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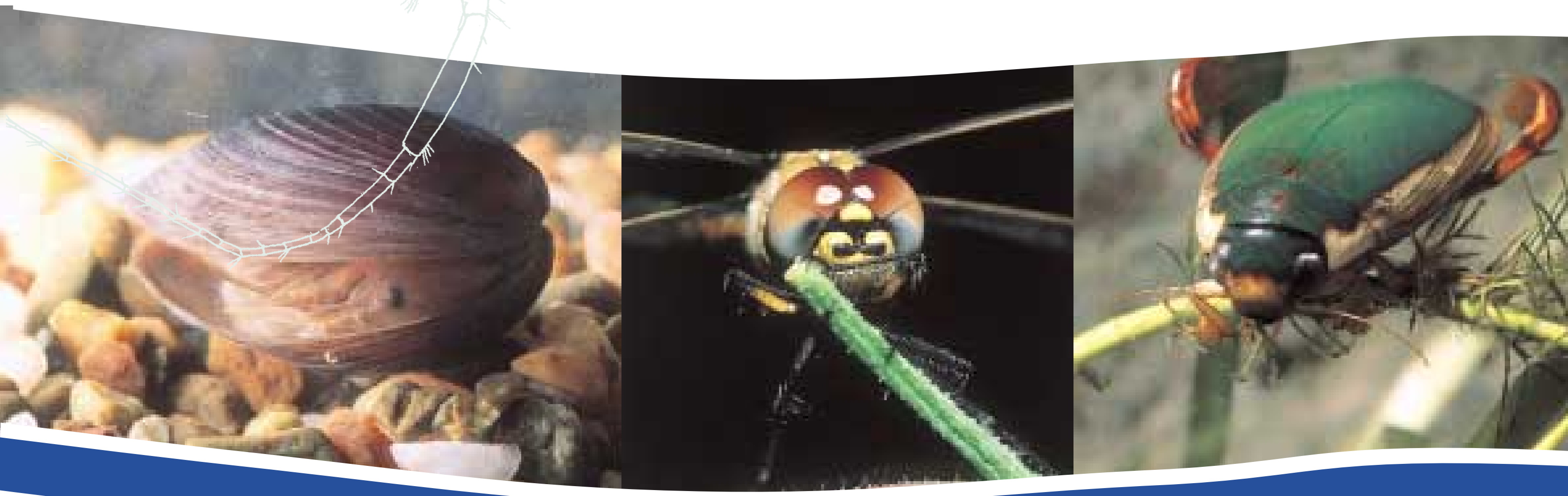
Critter Catalogue

A guide to the aquatic invertebrates of South Australian inland waters.



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A guide to the aquatic invertebrates of South Australian inland waters.

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Dedication

WD (Bill) Williams, AO, DSc, PhD

21 August 1936—26 January 2002

This guide is dedicated to the memory of Bill Williams, an internationally noted aquatic ecologist and Professor of Zoology at the University of Adelaide. Bill was active in the science and conservation of aquatic ecosystems both in Australia and internationally.

Bill wrote *Australian Freshwater Life,* the first comprehensive guide to the fauna of Australian inland waters. It was initially published in 1968 and continues to be used by students, scientists and naturalists to this day. Bill generously allowed illustrations from his book to be used in earlier versions of this guide.

Bill actively promoted the study of aquatic science to managers and politicians, with the aim of improving the way we manage our waters. Consistent with Bill's approach, we hope that this guide promotes a greater understanding of aquatic invertebrates and enthusiasm for the protection of our aquatic ecosystems amongst a wide audience.

Acknowledgments

This South Australian *Critter Catalogue* has evolved over a number of years. Earlier editions and drafts of the Critter Catalogue have been widely used by Waterwatch participants, and feedback from readers has contributed to this final version. The authors would also like to thank the following contributors.

Past and present Waterwatch staff:

- Ross Wissing for initially supporting this project and Deb Thomas for managing tenders and progressing the project. Many other past and present South Australian Waterwatch staff also provided feedback that has improved this guide.
- Simone Williams, EPA Community Education and Monitoring, for an outstanding job pulling it all together—this guide would not have been published without her managing most of the pre-publication tasks.

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Australian Water Quality Centre for the loan of invertebrate specimens and The Murray Darling Freshwater Research Centre.

CSIRO for the photographs that have been reproduced on the front cover of this document—© Edward Tsyrlin & John Gooderham—reproduced from *The Waterbug Book: A guide to the freshwater Macroinvertebrates of Temperate Australia* (2002), with permission of the publisher of the book—CSIRO Publishing.

Alice Wells, Australian Biological Resources Study, Environment Australia, for scientific editing.

John Bradbury for doing a great job with the illustrations.

Foreword

Our creeks, rivers, ponds and wetlands contain a vast diversity of living creatures. They are not just homes for fish, frogs and birds. These systems are dominated by aquatic invertebrates—animals without backbones. They are an important part of the aquatic food web and essential to the healthy function of aquatic ecosystems. Without them our waters would be almost lifeless.

These aquatic invertebrates are good 'biological indicators', and studying them can tell us about the health of our aquatic ecosystems. It also educates us about broader biological and ecological issues. Many of these creatures have evolved remarkable adaptations to solve some of the challenges of life in water, such as the jet propulsion used by dragonfly larvae to escape danger!

Understanding these critters and how they survive is interesting in its own right; however, it also encourages us to appreciate the value of aquatic systems from a perspective other than human use. Hopefully this will promote better custodianship of our aquatic resources and encourage behaviour that minimises pollution. This will lead to better quality waters for humans as well as the natural ecosystems that depend on them.

On behalf of the Environment Protection Authority (EPA) I am pleased to release this *Critter Catalogue*. It is a scientific resource for the community that provides an informative guide to the natural history of the aquatic invertebrates of South Australia. The *Critter Catalogue* is a valuable tool for Waterwatch participants, teachers, high school students and community groups, providing them with information on South Australian aquatic invertebrates to help them more effectively monitor, understand and protect their local aquatic environments.

Dr Paul Vogel

Chief Executive

Environment Protection Authority

Contents

Contents

1 Introduction

The *Critter Catalogue* is an information guide to the aquatic invertebrates of South Australia's inland waters. This guide is aimed at Waterwatch staff and participants, teachers, secondary students and community groups.

The *Critter Catalogue* is written to accompany *The Colour Guide to Invertebrates of Australian Inland Waters* by Hawking and Smith (1997), *Australian Freshwater Life* by Williams (1980) and *The Waterbug Book* by John Gooderham and Edward Tsyrlin (2002). These books provide more detailed information on the invertebrates of Australian inland waters. *The Colour Guide to Invertebrates of Australian Inland Waters* and *The Waterbug Book* also have excellent photographs of invertebrates.

A locally relevant and user friendly guide to aquatic invertebrates

Many texts on aquatic invertebrates are aimed at scientific audiences. These often contain complicated technical language that is difficult for the everyday reader to understand. This guide provides a simpler summary of the diversity, habits and nature of aquatic invertebrates of this state.

Unfortunately, some technical language is still required—without it we could not effectively express the biological ideas contained in this guide. The glossary will help to explain these terms. If you are after further guidance or you wish to use some of the references listed at the rear of this guide, a copy of *Henderson's Dictionary of Biological Terms* (Lawrence 1995) will be very useful. It provides a comprehensive list of biological terms and includes a useful guide to the origins of some common biological words. This is a great help when trying to decipher some of the language that biologists use.

Information in this guide has been drawn from scientific textbooks, guides, identification keys, internet sources and research papers. To promote readability we have decided not to cite references in the traditional scientific manner; however, the bibliography provides a list of sources. Not all biological information, especially local observations, are published so expert advice from biologists has also been used. This local knowledge has enhanced the relevance of this guide to South Australia.

Why a guide for South Australia?

In general, South Australia's aquatic invertebrate fauna is less diverse than the eastern states: we have fewer families and often fewer species in each family. Many families found in the northern tropics, alpine regions, Tasmania, and the south-west of Western Australia are absent from South Australia.

Most of the organisms covered in this guide are present in other areas of the country, so this guide may be of use to readers from other states. However, some of the information within is specific to South Australia so interstate users should use this guide with care.

The numbers of species, families or other taxonomic groupings within each section should be considered indicative only. New species to South Australia are regularly discovered and, with most taxa having many undescribed and unknown species, numbers are likely to regularly increase within Australia and internationally. Estimates such as these are often out of date by the time they are published and some information for this guide has been taken from books that are a few years old, including CSIRO's *The insects of Australia (*1996) and Hawking and Smith's *The Colour Guide to Invertebrates of Australian Inland Waters* (1997).

