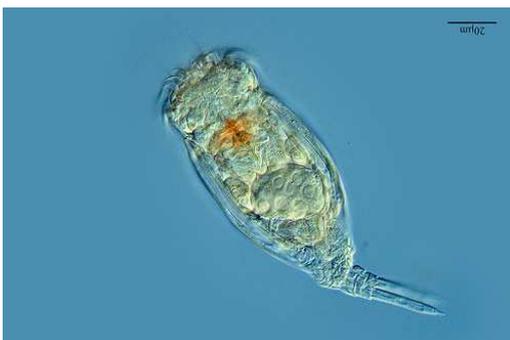


Australian Waterlife



Freshwater Aquatic Microfauna:

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Freshwater Microfauna :

The Australian freshwater microfauna are typically comprised of four major groups of small, microscopic invertebrate animals: the rotifers, ostracods, copepods and cladocerans. The rotifers constitute a phylum found almost exclusively in freshwaters and are not included in this preamble.

The ostracods, copepods and cladocerans are groups of the large sub-phylum Crustacea. The ostracods are a Class with 6 super Families and approximately 100 species known from Australian inland waters. Copepods constitute a Class which is widespread in both freshwater and marine environments. There are three Orders: the Calanoida, the Cyclopoida and the Harpacticoida. Cladocerans constitute 8 Families and are a group of small animals living primarily in freshwater environments.

All of these major groups have species adapted to pelagic (open water), or littoral (shallows, vegetated), and benthic (bottom) environments. Together the aquatic microfauna may collectively number in the 1000s per litre of water, or in the millions per square metre of the benthos. These microcrustacea are an important group as they link all of the major components of the aquatic food web together. Many copepods and all cladocerans in Australia are herbivorous consuming algae, and provide a food source for larval, juvenile fish and small fish species, plus aquatic birds. Many Cladocerans may also consume detritus and bacteria. Many cyclopoids are predatory feeding on insect larvae (eg Mosquitoes), and some may even prey on fish larvae (eg Carp). In south east Asia and Africa they have even been used in malaria control. Carnivorous ostracods are known to predate on amphibian eggs with a mortality rate of more than 90%.

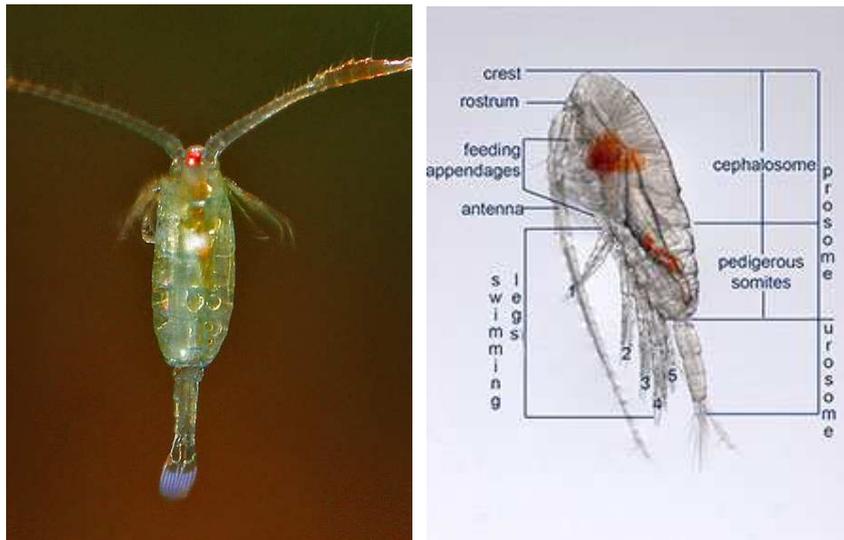
Freshwater microfauna are an important subject for freshwater toxicology and for understanding the environmental effects of human activities on lakes and wetlands. Filter-feeding cladocerans are among a few known animals that can clear pollution-caused algal blooms in lakes. Moreover, cladocerans are a critical part of freshwater ecosystems, as most larger freshwater organisms depend directly on them as a significant source of food.

