was introduced from New Zealand and occurs in the lower Murray tract. It is possible that this species will also become widespread throughout the Murray and its tributaries.

**Arachnida (Water mites)**

Water mites are a common fauna of the Murray River and its floodplain wetlands but are not well documented because they are difficult to identify. Reliable identification of water mites of the Headwater tract has shown that there are representatives of three major groups: Hydracarina, Halacaroida, and Oribatida. The last two groups are few in number with only single species of each group being recorded, whereas the Hydracarina are abundant and diverse. An unknown species of Oribatida is commonly collected from gravel beds in the river. Also commonly collected is the halacaroidean *Peza ops*, a terrestrial-like mite, whose gnathosoma has a long, curved, slender rostrum, with the pedipalps inserted above the rostrum (Fig. 7). The common Hydracarina are *Coaulastria*, *Australiorbates, Killimobates, Flabellifrontipoda, Hydroma* and *Unionicoleta.* Watermites are also common in floodplain wetlands with over 20 morpho-species recorded from wetlands along the Murray in South Australia (Suter et al. 1993).

Water mites have also been found parasitising the freshwater mussels, with six species being associated with *Velasunio ambiguus* and 3 of those with *Alathyria*
Crustacea (Shrimp, yabbies and crabs)

The crustaceans are a major component of the aquatic invertebrate fauna of the Murray River, and are the dominant invertebrate group in the lowland tracts of the river. In the Headwater, Riverine and Mallee tracts the Crustacea represent between 2-5% of the aquatic invertebrate community, but in the Lower Murray tract the proportion of crustaceans increases to 10-15% of the macroinvertebrate community (Bennison et al. 1989).

Amphipoda (Sideswimmers, scuds)

The amphipods, side swimmers or scuds, are small fast swimming crustaceans that have a very distinct distribution in the Murray River. Generally they are rarely found in the main channel upstream of the Darling River junction. Amphipods become a major component of the lower river fauna in South Australia with Austrochlionia spp. and two species of gammarid amphipods reaching high abundances downstream of Morgan.

Decapoda (Yabbies, crayfish, shrimps and prawns)

Shrimps and prawns are represented along the Murray River by three species, Paratya australiensis, Macrobrachium australiensis and Caridina mccullochi. All three species occur in both the main channel and floodplain wetlands. Paratya becomes more abundant in the main channel in the lower sections of the river system and this could be a response to altered flow regime due to the presence of locks and weirs. In contrast, Macrobrachium is more prevalent in the foothills of the Headwater tract. Caridina is rare at all sites along the river.

The Murray River has two species of freshwater crayfish, the Common Yabby Cherax destructor (Fig. 8) and the Murray River Crayfish Euastacus armatus (Fig. 9). Both species are omnivores feeding on detritus, algal biofilm and carrion. The yabby is the smaller of the two species (<250 g in weight; Geddes 1990) and is common in billabongs, backwaters and other wetlands on the floodplain. Following floods, numbers can increase rapidly and large numbers are caught from wetlands along the floodplain. Cherax destructor now occurs in the main channel of the river in the Lower River tract where the locks and weirs have changed the flow regime from a river to a series of long narrow lakes. The Murray River crayfish is the second largest freshwater crayfish in the world (reaching up to 3 kg in weight; Geddes 1990) second only to the giant freshwater crayfish Astacopsis gouldi from Tasmania. It lives in the main channel of the river and tributaries where flow rates are higher. Geddes (1990) noted that C. destructor is adapted to slow flowing, warm water and is active in the warmer months (September to May) whereas, E. armatus is adapted to cool waters and strong flowing rivers and is active in the cooler months (May to October) when oxygen concentrations are high. The occurrence of the two species in the Murray River follows a similar pattern to the mussels with the riverine species (E. armatus) being replaced by the floodplain species (C. destructor) in those sections of
the river which are controlled by the locks and weirs. Geddes (1990) suspects that natural populations of *E. armatus* are now extinct in South Australia. The distribution of the Murray River crayfish is also influenced by fishing pressure and habitat modification. Snags in the Murray River provide large stable substrates for macroinvertebrates and both number of species and abundance is higher on snags than on the associated river bed (Lloyd et al. 1991). The removal of over 13 million snags from the river (Thoms et al. 2000) not only has affected the fish populations but also the macroinvertebrates, and most probably the Murray River crayfish.