Why study aquatic invertebrates?

Aquatic invertebrates are very different from the larger vertebrate animals that most people are familiar with. They are a diverse group with a vast range of different body shapes, behaviours, and life cycles. Aquatic invertebrates have adapted to a wide variety of conditions, such as developing ways of surviving during periods of drought, adapting to increased salinity, and surviving in highly polluted waters. Aquatic invertebrates are fascinating creatures in their own right but they also teach us about the quality and health of our waterways.

The number of different kinds of invertebrates (richness) and the total number of invertebrates (abundance) can be used to measure the health of aquatic ecosystems. As a general rule, the more types of invertebrates you find in an aquatic system (that is, the higher the richness) the healthier the aquatic system. Low richness may indicate that an aquatic system is under stress. Similarly, low abundance (that is, very few animals in total) often indicates that an aquatic system has been subject to an impact, while a high abundance may indicate a healthier system.

However, it is important to note that natural events can change the richness and abundance of aquatic invertebrates. If you sample a stream that has just started flowing after a dry period, you will probably find low abundance and richness as the invertebrates have not had time to colonise the stream. Likewise, a stream that has recently been scoured by a flood will probably have a low abundance and richness as the invertebrates have been swept away. Natural impacts such as these are a normal part of the functioning of aquatic systems. It is important that changes in invertebrate communities due to these events are not mistaken for human impacts such as pollution.

Water bodies around our state range from near-pristine conditions to seriously degraded. Each of these water bodies will contain a different community of aquatic invertebrates. Some types of aquatic invertebrates are very sensitive to pollution and other disturbances, while some are more tolerant and are able to survive in degraded streams. The sensitivity of the invertebrates present at a location tells us about the health of that water body.

Where available, each class, order or family of aquatic invertebrates presented in this Critter Catalogue has been given a sensitivity rating. This rating is based on Bruce Chessman's Australian 'SIGNAL2' system. Ratings range between 1 and 10. A low rating means the aquatic invertebrates are able to tolerate a range of types of water pollution. A high rating indicates that the aquatic invertebrates are sensitive to most forms of pollution and prefer to live in streams with unpolluted water. See page 19 of *The Waterbug Book* for a more extensive discussion of SIGNAL2.

Collecting and observing aquatic invertebrates

To accurately assess the health of a stream or river it is important to collect aquatic invertebrates using appropriate methods. Aim to maximise your chances of collecting as many different types of invertebrates as possible. Many invertebrates live on surfaces, such as the bottom of streams or on the side bank amongst water plants. Simply waving a net through the top of the water will not be very effective. Sweeping a net through plants and against undercut banks as well as vigorously kicking the stream bed will result in a much better sample. Some aquatic invertebrates also cling to the undersides of rocks, so it is often worthwhile overturning some rocks to see what you find.

Australian Freshwater Life (1980) and *The Waterbug Book* (2002) have further information that you might find useful on collecting aquatic invertebrates.

Why not just study water chemistry, or fish, frogs and birds?

Aquatic invertebrates are generally abundant across the entire range of aquatic habitats and are easy to collect. In comparison, fish, frogs and waterbirds are often less abundant, are not distributed throughout all aquatic environments, and are more difficult to collect. They are often protected by legislation and you may require permits to collect them. While you may record the presence of these larger animals in the aquatic environment you should generally avoid collecting them.

Monitoring water chemistry provides information on water quality at the time of sampling, but sampling aquatic invertebrates can provide information on water quality and other factors at a site over the few weeks or even months before sampling. Aquatic invertebrates are a good indicator of the stresses on aquatic systems, reflecting the physical, chemical and biological interactions that take place in catchments and river systems.

For many monitoring programs an integrated approach is best. Measuring water chemistry in conjunction with biological assessment using invertebrates will give a more complete picture of the health of an aquatic system than either on its own. Water chemistry information may be helpful in explaining the presence or absence of different invertebrates.

How can I identify invertebrates?

The *Critter Catalogue* is not intended to be an identification tool. If you try to identify aquatic invertebrates by comparing them to the drawings in this guide you are highly likely to make identification errors. This is because general similarity does not guarantee a correct identification—often the characteristics used to identify an invertebrate are small and not visible to the naked eye. Magnification makes identification much easier.

If you aim to accurately identify an unknown aquatic invertebrate, an identification guide should be consulted. Guides vary in complexity—*Freshwater Invertebrates* by Ralph Miller, published by the Gould League, is a useful simple key to most groups of aquatic invertebrates.

An excellent and easy-to-use key to most of the invertebrate groups presented in this guide starts on page 20 of *The Waterbug Book*. Through *The Waterbug Book* there are also keys to families of many groups—these are listed in the identification section for each taxa.

Identification help is also available on line. Web-based keys and general information on invertebrate groups can be found at www.lucidcentral.com/keys/lwrrdc/public/Aquatics/

This excellent resource has been developed by CSIRO Entomology and Environment Australia's Australian Biological Resources Study.

The more experienced reader might like to consult the bibliography and, in particular, the excellent range of keys from the Murray-Darling Freshwater Research Centre. *Australian Freshwater Life* is also handy for identification, although, as it was published in 1980, some keys are out of date. However, note that for some groups identifying the family can be difficult, even for specialists.

When identifying invertebrates you can use the information in this guide in conjunction with the keys above. For example, if you identify an invertebrate that is not listed in the *Critter Catalogue* as occurring in South Australia, check your ID carefully—you have probably mis-identified your specimen.

One final comment on identification—adults and final instar larvae are usually easier to identify than juveniles. Not only are they larger but they will have developed the characteristics that scientists use to tell them apart. Also, aquatic invertebrates are easily damaged when they are being collected. The bits that get knocked off, like gills, legs, heads and antennae, are often important diagnostic features. Handle your bugs carefully and try not to damage them.

Scientific names, biological classification and taxonomy

A great abundance and variety of life exists on earth. Organising and describing all these living things is a long and difficult process. Scientists have described over one million species of plants and metazoan (multicellular) animals; however, many organisms are yet to be discovered.

Biologists have developed systems and concepts to help us understand and organise our knowledge of living organisms. Most biologists believe that life has developed through a process of evolution by natural selection, first described in 1859 by Charles Darwin in his book *The Origin of Species*. The idea that all organisms on earth have evolved from a common ancestor over time means that they are related. Scientists organise living things into groups based on how closely they are related to each other.

Unfortunately, scientists often give organisms complicated scientific names that are hard to remember and often even harder to spell. However, this means that each species has its own unique name which cannot be confused with any other species. Common names are often simpler and easier to remember than scientific names, but their use creates some major problems. For example, different species can be given the same common name: the freshwater crayfish *Cherax albidus* and *Cherax destructor* are both commonly called 'yabbies'. In some cases, one species can be known by different common names in different places, such as the fish *Macquaria ambigua*, which is known by at least three common names: 'yellowbelly', 'callop' and 'Murray perch'.

There is a standard hierarchical method of classifying and naming animals. All animals belong to the Kingdom Animalia. Within this kingdom there are at least 35 Phyla. The animals which are most familiar to us—mammals, birds, reptiles, amphibians and fish—belong to the Chordata, a phylum not covered in this guide.

Within each Phylum there are classes, within classes there are orders and so on, down to species. The classification of the yabbie is presented below:

Classification level	**Scientific name**	**Common name**
KINGDOM:	Animalia	animals
PHYLUM:	Arthropoda	
CLASS:	Crustacea	crustaceans
ORDER:	Decapoda	
FAMILY:	Parastacidae	crayfish
GENUS:	*Cherax*	
SPECIES:	*destructor*	yabbie

Unfortunately, not all scientists agree on the same taxonomic structure. For example, in this guide phylum Arthropoda contains the classes Collembola (springtails), Insecta (insects), Crustacea (crustaceans) and Arachnida (spiders and mites). Some authors believe that Arthropoda should be a super-phylum and Collembola, Insecta, Crustacea and Arachnida should each be a phylum.

Discussion of the scientific debate over classification is beyond the scope of this guide, but readers should be aware that different authors might use different classifications. There is an excellent discussion of the idiosyncrasies of scientific classification on page 17 of *The Waterbug Book*. In the Critter Catalogue, taxonomic structure, scientific names and common names follow those in Hawking and Smith (1997). This book is a useful reference for users of the Critter Catalogue, and consistency will make things easier for people using these books together.