In Europe and the USA, changes in species composition and abundance of cladocerans have been used as bio-indicators for watershed deliveries, climate and atmosphere changes, eutrophication and acidification of water bodies. In Australia, studies have shown a link between changes in cladoceran assemblages in billabongs, and the European settlement in the Murray Darling Basin.

To-date the use of these animal groups in aquatic ecological studies in Australia has been overlooked for a variety of reasons. To put it briefly, the aquatic microfauna are arguably the most important link in the aquatic food web. As a group they link all the components in the food web, living and non-living together.

Copepoda : Calanoida :

In Australian inland waters there are 2 Families, the Centropagidae with 4 genera and with 41 species found across the country, and the Diaptomidae occurring in northern Australia with 1 genus and 2 species. The pictures below are typical of the copepod Centropagidae microfauna (e.g. *Boeckella* and *Calamoecia*).



These taxa are found mainly in the open water environment of Australian inland waterways and standing bodies of water, such as reservoirs or lakes. The free-swimming copepods move through the water in jerky motions by moving their swimming legs.

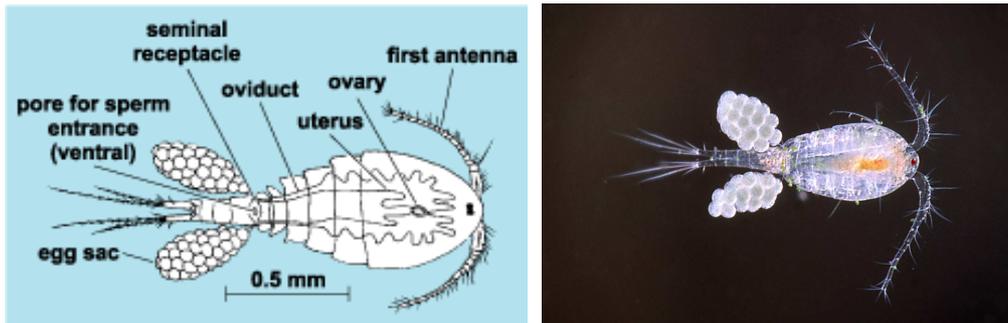
These small animals typically are herbivorous or omnivorous, feeding on algae, detritus and even bacteria. Typical body length is 700um-1.7mm. A few species are predatory, opportunistically attacking other copepods and cladocerans.

The taxonomy of the Calanoida is based on the arrangement of the 5th pair of legs in the males of the species. Copepods have a hard exoskeleton, many legs (used for swimming and gathering food), a segmented body, and jointed appendages. Although lacking compound eyes, they have a single simple eye in the middle of the head (sometimes it is only present in the larval stage); this simple eye can only differentiate between light and dark. There are two pairs of antennae; one pair is long and one pair is short.

Calanoids generally eat bacteria, diatoms, and other tiny, single-celled organisms in the water. Some are predacious eating rotifers and other small micro-fauna. They are important in our waters as this group of animals provide a link between the bacterial decomposition pathway and the food web present in our waters. They are the main food source of many macroinvertebrates, juvenile and small fish species.

Copepoda : Cyclopoida :

There are currently 18 Genera of Cyclopoids found within Australian inland waters with approximately 120 different species. Each species with their own ecology and environmental preferences. Many are voracious predators with some even noted for attacking fish larvae. As predators cyclopoids may have a substantial impact on their prey, for example *Mesocyclops* sp. may crop >25% of its prey population per day.



The above two pictures are typical of the cyclopoid microfauna found in many inland waters and associated water ways. These animals are typically found in the littoral zone of inland waters and are quite voracious predators. Some taxa have even been recorded attacking and killing fish larvae (eg Carp). In one study nearly 90% of the fish larvae were removed by cyclopoid predation.

The taxonomy of this group is based on the arrangement of the respective segments of the female 5th pair of legs of the females. See the Pictures below. Typical body length is 600um -1.3mm.