The small spider crab *Amarinus lacustris* is commonly found in streams with elevated salinities. This species is only found in the lower Murray downstream of Murray Bridge where it lives in the roots of the willow trees that dominate the riparian zone.

**Syncarida**

The syncarids are primitive crustaceans that lack a carapace over their thorax and although extant syncarids were marine inhabitants all living forms are now restricted to fresh waters (Williams 1980). A single specimen of a syncarid crustacean *Koonunga* sp. has been recorded from the Murray River near Albury. Syncarids of this genus are usually associated with deep hyporheic gravels, and so are rarely found in rivers unless washed out during high flows.

**Isopoda**

Two species of isopod occur in the Murray River, *Heterias pusilla* and *Tachaea picta*. *H. pusilla* is a small isopod which lives in fine organic deposits in the Riverine, Mallee and Lower Murray tracts. They are occasionally recorded from the upper catchment, but they generally are rare. *Tachaea picta* has a more restricted distribution occurring only in the Lower Murray tract downstream of the Darling junction, but rarely downstream of Morgan. The distribution of *Tachaea* is usually restricted to the Darling River where it is parasitic on shrimps and prawns. During Darling River flood, *Tachaea picta* is washed into South Australia and becomes common in the lower Murray River.

**Insecta**

The insects are the dominant macroinvertebrate fauna in the Murray River representing over 70% of the communities in the main channel and wetlands in all tracts.

**Ephemeroptera (Mayflies)**

The mayflies are a primitive order of insect with an aquatic nymphal stage and two terrestrial winged stages, the subimagio and imago or spinner. They are diverse in the Murray River with over 20 species being recorded along its length but they represent less than 5% of the aquatic community. The number of species present declines along the river's length with approximately 15 species in the Headwater tract, less than ten species at Albury and downstream in the Riverine tract and only four species downstream of the Darling River junction. This reduction in taxa can also be seen at the generic level with Coloburiscidae (*Coloburiscoides* Oniscigasteridae (*Tasmanophlebia*) Baetidae (*Edmundsiops*) Caenidae (*Irpacaelis* and *Tasmanocaelis*) and the Leptophlebiidae (*Atalophlebia, Nousia, Koornonga, Umerophlebia, Neboissophlebia* and *Austrophlebiidae*) common in the Headwater tract. In the Riverine tract downstream of Albury only *Atalophlebia, Neboissophlebia, Edmundsiops, Irpacaelis* and *Tasmanocaelis* are found. *Atalophlebia, Cleoon* and *Tasmanocaelis* are the only genera that occur in the Lower Murray tract. The reduction of taxa may reflect a natural gradient from upland to lowland river conditions as *Coloburiscoides, Edmundsiops, Nousia, Koornonga, Austrophlebiidae* and *Neboissophlebia* all occur in cool, highly oxygenated flowing streams that are usually associated with upland reaches. The genera *Atalophlebia, Cleoon* and *Tasmanocaelis* are more commonly associated with warm, slow flowing habitats.

Pardo et al. (1998) recorded a decline in mayfly diversity in the Mitta Mitta River downstream of Dartmouth dam (11 species) compared with an unregulated tributary (17 species). There were fewer leptophlebid mayflies in the regulated com-
pared with the unregulated river. They argued that the pattern of flow and cold water releases in summer in the regulated Mitta Mitta Rivers adversely affected the mayfly community. The relative abundance of nymphs of *Coloburuscioides* was not dramatically affected by the regulated flows (21% in unregulated and 27% in regulated), but *Edmundsiops hickmani* declined from 53% to 13% (Pardo et al. 1998). These two species are restricted to the fast flowing mountain streams where they are found on rocks or on logs in the fast flowing water. *Coloburuscioides* wedge their bodies between rocks using their spines on their gills as anchors (Dean and Suter 1996) and use the long hairs on their legs and mouthparts to trap particles of organic material flowing by in the fast flowing water.

The two genera of the Baetiidae recorded in the Murray River, *Edmundsiops* and *Cloeon*, occupy the lotic and lentic habitats respectively. *Edmundsiops* is restricted to the upper catchment, whereas *Cloeon* is associated with the lower tracts in stationary waters and wetlands particularly in beds of aquatic plants.