Geological time scale

In the Critter Catalogue, the age of a species, family, order or phylum is referred to in terms of the geological time scale. Figure 1 displays graphically the different geological ages in terms of millions of years from the present. For example, the current Holocene period is the most recent stage in the geological time scale and started 0.01 million years ago (mya) or 10,000 years before the present.

Figure 1: A summary of the geological time scale

mya	4560	3800	2500	545	495	443	417	354	290	248	206	142	65	58	37	24	5	1.8	0.01	0
Eon	Precambrian			Phanerozoic																
Era	Hadean	Archean	Proterozoic	Palaeozoic						Mesozoic			Caenozoic							
Period				Cambrian	Ordovician	Silurian	Devonian	Carboniferous	Permian	Triassic	Jurassic	Cretaceous	Tertiary					Quaternary		
Epoch													Palaeocene	Eocene	Oligocene	Miocene	Pliocene	Pleistocene	Holocene	

Reference: Silsby, J. 2001. Dragonflies of the world. CSIRO Publishing, Australia

Key to layout of the Critter Catalogue

The invertebrates in the *Critter Catalogue* are organised within taxonomic groups, and information is provided within each group under the headings below. As some groups are more diverse than others, better known or perhaps even more interesting, the amount of information within each section does vary between groups.

Background

The number of species, geographical range and diversity of the group worldwide, in Australia and in South Australia; the proportion of members of the group that are aquatic and the life stages that are aquatic. Comments are provided on group relationships, age of species, and fossil record.

Size

Length in millimetres.

Features

Physical features.

Diet and feeding

What and how they eat.

Locomotion

How they move.

Gas exchange (breathing)

How they obtain oxygen.

Lifecycle and reproduction

Life stages, how long each stage lasts, how the mature animals mate, and how they lay eggs or otherwise produce young.

Habitat

Macro- and microhabitat.

Critter facts

Interesting and exciting facts about the group.

Identification

Easily identifiable features, how hard it is to identify, and what taxa you could mistake it for.

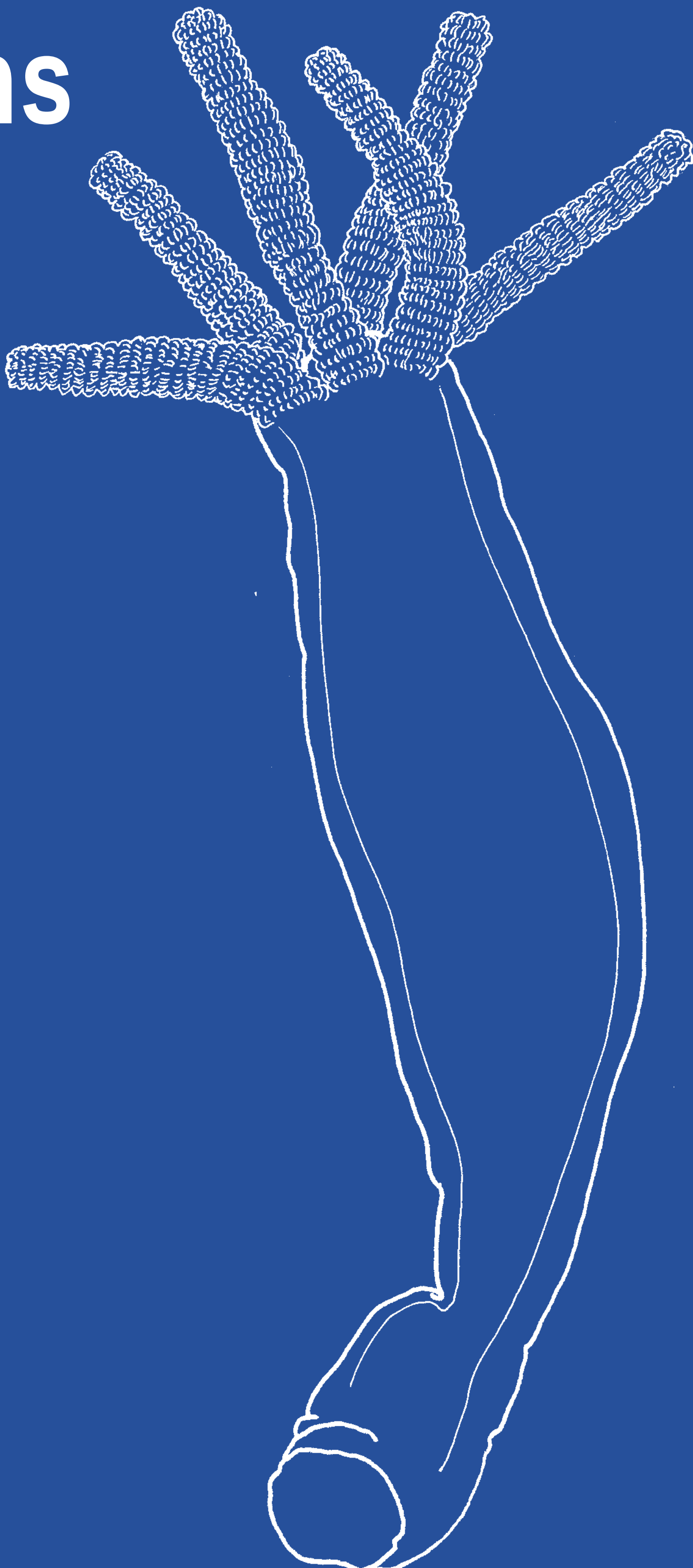
Classification and sensitivity

Classification of the aquatic taxon within the group and their sensitivity rating (from 1-10, NR for not rated; presented in brackets) based on Australian SIGNAL2 scores.

References

Where the species is referred to in Hawking and Smith (1997), Williams (1980) and Gooderham and Tsyrlin (2002).

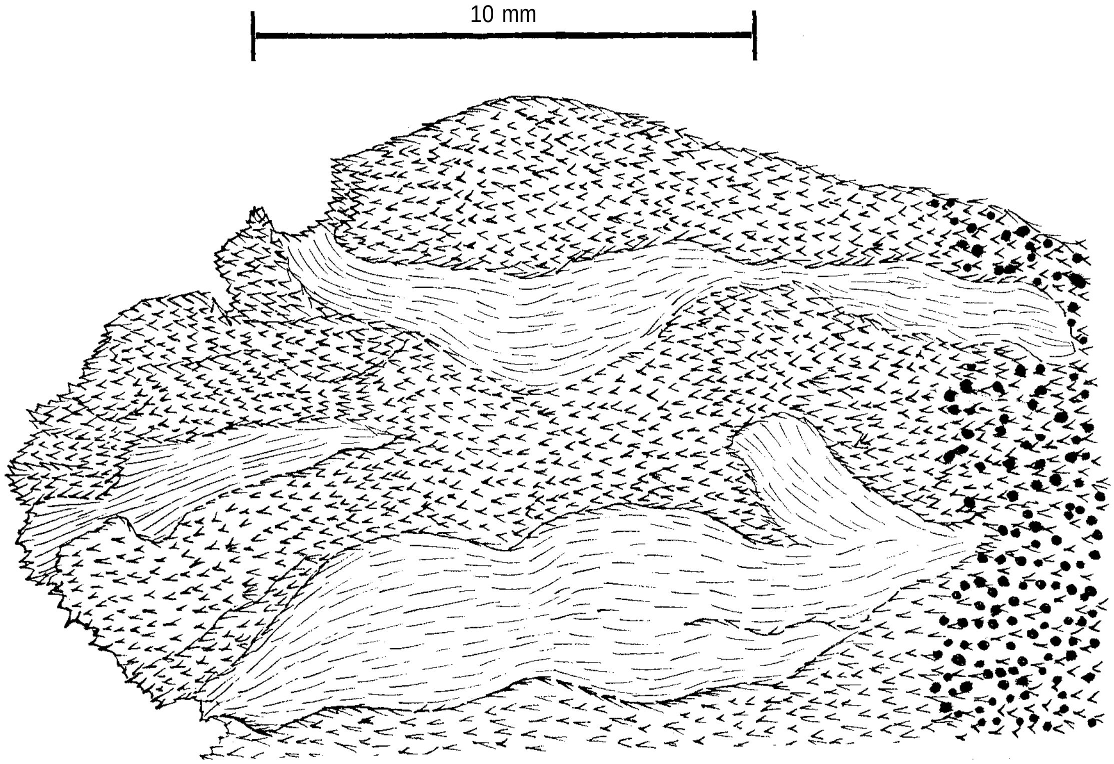
Sponges, hydras and worms



2 Phylum Porifera—sponges

Background

Most sponges are marine, but worldwide there are about 150 species of sponges that live in freshwater systems. In Australian inland waters ten genera and 24 species have been recorded, all from the family Spongillidae. At least two species are known to occur in South Australia. Fossil records of Porifera date back to the Cambrian period, around 550 million years ago.