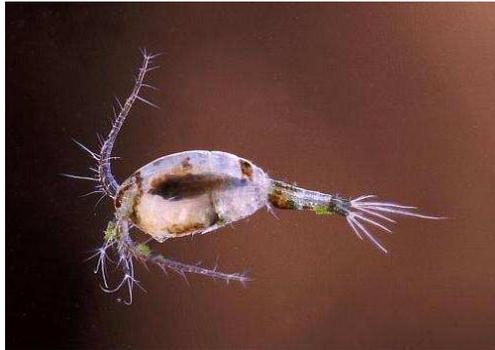


The above pictures are of the genus *Mesocyclops*. The level of microscopy required is shown in the second picture of the 5th pair of thoracic legs on which taxonomic identification is based on the arrangement of leg segments.

There is no published key to the Australian Cyclopoida. All taxonomic identification is based on material gleaned from internationally published material.

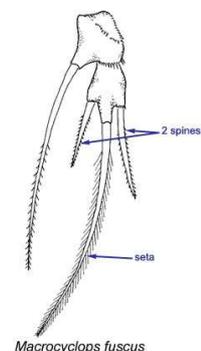
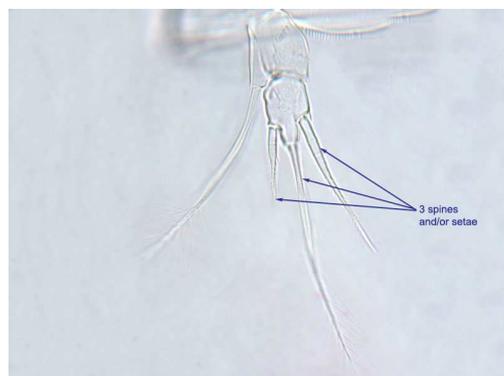
Cyclopoida : Macrocyclus sp

This cyclopoid genus is the largest known from Australian inland waters. The picture below is of the genus *Macrocyclus*. There are two species of this genus currently identified from Australian waters. These two species are *Macrocyclus albidus* and *Macrocyclus distinctus*.



Their distribution and abundance may be attributed to pH and temperature, but the effects vary with the species. In the benthic regions of lakes it is not uncommon to find copepod densities up to 70,000 individuals per metre squared.

The level of microscopy required on which taxonomic identification of the Cyclopoida is based, is shown in the two pictures below of the 5th pair of thoracic legs.



Macrocyclus spp. are quite large when fully mature, with reproductive adults 1.6-2.1mm in total body length. Specimens have been known to reach 3-4mm. This genus occurs largely within the littoral and benthic zone of ponds, wetlands etc. It is a voracious predator attacking not only rotifers, cladocerans, copepods but also the early stages of its own species.

Such predatory cyclopoids are believed to be a primary factor in controlling the distribution and abundance of Rotifera.

Cladocera :

Cladocerans other-wise known as water fleas are small, often transparent animals, whose general shape and jerky swimming action accounts for their common name of “water fleas”. Although abundant in nearly all waters they are often overlooked.

A total of eight Families of Cladocera are known from Australian inland waters. These include the Sididae, Bosminidae, Chydoridae, Daphniidae, Ilyocryptidae, Macothricidae and Moinidae. Generally cladocerans are small in size with the greater majority of species being less than 1mm in total length.

Cladocerans occur where ever there may be water; such as lakes, marshes, ponds, dams, pools, puddles, temporary waters, billabongs, cut-off river meanders, ox-bow lakes, wetlands, and even in sphagnum moss. Most species are sensitive to salinity.

Typically the cladocerans are the most abundant of the micro-crustaceans within aquatic systems, reaching densities greater than 1 million animals per metre squared, with as many as 30 species being present.

Whether a species occurs in a body of water depends upon:

- 1) Probability of colonization of the water body
- 2) Chemical and physical requirements of the species
- 3) Food conditions within the water
- 4) Predators living within the water

Almost all members of the Families Chydoridae, Ilyocryptidae and the Macothricidae are benthic, living on and in various surfaces, particularly aquatic macrophytes, coarse plant debris, other organic debris and swim only very short distances.