The nymphs of the Oniscigastriidae (*Tasmanophlebia*) occur in standing waters and slow flowing reaches of rivers and streams from the mountains to near sea level. They are normally found on sandy substrates (Dean and Suter 1996), but they do not occur downstream of Albury in the Murray.

The caenid mayflies, the smallest mayflies in Australia, are found along the river’s length and also in the floodplain habitats. These mayflies are detritivores and live in silt and sand particularly on logs and in leaves on the bottom. They are rarely seen as they emerge from the river to fly as dusk falls and they only fly for a short period, maybe two to three hours, during the night. Swarms may continue all night but emergence ceases as the sun starts to rise. Dawn swarms continue for an hour or two after sunrise. The caenids are poor fliers and dispersal is also restricted. Five species are commonly found along the Murray River. *Irpacaelus deani* and an undescribed species *Tasmanocoenis* sp. B is found in the Headwater tract down to Albury; *Tasmanocoenis* sp. B, *Tasmanocoenis tillyardi*, *Tasmanocoenis tonnoiri* and *Tasmanocoenis arcuata* occur from Albury downstream to Echuca; and *Tasmanocoenis tillyardi* and *Tasmanocoenis arcuata* are common in the Riverine, Mallee and Lower Murray tracts. The two headwater species *I. deani* and *Tasmanocoenis* sp. B appear to be influenced by inter-basin transfers of water from the Snowy River catchment. *Irpacaelus deani* has higher abundances above the transfer point at Khancoban and *Tasmanocoenis* sp. B increases downstream of the transfer point (McNerney 2000). In years when transfer volumes are high *Tasmanocoenis* sp. B abundances increase and years when transfer volumes are low favours *Irpacaelus deani*.

**Odonata (Damsel flies and dragonflies)**

The dragonflies and damselflies have aquatic larval stages and terrestrial adults. Sixteen species of damselflies and 28 species of dragonflies have been recorded from the Murray River and its floodplain. They represent less than 5% of the macroinvertebrate community in the main channel of the river (Bennison et al. 1989), but up to 10% in the wetlands. Many of the species are obligate stream-dwellers, restricted to the flowing part of the river channel. However, downstream from Echuca the river flow has been reduced by the construction of many locks which form large impoundments of still-waters which have allowed colonisation by standing water species.

In the montane section of the Headwater tract the damselflies (Zygoptera) are restricted to three species, *Austroargiolestes calcarius*, *A. icteromelas* and *Synlestes weyersii*. The fauna changes after Khancoban to a valley fauna, with *Nosostiota solida* and *Rhadinosticta simplex* the dominant damselflies down the length of the river with *Pseudagrion aureofrons* from Lake Mulwala to South Australia. The floodplain wetlands contain standing water species *Xanthagriion erythroneurum*, *Austrolestes anals*, *A. leda*, *Ismaura heterosticta* and *I. aurora*.

The dominant species of dragonflies (Anisoptera) in the upper montane reaches of the Headwater tract are *Austroaeschna flavomaculata*, and *Synthemis cestalacta* the larvae of which survive the winter
snowy conditions. Below the snow line the dragonfly fauna is characterised by the gomphids *Austrogomphus guerini*, *Hemigomphus gouldii*, the aeshnids, *Austroaeschna atrata*, *A. inermis*, *A. pulchra* and the synthemistid, *Eusynthemis brevistyla*. The fauna changes after Khancoban to a valley fauna of *Austroaeschna unicornis*, *Austrogomphus ochraceus*, *Apocordulia macrops*, *Cordulepha pygmaea* and *Eusynthemis virgula*. *Austroaeschna unicornis* ranges from the Khancoban valley reach through to South Australia, whereas the other species are only common to above Lake Mulwala, except for *A. macrops* which has been recently collected from the Barmah Forest, near Mathoura (Hawking unpubl. data). The gomphid *A. ochraceus* is replaced by its congener *A. australiae* from Lake Mulwala to the lower reaches in South Australia. *Hemicordulia tau* is very abundant in the lakes and locks but it also found along the total length of the river. The opportunistic species, *Hemianax papuensis* (Fig. 10), *Orthetrum caledonicum*, *Diplacodes bipunctata* and *D. haematodes*, can be found in the slow flowing and backwater areas of the lower Murray now occurring in both the wetlands and main channel.