Internal structure of a species of freshwater sponge, family Spongillidae

Size

Spongillids range from very small to several metres in breadth and are usually less than 20 mm thick. Size depends on the species and age of the sponge, as well as environmental conditions.

Features

Spongillidae are usually mat-like, spongy to touch, and dull coloured—often grey, brown or yellow. Some sponges in this family have symbiotic algae within their cells and can be green. While most freshwater sponges are small and are found encrusted on rocks, some are irregular in shape and develop branches; some species exhibit both forms. The speed of water flow may influence a sponge's shape.

Structurally, sponges are simple multicellular colonies supported by a rigid skeleton of silicon-based spicules that are bound together by collagen. They do not have tissues or organs, but have specialised cells within the colony that carry out different tasks such as feeding, reproduction and digestion.

Sponges have a series of canals inside the body, microscopic channels called 'ostia', through which water is drawn inward, and macroscopic channels called 'oscula', through which the water is expelled. Specialised cells known as 'choanocytes' have flagella which are long, thin whip-like structures that beat to create the water flow through the sponge. Sponges can control the flow of water through the canals in the body and, on some occasions, stop flow completely.

Diet and feeding

Spongillidae are filter feeders and they collect food particles up to 50 µm (1/20 of a millimetre) in diameter from the water column. These particles are drawn into specialised cells called 'amoebocytes' to be digested. Sponges feed on small organic particles, including bacteria, algae and other fine plankton.

Locomotion

Adult sponges do not move about (they are 'sessile'), but sponge larvae use 'cilia', tiny hair-like structures, to swim until they attach themselves to a surface. This swimming experience lasts less than two days.

Gas exchange (breathing)

Sponges rely on the flow of water to obtain oxygen and to remove waste. Sponges exchange gases by diffusion, which is a very efficient method given the large surface area that sponges have exposed to the water.

Life cycle and reproduction

All life stages of Spongillidae are fully aquatic. They can reproduce both sexually and asexually.

To reproduce sexually, a sponge releases sperm into the water which may eventually be drawn into another sponge and fertilise its eggs. Transfer of sperm from one sponge to another is passive and entirely dependent on water currents. A free-swimming ciliated larva is produced which after a few days settles, attaches itself to a substrate, and metamorphoses into a tiny sponge.

Asexual reproduction involves the development of resistant seed-like bodies called 'gemmules', that are important in dispersal of the sponges. A gemmule is a group of soft, undifferentiated sponge cells, usually less than 1 mm long, surrounded by a hard covering of spicules. If environmental conditions become unfavourable, a large number of gemmules may be produced before the adult sponge dies. The gemmules are quite tough and can survive harsh conditions. When conditions improve the gemmules then hatch and develop into adult sponges which are genetically identical to their parent.

Habitat

Sponges encrust various substrates, including rocks, twigs and logs, mainly in standing waters and slow-flowing areas of streams and rivers. They have been found in both fresh and saline inland waters. They are more common at depths shallower than 2 m and prefer hard surfaces, rather than habitats that are silty or muddy. Sponges are not very common in South Australia and you might overlook them due to their dull colours and habit of encrusting rocks and logs. Some pollutants may cause growth and developmental abnormalities in sponges.

Critter facts

Sponges are animals, but they were not recognised as such until the eighteenth century. Before this time people thought they were plants. Sponges support a number of specialised predators—they are eaten by larval Neuroptera (lacewings) of the family Sisyridae (sponge-flies). These insect larvae are entirely dependent on sponges for food. They pierce the sponge cells and suck out the cell contents. The tiny worm-like larval *Xenochironomus*, a genus of Chironomidae (non-biting midges), live in sponges while feeding on them.

Identification

If you can find them sponges are quite easy to recognise. Freshwater sponges look similar to marine sponges. They are often quite small and will not be found without careful observation. They can usually be found attached to rocks and can be mistaken for egg sacs. The key starting on page 21 of *The Waterbug Book* should help you tell a sponge from other animals.

To identify them to species you need to examine the structure of their spicules under a microscope.

Classification and sensitivity

Phylum Porifera (4)

Order Demospongiae (NR)

Family: Spongillidae (3)

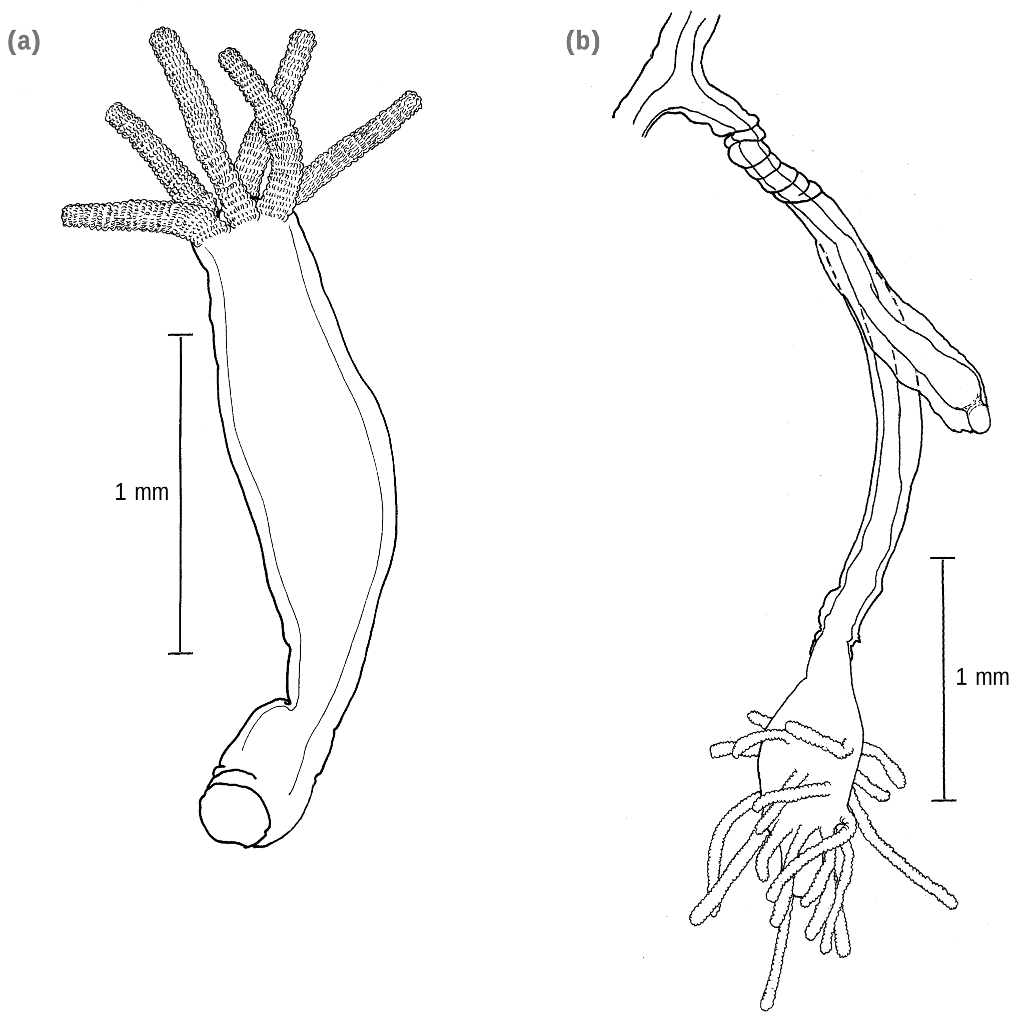
References

Hawking & Smith 1997, p 7; Williams 1980, p 32; Gooderham & Tsyrlin 2002, pp 32-33.