Most species of the remaining Families of cladocerans are primarily planktonic where their swimming lifestyle makes them independent of surfaces. Besides differing in habitat, planktonic and benthic cladocerans differ in ecological relationships. Therefore to say that everything learnt about *Daphnia* or *Chydorus* applies equally to all cladocerans is misleading and incorrect.

Large planktonic species of cladocerans such as *Daphnia* appear to be most efficient in cleaning up water bodies made turbid by blue-green algae. The size and feeding rates of large *Daphnia* make them especially efficient at the clearing of water bodies of algae. Smaller cladocerans such as *Bosmina* and *Ceriodaphnia* , while less prone to predation by fish, invertebrates etc, are less efficient at clearing of algae from water bodies.

Cladoceran significance in aquatic food webs has largely been ignored in Australia. This particularly true of the Chydoridae. Firstly taxonomic keys are often inaccessible, incomplete or inaccurate to species level for the average aquatic ecologist. Even at the Family level of taxonomic resolution, the Chydoridae have been confused with members of other Families (e.g. Bosminidae). Secondly as they commonly live in amongst aquatic

vegetation and the benthos of inland waters, they do not appear in plankton samples, the common habitat sampled for aquatic micro-invertebrates; or their numbers are so low that they are regarded as unimportant. Aquatic vegetation and the benthos is routinely sampled for macro-invertebrates, however the chydorids are ignored as by-catch, or excluded due to the mesh size of the net (500um) misses the majority of species, and as the sampling is for macro-invertebrates, any chydorids present are regarded as contaminants, insignificant due to their small size, or under sampled, not identified or enumerated. However overseas studies has shown that they have high species richness and high densities, often being the most abundant animal taxa present.

In Europe and the USA , where chydorid taxonomy and ecology is better known, chydorids are used as **bio-indicators** for climate change, eutrophication, and acidification of water bodies. Chydorids are just as sensitive to environmental conditions as Diatoms, and studies have shown that species composition of chydorid communities is dependent on the physicochemical conditions of a water body. Their body parts preserve well in sediments plus their ecology and community relationships are stable over time, thus making them useful for paleolimnological studies.

Chydorids have radiated extensively within Australia, thus making them good bio-indicators, as in a healthy water body, several species may co-exist in the same environment. Of all the cladocerans they possess the greatest degree of radiation, and in Australian inland waters the levels of selective pressures which may cause genetic divergence seem higher than elsewhere. This makes the Chydoridae ideal for studies on evolution and adaptive radiation.

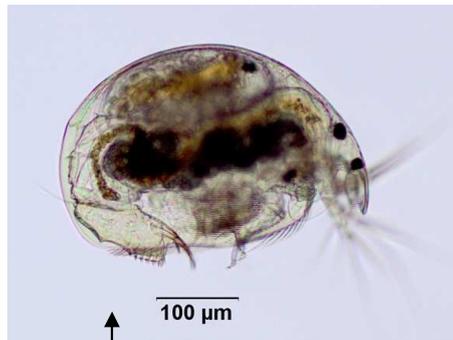
Much of the above discussion relating to the Chydoridae is true for most of the other taxonomic groups of Cladocera.

Cladocera : Chydoridae :

The Chydoridae are the most diverse cladoceran family with Australia and appears to have undergone adaptive radiation to suite environmental conditions. There are more than 30 different genera with more than 82 different species found across the country, with many endemic to particular regions. Australia has the largest number of species and highest level of endemism in the world.

The Chydoridae occur predominantly in the littoral region of vegetated water bodies in slow moving waterways, lakes, wetlands, billabongs, springs, temporary water, water holes throughout the country. They are also present in caves, underground waters and in bryophytes.

Alona sp.



Chydorus sp.



Note the post abdominal foot ...the shape of the indent at base of the tooth, the large spine at the base of the tooth, and the teeth on the foot.

Some members of the Chydoridae live on the stems or stalks of aquatic vegetation, consuming the film of algal mucilage or Diatoms that may cover such plants. Others live within or just above the sediment, grazing on bacteria and/or detritus.