**Plecoptera (Stoneflies)**

Stoneflies are cold water adapted and the nymphs of most stoneflies occur throughout winter and spring, and are rarely found during summer. McInerney (2000) recorded reduced abundance of stoneflies in spring to summer as they emerged to terrestrial adults. Stoneflies are generally found in fast flowing cool water streams and rarely occur in wetlands on the floodplain. Therefore they are almost all restricted to the Headwater tract where their relative abundance is less than 5% of the macroinvertebrate community. Stoneflies do occur in the Riverine tract in areas of fast flows and usually a constricted river channel (e.g. the Barmah Choke). The Murray River fauna has representatives from four families, with the Gripoterygidae being dominant with at least 15 species in the genera *Dinotoperla*, *Riekoperla*, *Newmanoperla*, *Illiesoperla* and *Leptoperla*. McInerney (2000) recorded abundant *Dinotoperla serricauda* and *Riekoperla rugosa* downstream of the Khancoban pondage due to the reduced temperature of the water from the Snowy inter basin transfer. Downstream Albury stoneflies are rare with *Dinotoperla serricauda* being recorded in the Mallee tract where the velocity of water is high. In the lower river tract only one species has been found, *Dinotoperla evansi* was recorded in the Murray River near Murray Bridge. This warm water species also lives in farm dams (Suter and Bishop 1990) and may well have colonised the lower Murray from this source.

The other families represented are the Austroperlidae, Notonemouridae and Eustheniidae. The Eustheniidae are predatory stoneflies and are represented by three genera, *Cosmioperla*, *Thaumatoperla* and *Eusthenia*. These large insects are only found high in the headwaters of the upland tributaries of the Murray River. Also only in the headwater tributaries are the Notonemouridae (*Austrocerca tasmanica*) and the Austroperlidae (*Austropentura victoriae*, and *Acruroperla atra*). *Acruroperla atra* is found associated with accumulations of dead leaves or leaf packs in pools in the upper catchment.

**Megaloptera (Dobsonflies)**

The Corydalidae are large (up to 50 mm) predatory aquatic insects with a short lived terrestrial adult. They are represented in the Murray River by a single species *Archichauliodes (Riekhochauliodes) gutiferus* (Walker) which is restricted to the Headwater tract where the river is fast flowing and the substrate is dominated by rocks and cobbles overlying sand. *Archichauliodes* larvae can also be found under rocks in dry stream beds in upper catchment intermittent streams.
Hemiptera (True bugs)

Aquatic bugs are characteristic of still waters and backwaters, and so are often associated with wetlands rather than rivers. In the Murray over 30 species are recorded from along the bank edge of the main river usually in areas where flows are slow but their relative abundance is less than 5%. The aquatic bugs are nearly all predators and consume gaseous oxygen from the air rather than dissolved oxygen from within the water. They lay their eggs in or on plants or attached to a firm substrate (Lansbury and Lake 2002) and the females of one genus of giant water bugs (Belostomatidae: Diplonychus) lay their eggs on the back of the males (Hawking and Smith 1997). The aquatic bugs occupy two distinct habitats, being either fully aquatic or surface dwellers.

The fully aquatic bugs are dominated by the water boatmen (Corixidae), with Micronecta, Sigara, and Agraptocorixa the most common genera, and the backswimmers (Notonectidae; Fig. 11) represented in the Murray River by Anisops and Enithares. Micronecta annae is common along the whole length of the river and in floodplain wetlands. M. gracilis and M. robusta are also common in the Riverine, Mallee and Lower Murray tracts. In the main channel of the Murray, Sigara sublaevifrons and Agraptocorixa hirtifrons appear restricted to the Headwater tract, but it is widespread in wetlands from Albury to South Australia (Suter et al. 1993). Sigara truncatipennis is restricted to the Lower Murray tract whereas Agraptocorixa euryhame was throughout the river's length.

Four other families, Nepidae, Naucooridae and Belostomatidae (Fig. 12) and Pleidae are also fully aquatic and occur in the Murray, but usually are rare and mainly associated with floodplain wetlands. The Nepidae are represented by the water scorpion (Laccotrephes tristis) and the needle bug (Ranatra disse). These are large species (up to 50 mm) with a long respiratory tube extending from their abdomen which enables them to hunt below the water surface and breathe air through the tube which they extend beyond the surface tension of the water. The giant water bug Diplonychus eques (Belostomatidae) and the creeping water bug Naucoris congrex (Naucooridae) are also quite large (>15 mm long) and occur in macrophytes particularly in floodplain wetlands. As the name suggests the pygmy backswimmers (Pleidae) are quite small (<2.5 mm) which makes this group rarely seen, but they do occur in wetlands along the Murray.