3 Phylum Cnidaria—hydras and jellyfish

Background

Cnidarians (pronounced with a silent 'C') are simple, radially symmetrical invertebrates with tentacles. There are over 9000 described species of cnidarians worldwide. Most are marine, including corals, jellyfish and sea anemones. Three families in the order Hydrozoa—Hydridae, Clavidae and Olindiidae—have freshwater representatives in Australia. The family Olindiidae consists of freshwater jellyfish that occur in large, still water bodies. The family Hydridae, which includes the hydras, and the family Clavidae, which includes the colonial genus *Cordylophora*, are both found in many inland waters of South Australia. Clavidae have both marine and freshwater representatives, but Hydridae are found only in inland waters. Freshwater jellyfish have been recorded from South Australia, but are rare. Cnidarians first appear in the fossil record in the Precambrian era, over 600 million years ago.



(a) a species of *Hydra* (family Hydridae) and (b) part of the colonial structure of *Cordylophora* (family Clavidae)

Size

Individual hydras grow up to 25 mm long, including tentacles, but are usually much smaller. *Cordylophora* colonies measuring up to 100 mm in height have been found, but they are usually only 10ñ20 mm high. Freshwater jellyfish in Australia are small, growing to a maximum of 25 mm in diameter.

Features

Cnidarians have a simple nervous system comprising an irregular net of connected nerve cells.

Hydras can be green, brown, white, grey, tan or red in colour. At one end of a hydra's simple tubular body is a disc that it uses to grip the substrate; at the other end is a circle of three to eight tentacles. These tentacles contain stinging cells, or 'nematocysts', which are used for defence and to capture food. Nematocysts only develop in cnidarians, although they can be 'redeployed' for defence by some other animals that eat cnidarians! This is discussed in the critter facts in the next section on flatworms and planarians. Within the circle of tentacles is a mouth, but this is not a permanent aperture. It is only open when the animal needs it. The mouth is the sole opening to the gut cavity, which means hydra take in food and get rid of waste through the same hole. Nitrogenous waste is also expelled through the body surface.

Members of the genus *Cordylophora* have the same basic body structure as species of *Hydra*, but instead of living as separate individuals, buds are connected by a branching stem called a 'stolon', forming a continuous colonial structure. In addition, *Cordylophora* species have two types of buds—polyps that usually have 10ñ20 tentacles, and 'gonophores', which are reproductive and lack tentacles.

Jellyfish are relatively transparent, umbrella-shaped and have fine tentacles hanging down around the rim. They are solitary creatures.

Diet and feeding

Cnidarians from the Olindiidae, Hydridae and Clavidae families are predatory. They capture and eat small crustaceans, insects and other invertebrates. There have also been reports from fish farms that they can catch larval fish.

Cnidarians use their nematocysts to entangle and paralyse their prey. Once stimulated, the nematocysts take only three milliseconds to release fully. A hollow thread-like tube is ejected with explosive force from the nematocyst. It is armed with spines and, once embedded in the flesh of its prey, it injects a poison to immobilise it. A hydra will use about 25% of its nematocysts to capture a small crustacean like a brine shrimp. Each nematocyst is used only once; a hydra can replace discharged nematocysts within 48 hours.

Once the prey is captured, the tentacles then move it through the mouth and into the gut cavity. Hydras can stretch their mouths and gut cavities to consume prey up to four times the diameter of their bodies. Digestion first occurs in the gut, where protein-digesting enzymes liquefy the prey. Individual cells then absorb and further digest small particles. Any part of the prey that cannot be digested is expelled through the mouth.

Green hydras gain their colour from single-celled algae that live in their body cells in a symbiotic relationship. Presumably they supplement their food supply with some nutrients from the photosynthesis of the algae.

Jellyfish from the Olindiidae family eat zooplankton of 0.2–2 mm in size. They capture prey with their dangling tentacles in a similar manner to hydras.

Locomotion

Hydras are generally sessile, but they can detach and move to another location by gliding slowly on their base. Sometimes they somersault, float or use their tentacles to move along. When anchored, they can also stretch and contract their bodies and bend them from side to side. *Cordylophora* remain anchored within their colony. Jellyfish are free floating and can move in the water column by alternately contracting and expanding their umbrella-like disc (in a pulsating motion).

Gas exchange (breathing)

Cnidarians obtain oxygen from the water by diffusion across the body surface, and presumably in green forms some oxygen is obtained from respiration of the algal cells.

Life cycle and reproduction

The life cycle of cnidarians is entirely aquatic. Cnidarians can have two life stages—a sessile stage called the 'polyp', such as hydras exhibit, and a free-swimming stage called the 'medusa', like the jellyfish. Not all cnidarians go through both life stages. Some occur in only one form or the other. Hydridae and Clavidae have only the polyp form. The major life cycle form of the jellyfish is the medusa, and there are both male and female medusae. As yet, none of the sessile hydra-like individuals have been identified for the Australian species of these jellyfish.

Most reproduction in hydras occurs by asexual budding. A small hydra grows from the side of its parent and then detaches to live independently. But sexual reproduction can also occur and hydras have been recorded as both hermaphroditic (both eggs and sperm produced by the same animal) and dioecious (separate sexes). Eggs form in the body wall of the hydra and, as the eggs grow, the body wall splits to expose them. Hydras release sperm into the water and these fertilise the exposed eggs. The fertilised eggs grow a chitinous shell and are then released. The eggs are very hardy; they remain viable even if frozen or dehydrated. Eventually, tiny hydras hatch from the eggs.

Cordylophora species reproduce asexually by expanding their colonies, but they also have reproductive buds called 'gonophores'. Between three and 20 eggs are formed in the female gonophores. Male gonophores release sperm into the water. The sperm swim to a female gonophore and penetrate the covering to fertilise the eggs inside. Larvae are then released, and settle and grow to form new colonies.

Habitat

Hydras occur in flowing and standing waters of varying salinities. They have been found at depths of up to 350 metres in lakes, in shallow water on the wave-swept shores of lakes, and also in shallow, fast-flowing streams, so they tolerate a wide range of conditions. They do not occur on soft surfaces as they generally attach themselves to solid surfaces like stones, twigs or vegetation.

Most Clavidae are marine, but *Cordylophora* occurs in standing and flowing inland waters, both fresh or saline. They have been found living in lakes with a salinity two-thirds that of seawater. *Cordylophora* can be found growing on twigs, sticks and leaves. They have even been found growing on the cases of trichopteran (caddis fly) larvae. Hydras and *Cordylophora* are both quite common in South Australia and have been found in many water bodies throughout the state.

Jellyfish are found in the open waters of both freshwater and saline lakes, but in South Australia they are not as common as the sessile cnidarians.

Critter facts

Hydras have excellent powers of regeneration after injury. If a hydra is cut into several sections, a new hydra will regenerate from each piece. In 1744, Abraham Trembley carried out an experiment where he inserted a knotted thread through the basal disc of a hydra and pulled it out of its mouth, turning the animal inside out. After a short time, the internal and external cells of the hydra migrated through the body wall and rearranged themselves. The hydra had turned itself 'outside in' and continued its life!

Freshwater jellyfish were first noticed by scientists near Adelaide in 1950. It is thought that one species has been introduced to Australia. Another genus, *Australomedusa*, has been found only in Australia. It was identified in two saline lakes in South Australia. Unlike some of the marine jellyfish, the freshwater jellyfish does not pose a hazard to swimmers.

Identification

The key starting on page 21 of *The Waterbug Book* should help you tell cnidarians from other animals and separate the three families from each other. Freshwater jellyfish are hard to mistake for other animals. Clavidae may be mistaken for small plants or algae due to their branching form.

Hydras may be mistaken for temnocephalids, which are flatworms from the phylum Platyhelminthes. Temnocephalids have a group of tentacle-like structures on their front end, but they are arranged in a row, rather than in a circle. Their bodies are also dorso-ventrally flattened, rather than tubular, and are bilaterally, rather than radially, symmetrical. Many temnocephalids have eyespots, which hydras lack.

Identification of cnidarians to genera and species is difficult and involves careful study with a microscope.

Classification and sensitivity

Phylum Cnidaria

- Order Hydrozoa (1)
  - Family Hydridae (2)
  - Family Clavidae (3)
  - Family Olindiidae (NR)

References

Hawking & Smith 1997, pp 8–10; Williams 1980, p 38; Gooderham & Tsyrlin 2002, p 6.