The Chydoridae typically feed by crawling along surfaces or through the sediment where they scrape up or filter food. Between species there is great variation in diet. Most of the specialization of the Chydoridae seems to be in obtaining food from slightly different microhabitats.

The greater majority of the Chydoridae are usually in the range of 300-600um, with few individuals or species larger than 700um (0.7mm) in total body length.

Cladocera : Macrothricidae

The Family Macrothricidae is one of the least studied groups of microcrustacea found within the littoral zone of inland waters. The Family has a global distribution and are believed to be the most primitive of the Cladocera. They typically are abundant in tropical and subtropical water bodies. Representatives of this family are often found in the temperate waters of southern Australia.

The Macrothricidae occur predominantly in the benthic littoral region of vegetated water bodies in slow moving waterways, lakes, wetlands, billabongs, springs, temporary water, and water holes throughout the country.

***Macrothrix* sp.**



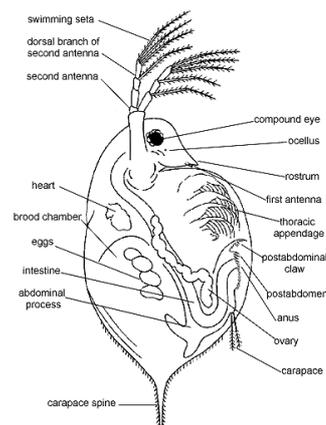
There are 4 Genera within this Family, with approx 17 species belonging to the Genus *Macrothrix* found in Australian fresh waters.

Macrothrix is a benthic dwelling genus, found in the littoral shallows of rivers, ponds, wetlands and lakes often amongst aquatic vegetation. Body size is often 0.4-0.8mm. They form an important part of the diet of small adults and juvenile stages of freshwater fish.

Cladocera : Daphniidae:

Daphnia is native to Australia, and inhabit large lakes as well as small temporary pools, and is found in the littoral zone of many inland waters, and often in the open waters of impoundments and wetlands.

Daphnia sp.



This genus has some 14 species and is quite widespread within Australian inland waters and often prevalent. Often when environmental conditions are right the genus may be present in quite large numbers. It is often the taxa present in waterways when organic enrichment i.e. algal blooms are present, with the population of a water body responding rapidly to algal blooms.

Daphnia may be the largest of the aquatic microfauna, with individuals reaching 5mm in total body length.

The Cladocera (e.g. *Daphnia*) are also referred to as water fleas. They are found in freshwater environments including swamps, lakes, ponds, streams and rivers. Most are filter feeders and ingest unicellular algae and similar small protists and bacteria.

In the northern hemisphere this genus is often used in ecological and ecotoxicology studies. More is known about ecology of this particular genus than of all the other genera found in the Cladocera.

Cladocera : Daphniidae

Ceriodaphnia species are widespread throughout Australian inland waters. Once believed to be mono-specific, this is now known not to be the case, with up to half a dozen species believed to exist within Australia.

***Ceriodaphnia* sp.**



Species determination within Australia is problematic as all the species so far recorded from Australia are believed to be new taxa and there is at this stage no taxonomic key to the genus.

This genus is often encountered in samples from the littoral zone of water bodies. It may also be encountered within the open waters of large bodies of water if there are no or few predators.

The diet of this taxa is believed to be algae. The maximum size of the genus is no more than 0.7mm with most individuals in the range 0.4- 0.55mm (400-550um).

Here in Australia, this genus has been in the past been used in ecological and ecotoxicology studies.

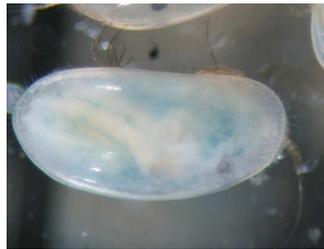
Ostracoda:

Ostracods are crustaceans and are surrounded by a shell that has been secreted around them. They are quite widespread though out the continent and are found in all sorts of inland waters. They range in size from 0.4mm up to 5mm.