The surface dwelling bugs include the water striders Tenagogerris, Rheumatometra, and Limnogomus (Gerridae), the small water striders Microvelia (Veliidae), the water treader Mesovelia (Mesoveliidae) and the water measurers Hydrometra (Hydrometridae). These taxa occur in both the main channel and floodplain wetlands of the Murray River. Tenagogerris euphrosyne and Rheumatometra phylacte occur in the Headwater and Limnogomus sp in the Riverine, Mallee and Lower river tracts. Microvelia oceanica occurs in the Riverine tract, Microvelia peramoena along the full length of the river including floodplain wetlands and Mesovelia hungerfordi is found in all tracts of the Murray both in the river and its wetlands.
Neuroptera (Lacewings)
There are two families of lacewings that occur in the Murray River, the Osmyliidae and the Sisyridae. The osmyliids (*Kempynus* sp.) are often found on large rocks and boulders in the splash zone in small upland streams, and have not been recorded downstream of Jingellic. The sisyrids or sponge flies (*Sisyra* sp.) occur in the Murray but are rarely found as they live in sponges on logs or rocks. Sponge-flies lay their eggs on vegetation overhanging a stream and the emergent larvae drop to the water and swim to a freshwater sponge. The larvae use their long straight jaws to probe the sponge tissue and feed on the contents (New 1991). They have been collected from logs in the Barmah-Millewa forest but may be more widespread, wherever sponges occur.

Coleoptera (Beetles)
Bennison et al. (1989) recorded the beetles as the second most species rich group of aquatic macroinvertebrates in the Murray River. Over 90 species were recorded with greatest richness in the Headwater and Riverine tracts. The beetles represented 15-20% of the composition of the macroinvertebrate community in the Headwater tract, less than 15% in the Riverine tract, less than 3% in the Mallee tract and less than 10% in the Lower Murray tract. Both the riffle beetles (Elmidae) and tiger beetles (Dytiscidae) dominated the Headwater tract but many species of the tiger beetles were also common in the Riverine, Mallee and Lower Murray tracts, particularly in the floodplain wetlands.

The riffle beetles can be found feeding on algae attached to logs and rocks in fast flowing streams in the upper catchment where they are both abundant and species rich. The headwater streams have at least 10 species within the genera *Kingolus*, *Simsonia*, *Notiorius* and *Australimnius*. Downstream of Albury the numbers of species and genera declines with only *Kingolus*, *Australimnius* and *Coaxelmis* (total of five species) in the Riverine tract and only a single species of *Kingolus* and *Coaxelmis* in the Mallee and Lower Murray tracts. In the lower gradient stretches of the Murray the elmids are found associated with logs and snags.

The predatory diving/tiger beetles (Fig. 13) are very active hunters that use gaseous oxygen to breathe and therefore must return often to the water surface to replenish their oxygen supply. They are usually associated with pool or pond habitats. Tiger beetles range from small (<5 mm), medium (5-15 mm) to large (15-34 mm). The small species in the Murray River include *Antiporus* with three species in the headwaters (*A. blakei*, *A. femoralis* and *A. gilberti*), but only a single species, *A. gilberti*, downstream of Albury. *Liodessus gemellus*, *L. amabalis* and *Sternopriscus multiradicatus* occur in the Lower Murray tract, whilst *Limbodes suicis compactus* and *Alloschius bistrix*, *Astragalus* are found along the full river's length. The medium sized tiger beetles include *Rhontus naturalis* found in all the Riverine and Riverine tracts only, and the widespread *Eretes australis* and *Megarhyssa* sp that are found in all tracts in all tracts and occasionally in the main channel. The large predatory diving beetles *Cybele* sp has only been recorded from the Mallee tract.

Diptera (True flies)
The true flies are the most species rich of the aquatic insects in the Murray River with 158 different species recorded by (Bennison et al. 1989). It is likely that the number of species of dippers is higher than this due to the improvements in the taxonomic literature since the study. The flies represented between 20 and 30% of the total species composition in the Headwater tract, but increased their dominance in the Riverine and Mallee tracts with 40 to 50% of the total species richness. In the lower Murray tract the impor...
tance of the dipterans declined to between 30 and 40%.