4 Phylum Platyhelminthes—flatworms, planarians and temnocephalids

4.1 Class Turbellaria-flatworms and planarians

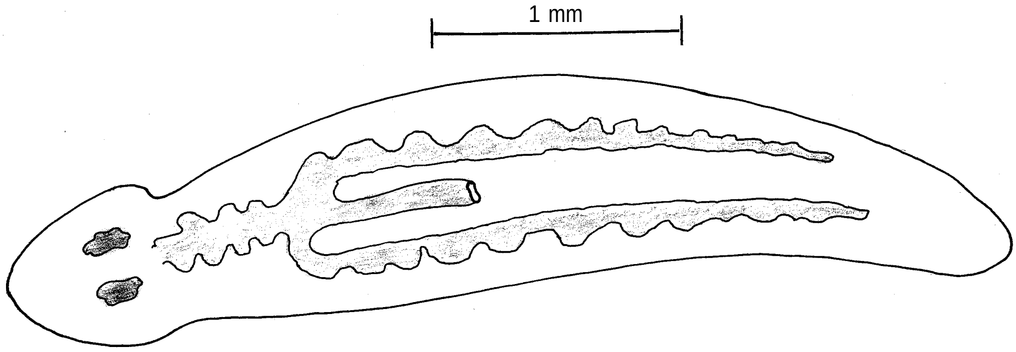
Background

There are three classes of Platyhelminthes: Turbellaria, Temnocephalidea and Trematoda, all with some members in fresh water. Platyhelminth fossils are reported from the Palaeocene epoch of the Caenozoic era, nearly 65 million years ago.

Turbellarians are free-living and are among the simplest and most ancient bilaterally symmetrical organisms. There are approximately 3000 species of Turbellaria worldwide. Most are marine, but there are also freshwater and terrestrial species. In Australia, Tricladida is the only order of Turbellaria with freshwater representatives. These are commonly known as planarians and eight species are recorded. Due to the difficulty of identifying planarians past class, the number of species of Turbellaria in South Australia is not known. Planarians are, however, quite common in South Australia and can be found in most water bodies throughout the state.

Members of the class Temnocephalidea are ectocommensal with other animals. They are discussed in the next section.

The class Trematoda has only one well known representative in freshwater systems in South Australia. This is the species known as the sheep liver fluke. One of its microscopic larval stages may be found in water bodies that contain a particular species of gastropod snail in which it lives, while other life stages are terrestrial or parasitic in mammals, particularly sheep. Other trematode species have been found in freshwater snails in South Australia, but are rarely collected. Their adult stages probably infect birds.



Dorsal view of a Turbellaria

Size

In South Australia, planarians range from very small to about 30 mm long. Preserved animals may not be much more than 10 mm in length because they contract after death. In Siberia's Lake Baikal, the largest freshwater lake in the world, one species of triclad flatworm grows to 60 cm long.

Features

Most planarians found in South Australia are elongate, flat, soft-bodied animals. Most commonly they are brown or grey, but they can also be red, green, white or transparent. They usually have two pigmented eyespots on the head. Their small brain consists of two lobes of nerve cells from which two nerve cords extend along the body. All planarians have a blind gut that opens to a ventral mouth partway along the body. Many have a muscular tube, called a 'pharynx', which they use for feeding. In some animals, the pharynx can extend to up to half the length of the body. Planarians have primitive excretory organs that aid in regulation of body fluid concentration. Nitrogenous waste passes out through the surface of their bodies.

Diet and feeding

The diet of planarians includes soft or decomposing animal matter, against which they press their bodies when feeding. They also prey on small animals such as crustaceans, worms and hydras. They entrap prey, wrapping their body around it, and immobilising it with sticky mucus. Small food particles are swallowed whole. Larger food particles can be partially digested externally by enzymes, then the muscular pharynx is used to break down the food and suck it into the gut. Cannibalism has been recorded among planarians kept in laboratory cultures.

Planarians have a 'blind' gut so they must both ingest food and expel waste through their mouths. They can live for months without food by metabolising their body tissue, which causes the body to shrink in size.

Locomotion

Most planarians are unable to swim; instead, using the tiny hair-like cilia that cover the body, they glide over surfaces. Some use muscular contractions of the body to move. They are very flexible and can expand and contract their bodies in a leech-like manner.

Gas exchange (breathing)

Due to their small body size and large surface area, planarians can obtain oxygen directly from the water by diffusion. Oxygen is transported around the body by diffusion, and similarly, some types of waste are eliminated from the body by diffusion.

Life cycle and reproduction

Most planarians are hermaphroditic. However, they rarely self-fertilise: sexual reproduction between a mating pair is usually achieved through reciprocal copulation, where each flatworm releases sperm into the other. External female reproductive openings are absent from some species and, in such cases, the penis acts as a hypodermic syringe, piercing the body wall of the mate and injecting sperm directly into the body tissue. The sperm then make their way to the eggs and fertilise them. Two kinds of eggs can be produced: thin-shelled ones that hatch quickly (within a few weeks), and thick-shelled resting eggs that are resistant to desiccation. These resting eggs allow a planarian population to survive during dry conditions, which is an important consideration in much of South Australia. Sexual reproduction usually occurs during autumn.

In some species, a larva is produced. This larva swims about for a few days using long cilia and then settles to the bottom to become a flatworm. Other species do not have larvae and the newly hatched young resemble their parents.

Several types of asexual reproduction also occur. Parthenogenesis-the development of an egg without fertilisation-is common. Reproduction can also occur by 'transverse fission', a type of splitting of a single animal to create two new ones. The planarian body pinches in around the middle until the posterior end clings to the ground. The anterior end then pulls until the body splits. The anterior segment grows a new 'tail' and the posterior grows a new head.

Water temperature may influence the rate of asexual and sexual reproduction, but some species only reproduce one way or the other. Asexual reproduction usually occurs during summer. One species of Turbellaria is known to reproduce asexually only at night. During the day, the brain in this species produces a substance that inhibits asexual reproduction. Flatworm life span is uncertain, but in captivity members of one species lived from 65 to 140 days.

Habitat

Planarians have been found in many different types of water bodies-dams, ponds, rivers and streams, and fresh and saline waters. They have been found in salinities up to one-third seawater and at depths of up to 100 metres. Planarians glide over the substrate and sometimes move along the underside of the surface film of the water. They can be found on hard and soft substrates, but are more common on harder, rocky surfaces. They actively avoid strong light, preferring to cling to the underside of stones and sticks. They are sensitive to organic pollution, preferring waters with moderate nutrient levels.

Critter facts

Flatworms have a range of interesting lifestyles. One ectocommensal flatworm, for example, lives in the armpits of freshwater turtles in New South Wales. Some species of planarian can eat hydras without setting off the nematocysts, or stinging cells. Within 20 hours of ingestion, these stinging cells move to the surface of the flatworm's body, where they are used by the flatworm for its own protection.

Identification

The key starting on page 21 of *The Waterbug Book* should help you tell Platyhelminthes from other animals. Planarians might be mistaken for leeches (order Hirudinea), but leeches have segmented bodies while planarians have elongate, unsegmented bodies. When alive, they can be seen gliding over surfaces or on the underside of the surface water film. Planarians generally contract strongly when preserved and often lose their characteristic dorso-ventrally flattened shape.

Temnocephalids are distinctly different from other platyhelminthes as they have characteristic finger-like projections. Identification of platyhelminthes to order, genus or species requires examination of internal features, such as the structure of the gut.

Classification and sensitivity

Phylum Platyhelminthes

- Class Turbellaria (2)
  - Order Tricladida (NR)
  - Order Rhabdocoela (NR)
  - Order Allocoela (NR)
- Class Temnocephalidea (5)

References

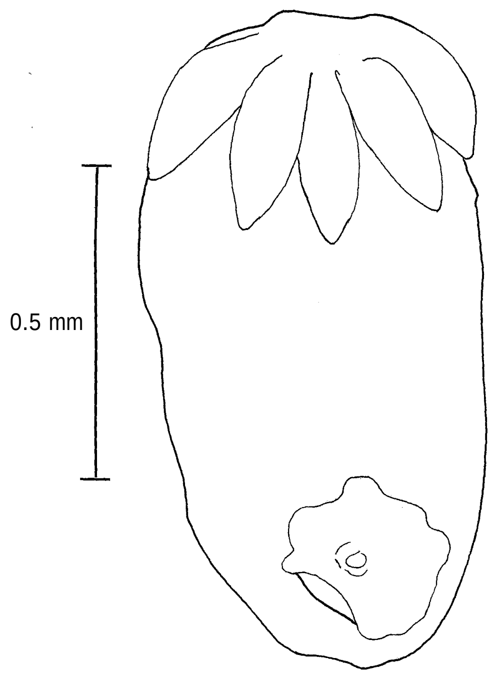
Hawking & Smith 1997, pp 11-12; Williams 1980, p 50; Gooderham & Tsyrlin 2002, pp 38-39.