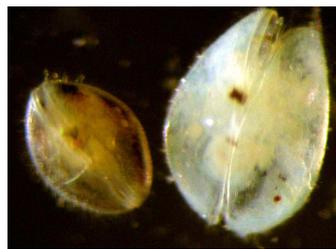
Ostracods are the oldest known microfauna with fossils dating back to the Cambrian. The ostracods occupy a wide range of habitats and are found in nearly every sort of aquatic habitat. These range from temporary waters to permanent ponds, lakes, intermittent waters, ditches, irrigation canals, within underground aquifers, moist organic mats on forest floors and even in the cups of certain plants.

Ostracods have a range of conditions each can survive in, including salinity, temperature, and acidity. Knowing these tolerance levels allows scientists to make estimates of past climates from collections of ostracods shells found in wetland sediments.

Candonocypris sp.



Cypretta sp.



Ostracods are primarily benthic animals and are rarely found in the plankton of water bodies. Most forms are free-living . The species may have a swimming, clinging, climbing or burrowing life style. Because swimming is energetically demanding, most ostracods can only swim short distances.

The greater majority of the ostracods are detritivores and herbivores. Their diet is restricted to algae and organic detritus. A few are known to be carnivorous. Some ostracod taxa are opportunistic predators and display foraging behaviour. For example, *Australocypris insularis* may influence the structure of the aquatic microfaunal community in saline lakes. Other ostracod species have been observed to consume snails. Four species have been shown to consume amphibian eggs consuming up to 90% of the egg mass.

Physical and chemical characteristics of the aquatic habitat are important factors in ostracod distribution and abundance. A high percentage of the ostracods are found only in bicarbonate rich water. Bicarbonate after being converted to carbonate is the prime constituent of the animals shell.

Ostracods are typically identified taxonomically from adult specimens. There are approximately 200 species identified from Australia.

Why include microfaunal community assessments in studies of environmental impacts and water quality?

Aquatic microfauna are an extremely important link in the aquatic food web, serving both as consumers- of algae, bacteria, other microorganisms, plus larval macro-invertebrates and fish fry: - and as prey for larger animals such as macro-invertebrates, small fish species and the juvenile stages of larger species, and many water birds.

Aquatic microfauna are an important part of the diet of birds. For example the diet of swans consists mainly of aquatic vegetation, however they are also insectivores as young swans (cygnets). In particular, cygnets need a protein rich diet, consuming small crustaceans and insects as their main source of food. Similarly ducks and geese also consume a wide variety of aquatic plant material, plus associated microcrustaceans.

Therefore the presence or absence of microcrustacean species in a water body may provide us with useful ecological information. In addition the inclusion of aquatic microfaunal community analysis can help provide a more thorough understanding of water quality.

In some inland waters, the relative abundance of microfaunal species or types can be used as an indicator of water quality. Some species are limited by physicochemical variables, such as oxygen, temperature, pH or salinity. Microfauna are also affected by competition between species, predation by other species, and food availability.

The microfaunal species composition in a particular consistent water body usually remains somewhat stable over time, and the sudden appearance of new species or disappearance of existing species may indicate a change in water quality due to toxic substances, eutrophication, or imbalance between piscivorous and planktivorous fish; or as in the case of large or deep reservoirs, due to a flushing event or a turn-over event following thermal/chemical stratification.

In temporary water bodies or those subject to wide fluctuation in water levels, the changes in temperature, nutrients, ionic content, pH and the underwater light regime influence on aquatic plants and algae, may also influence microfaunal species type and number of individuals per species that may be present in the water body at a given point in time.

Therefore a routine monitoring program involving the aquatic microfauna, utilizing proper scientific sampling techniques is recommended. There are different methods used to sample particular habitats and in sampling for Rotifera and Microcrustacea. Continuous, long-term monitoring of microfauna community structure are useful in detecting patterns and changes in species composition, these in turn may be related to changes in water quality. A routine monitoring program also helps to separate the ordinary effects of seasonal changes upon the microfaunal community from changes caused by other factors.

In short the aquatic microfauna are arguably the most important link in the aquatic food web. As a group they link all the components in the aquatic food web together.