Adults of the biting midges (Ceratopogonidae), blackflies (Simulidae) and mosquitoes (Culicidae) are the main nuisance insects associated with the river. The larvae of the ceratopogonids are found along the length of the Murray, but there are more species in the Riverine and Mallee tracts than in the Headwater or lower Murray tracts. These animals are more frequently found in the drying mud of wetlands and in the lower Murray in saline seepages along the cliffs near irrigation areas where they can cause significant nuisance value (e.g. Loxton; Suter unpublished data). The blackflies are usually associated with flowing water and firm stable substrates like rocks and logs. There are few species in the Murray all upstream of Swan Hill, with Austrosimulium furiosum in the Headwater tract, Austrosimulium montanum, A. bancrofti, Simulium ornatus and Simulium nicholsoni in the Riverine tract. Mosquitoes are rare in the main channel of the Murray River, but they do breed on the floodplain particularly following floods when water becomes trapped in isolated pools and ponds.

The non-biting midges (Chironomidae) are the most diverse of the dipterans, and are found in all habitats along the length of the river. There are predatory midges (Tanytarsinidae), organic feeders (Chironominae, blood worms), filter feeders (Chironominae, Tanytarsini) and wood borers (Chironominae). The wood borer Stenochironomus watsoni is found in all tracts of the river associated with logs and submerged bark from riparian trees. Many of the filter feeders (Kiefferulus martini, Rheotanytarsus spp. and Tanytarsus spp.) are also associated with logs and snags where they build tubes from which they can catch organic material flowing past. Rheotanytarsus spp., which are only found in the Headwater tract, construct a silk net attached to its tube to trap its food. The Chironominae dominate the Riverine, Mallee and Lower Murray tracts.

An interesting observation was made by Pettigrove (1989) that the larvae of Procladius paludicola showed abnormalities of the mouthparts in the Mallee region of the Murray River. Similar abnormalities have been shown to be associated with exposure to chemicals such as heavy metals and pesticides (Madden et al. 1995; Madden et al. 1992; Warwick 1990). In the lower Murray tract P. paludicola is rare in the main channel of the river, but is the major predacious midge in saline evaporation basins and other wetlands on the floodplain (Suter et al. 1993; Suter et al. 1995). This species is also abundant in rice fields and with Chironomus tepperi can attain very high numbers and become a nuisance insect. Chironomus tepperi is an early coloniser of wetlands following floods and can attain very high numbers providing a primary food supply for native waterfowl (Maher and Carpenter 1984). However, in rice fields these large numbers can cause damage to the rice crop (Stevens 1995) thereby escalating these beneficial insects to an economic nuisance. The rapid colonisation and population growth of C. tepperi in floodplain wetlands and rice fields appears associated with the high levels of organic material present in the sediment (Suter et al. 1995).

Trichoptera (Caddisflies/Casemoths)

The caddisflies have a terrestrial stage that resembles a moth, but the larvae are aquatic and construct a diverse array of cases in which they live. In the main channel of the Murray the caddisflies represent approximately 15% of the aquatic community in the Headwater tract and between 5-13% in the Riverine, Mallee and Lower Murray tracts (Bennison et al. 1989). Although they are found in a wide range of habitats the greatest number of species occur in cool flowing streams and as such have a very distinct upper catchment distribution in the aquatic macroinvertebrate community of the Murray River. At least 12 families (Atriplectidae, Calamoceratidae, Calocidae/Helcophidae, Conoecuscidae, Ecnomidae, Hydrobiosidae, Hydropsychidae, Hydroptilidae, Leptoceridae, Limnephilidae, Odontoceridae, Philorheithridae) with >30 species of caddisflies are recorded from the Headwater tract whereas the Riverine, Mallee and Lower Murray tracts have only 3 families present (Ecnomidae, Hydroptilidae and Leptoceridae) with fewer than 15 species.

The caddisflies are sensitive to environmental change, particularly in the high
quality waters of the upper catchment. They have a diverse range of habitat use and diet and so alteration to water quality, hydrology or addition of pollutants affects their community structure. McInerney (2000) found that there was a reduction of the community structure of the caddisflies as a response to the inter-basin transfer of water from the Snowy Scheme. The predacious caddisflies *Taschorema evansi* and *Economina* sp. show a reduction in abundance downstream of the inter-basin water transfer while the leptocerid caddisflies *Triplectides ciusius* and *Triaenodes* sp. became more abundant downstream of the inflows.