4.2 Class Temnocephalidea-temnocephalids

Background

The taxonomic classification of Temnocephalidea has varied considerably since their discovery in Chile in 1846. Temnocephalids have been considered a separate class, an order of the class Turbellaria, and even a suborder within the class Turbellaria. We follow Hawking and Smith (1997, p 13) who list Temnocephalidea as a class.

Temnocephalids can be found throughout the world. Three genera and 15 species of Temnocephalidea are known to occur in Australia. The identification of these animals past class is difficult and the number of species present in South Australian waters is unknown. Platyhelminth fossils date back to the Caenozoic era, nearly 65 million years ago.



Ventral view of a Temnocephalid

Size

Temnocephalids are quite small, usually from 1 to 5 mm long, but some can grow up to 12 mm.

Features

Temnocephalids have flattened soft bodies. They are bilaterally symmetrical, have an adhesive disc on one end of the body, and have a row of 2-6 finger-like tentacles on the other end. Many temnocephalids have eyespots.

Temnocephalids are ‘ectocommensal’, which means that they live in association with another organism without harming it. They usually live inside or attached to crustaceans, such as yabbies and freshwater prawns.

Diet and feeding

Temnocephalids are predators of small organisms including crustaceans, nematodes, insect larvae and rotifers. Some species can consume animals greater than their size. Some species are cannibalistic. One species feeds on algae. Temnocephalids are able to survive for long periods without food.

Locomotion

Temnocephalids are not very good swimmers and move in a leech-like manner using the posterior sucker and anterior tentacles. Most of their time is spent attached to a substrate of some sort, either an animal host or a stable substrate such as rocks in the water body.

Gas exchange (breathing)

Temnocephalids obtain oxygen directly from the water by diffusion through their body surfaces.

Life cycle and reproduction

Temnocephalid individuals have both male and female reproductive organs. The structure of their reproductive systems allows for self-fertilisation, but it is believed that cross-fertilisation usually occurs. Eggs, in a resistant capsule, are attached to the crustacean host and hatch directly into small temnocephalids. They are able to live for up to two years, even when separated from their hosts.

Habitat

Temnocephalids have been found in still and flowing waters where the hosts occur. Studies have shown that their presence on crayfish may reduce the crayfishes' resistance to disease. They are commonly found in South Australian inland waters.

Critter facts

Although temnocephalids usually do not harm their host, they can make it hard for a crayfish to obtain oxygen if large numbers build up in the branchial chambers. Eggs laid on the shells of crayfish may reduce the market value of aquaculture stocks, due to their appearance.

Identification

Temnocephalids may be mistaken for turbellarians, although temnocephalids have tentacles. They most strongly resemble hydras, but most temnocephalids have eyes and are flattened, while hydras are eyeless and tubular.

Classification and sensitivity

Phylum Platyhelminthes

Class Temnocephalidea (5)

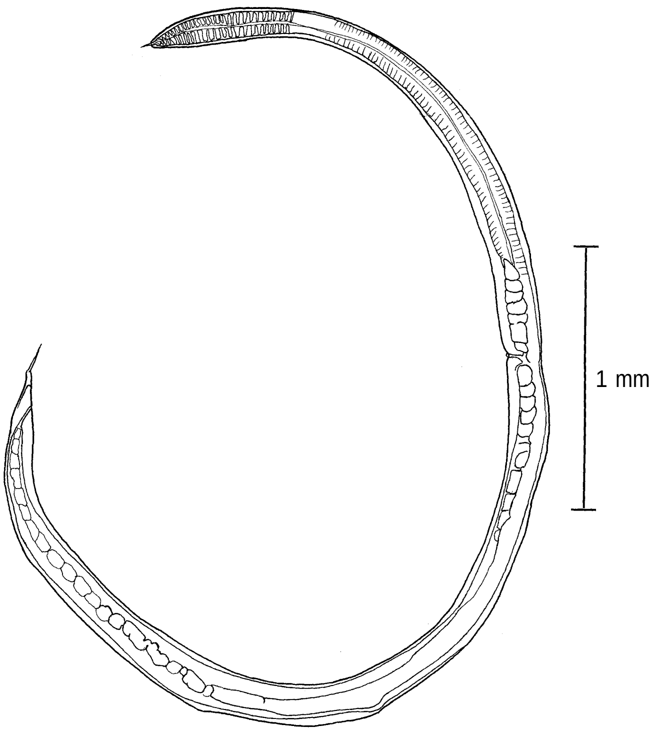
References

Hawking & Smith 1997, p 13; Williams 1980, p 46; Gooderham & Tsyrlin 2002, p 40.

5 Phylum Nematoda—round worms

Background

There are about 12,000 described species of Nematoda worldwide, but probably many more unrecognised species. Nematodes may be the most widespread and numerous of all multicellular animals. Many species are parasites of plants or animals, but free-living forms are common in inland waters, and in marine and terrestrial environments. They are found from the highest mountains to the deepest oceans and from hot deserts to the polar regions. In soil, they have been found in densities as high as 4,420,000 per square metre. Up to seventeen orders of Nematoda may be found in inland waters in Australia. The number of species in inland waters of South Australia is unknown and they are very difficult to identify beyond phylum level. Nematode fossils date back to the Carboniferous period, around 300 million years ago.



An unidentified species of Nematode

Size

Nematodes range in size from microscopic to 50 mm long. Many species of nematode slip through the mesh on sweep nets because of their small size.

Features

Nematodes are thin, elongate, unsegmented worms, cylindrical in cross-section. The posterior end of a nematode tapers to a point. The mouth is located at the very tip of one end and is surrounded by sensory buds. Sometimes, with the use of a dissecting microscope, the internal structures of the nematode can be seen.

Diet and feeding

Nematodes feed on a variety of organic matter, both dead and alive. They detect food using the sensory buds around the mouth. Many feed on fungi and bacteria. Others feed on plants by piercing the stem or root and sucking out the contents; these nematodes extrude a sharp spear-like object from their mouths and insert it into the plant. Still others are active predators feeding on small animals or even on other nematodes. Carnivorous nematodes may have teeth inside their mouths, or may have a long spear-like structure, similar to that of the plant-feeding nematodes. Prey are stabbed with the spear-like structure and juices are then sucked out.

Locomotion

Nematodes move through sediments with a thrashing, snake-like motion. They are not good swimmers and, when floating in water, whip their bodies around in an ineffective way. Their body movements are more effective when they are moving against sediment.

Gas exchange (breathing)

Nematodes exchange gases across their body surface by diffusion. Many species tolerate low concentrations of oxygen and can even remain active in anaerobic conditions for weeks at a time.

Life cycle and reproduction

Nematodes usually reproduce sexually, having separate sexes, but some species are hermaphroditic and others reproduce parthenogenetically. Some female nematodes produce pheromones to attract males when they are ready to mate. During sexual reproduction, the eggs are fertilised within the body of the female, where they are stored until she is ready to deposit them. Sometimes embryonic development can begin before the eggs are deposited. Most nematodes lay eggs, but some give birth to live young. Nematodes are also able to produce eggs that survive through dry conditions. Upon return of water and favourable conditions, the juveniles hatch from the eggs. Juvenile nematodes moult four times before reaching adulthood. Life cycle length of nematodes ranges from less than two days to over a year.

Habitat

Nematodes generally live in the interstitial spaces in aquatic sediments or on the sediment surface. They can be found in a variety of water types, from fresh to saline waters and from unpolluted to organically enriched waters. They are found in almost all water bodies throughout South Australia. The juveniles of one family of Nematoda, Mermithidae, parasitise invertebrates including aquatic species but, as adults, are free-living in soil or water.

Critter facts

When some species of Nematoda face unfavourable conditions, such as dehydration, they enter a state of hibernation, called 'cryptobiosis', which means 'hidden life'. Animals undergoing cryptobiosis appear dead but can revive when conditions become more favourable. They can remain in this state for months or years; some have even recovered from this state after a century. Animals undergoing cryptobiosis dehydrate slowly so that the moisture content of the body drops to less than one per cent. Water is replaced by two chemicals-glycerol and trehalose-and the internal structure of the animal is preserved in a crystalline-like form. Metabolism is 10,000 times lower than usual and can even stop completely. Animals in this state have been exposed to temperatures as low as -273°C (just above absolute zero) to 150°C and have subsequently revived.