The diet of larval caddisflies can be divided into three main types based on method of collection of food (Neboiss 1991). There are the net spinners, (Hydropsychidae) that construct silken retreats with a silk net at the entrance used to capture organic particles carried past in the current. The Hydropsychidae (Fig. 14) are almost restricted to the Headwater tracts where three species of *Cheumatopsyche* and one species of *Diplecrotana* occur. However, *Cheumatopsyche* also occurs downstream of Hume and Yarrawonga weirs where there is fast flowing water. The case makers (Calamoceratidae, Calocidae, Helicophoridae, Conosudidae, Hydroptilidae, Leptoceridae, Limnephilidae, Odontoceridae and Philorheithridae) shred and chew on leaves, or graze on algae. The Leptoceridae is the most species rich family in the Murray. In the headwaters at least 12 species are found mainly in the genera *Notarina* (5 spp.), *Triplectides* (4 spp.), *Oecetis* (2 spp.) and *Triaenodes* (1 sp.). *Triplectides australis* and *Triplectides australicus* occur along the length of the Murray with *T. australis* mainly in the main channel and *T. australicus* in the floodplain wetlands. Lectrides *varians*, an endemic species to South Australia, occurs in the lower Murray near Murray Bridge.

The third group include the free living *Economidae* and Hydrobiosidae. Species in these families are predators. The economids occur throughout the river and its floodplain, but at the species level there are distinct changes from headwaters to Lake Alexandrina. In the headwaters three species occur with *Economus pannus*, *E. continentalis*, and *Economina* F sp. AV9 (Cartwright 1997) common in the rivers and streams, but downstream of Albury *E. pannus* is only found in the Riverine and Mallee tracts. In the Albury area *E. pannus* occurs in the main channel of the river and *E. turgidus* and *E. cygnita* are found in wetlands on the floodplain. In South Australia *E. pannus* and *E. russelii* are both in the main channel and *E. turgidus* occurs with *E. pannus* in the wetlands.

**Lepidoptera (Aquatic moths)**

Moths of the family *Pyralidae*, subfamily *Nymphalinae* (Fig. 15), are the only lepidopteran group to have aquatic larvae or aquatic caterpillars (Hawking 2001). The taxonomy of this group is still in its infancy although recent work has enabled different species to be recognised (Hawking 2001). Five species of pyralid are found along the Murray River. One species inhabits rocks in the fast flow regions of the Headwater tract. The larvae construct silk retreats on rocks and feed on the attached algae on the rock surface. In contrast the other four species are found on macrophytes. Three species occur in the ribbonweed beds (*Vallisnera* in the fast flow of the upper Murray from Khancoban to Yarrawonga. They construct a case of *Vallisnera* strips attached to the plant leaf blades. One species is restricted to the pondweed *Potamogeton* in the slow flowing areas. The larvae construct a case by cutting a section of leaf and folding it back onto the leaf. This species is common in the *Potamogeton* beds of lower Murray River from Echuca to Woods Point.

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Conclusion
This paper has attempted to give an overview of the aquatic macroinvertebrate fauna of the Murray River without attempting to give an assessment of the condition of the river. Norris et al. (2001) recently concluded that the macroinvertebrate communities along the Murray River from Dartmouth Dam to Lake Alexandrina were in poor condition. They also highlighted the absence of pristine or minimally modified sites in lowland rivers in the Murray Darling Basin and recommended caution in the interpretation of the results. The current distribution of the macroinvertebrates has certainly been modified by the influence of regulation, particularly in the Lower Murray tract where the river now is a series of narrow lakes and some species have benefited at the expense of others (e.g. the yabby replacing the Murray crayfish), and introduced species have successfully invaded the river (e.g. Physa acuta). However, it is not possible to determine the extent of modification of the invertebrate fauna because there are only limited data prior to construction of the locks and weirs. In addition, the other lowland rivers in the Murray Darling Basin with which the Murray communities could be compared are also affected by regulation. This lack of a reference condition limits the ability to assess the condition of the Murray but we are not in the position to monitor the effects of management decisions (e.g. environmental flows) on the aquatic macroinvertebrate communities of the Murray River.

References