Nematode parasites of animals (including humans) are responsible for many diseases worldwide. *Loa loa* is an African eye worm that moves about in the tissues of humans and baboons. It sometimes crosses the eyeball, hence the name. Other nematodes cause 'elephantiasis', which is an enlargement of limbs, in humans. Severe cases of this disease are no longer common. The well-known heart worm is a nematode that affects dogs, wolves and foxes. These nematodes are transmitted by mosquitoes.

Identification

Nematodes are often overlooked because of their small size; they may even be mistaken for plant roots, but it is possible to see live nematodes unaided, as they swim through the water. The key starting on page 21 of *The Waterbug Book* should help you tell nematodes from other animals. They are generally long, colourless, translucent and shiny. With the bigger nematodes, some of the texture of internal structures can be seen through the outer layers of the body.

Identifying nematodes past phylum level requires a microscope to view the internal structures. This job is best left to specialists.

Classification and sensitivity

Phylum Nematoda (3)

References

Hawking & Smith 1997, p 15; Williams 1980, p 55; Gooderham & Tsyrlin 2002, p 36.

6 Phylum Annelida—bristle worms, segmented worms and leeches

Background

Annelids can be found in marine, freshwater and terrestrial environments. Over 8700 species have been described worldwide. These are divided into three main classes: Oligochaeta (segmented worms), Polychaeta (bristle worms) and Hirudinea (leeches). All are found in inland waters of Australia. In South Australian inland waters, there are at least 35 species of Oligochaeta and four known species for each of Hirudinea and Polychaeta. Ancestral annelids were probably marine animals that burrowed into the sand and mud of shallow coastal waters. Annelid fossils date back to the Cambrian period, around 550 million years ago.

Oligochaeta and Hirudinea are discussed in further detail in their individual sections below.

Size

Annelids range in size from 2 to 100 mm in unextended form. Polychaetes range from 2 to 30 mm and oligochaetes can reach 100 mm. Leeches, when stretched out, can reach a length of 200 mm.

Features

Annelids are often elongate, always segmented, and lack jointed appendages. Their gut, unlike that of Platyhelminthes, is tubular and has a separate mouth and anus. The body is soft and can be covered by hairs (in the case of Oligochaeta) or have suckers on the front and rear of the animal (in the case of leeches). Polychaetes are very distinctive animals with outgrowths on their sides, present on each segment along the entire length of the body.

Diet and feeding

Annelids feed on bacteria, organic matter and body fluids from animals such as fish, birds, frogs, and even humans. Some polychaetes are filter-feeders and others are known to be predators.

Locomotion

Annelids move through the water by undulating movements of their bodies. However, they spend more time crawling on or burrowing into the bottom than they do swimming in the water.

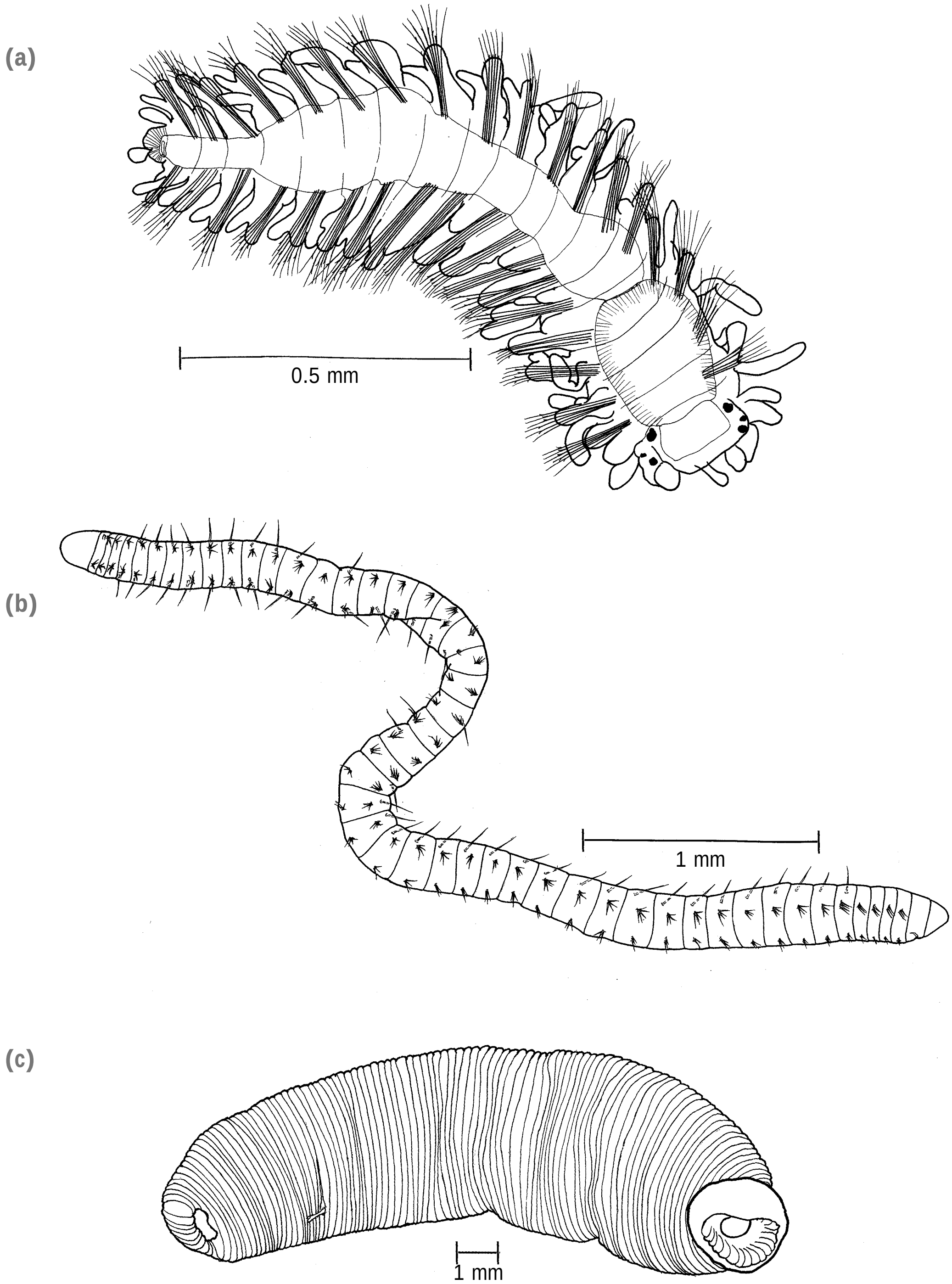
Gas exchange (breathing)

Gas exchange occurs by diffusion across the body surface of the animal.

Life cycle and reproduction

Annelids are hermaphroditic; some are able to reproduce both sexually and asexually. Oligochaetes can reproduce asexually by budding, or sexually by mating with another mature worm. The fertilised eggs will develop into free-swimming larvae. In the case of leeches, the eggs are carried around by the adult who protects them until the young hatch and are able to fend for themselves. The young are very similar in appearance to the adults.

Phylum Annelida—bristle worms, segmented worms and leeches



Members of the phylum Annelida including:

(a) a polychaete specimen from the family Syllidae

(b) a species of Oligochaete and

(c) a leech from the family Richardsonianidae

Habitat

Polychaetes are mainly marine, but a few species have been found in inland waters such as the Broughton River; they are often found in the estuarine sections of rivers and streams. Oligochaetes are found in just about every water body in South Australia; they are tolerant of polluted waters and can withstand high salinity levels. Leeches can usually be found in still water bodies, but sometimes occur in flowing water.

Critter facts

One of the distinctive traits of an annelid is that the body comprises many segments, or rings. In fact, the word 'Annelida' means 'little ring' in Latin.

Identification

The key starting on page 21 of *The Waterbug Book* should help you tell the different annelids from each other and distinguish them from other animals. Oligochaetes vary in appearance from small chubby-looking animals to very thin, elongate animals. They may be mistaken for nematodes but, unlike nematodes, have segmented bodies. They also have hairs (either short or long) on their body, which can be seen more easily on the larger worms.

Polychaetes are very easily recognised by the processes on the sides of their body. Leeches are quite easily distinguishable by the large circular sucker they have at one end. Some of the larger ones have stripes down their back.

Classification and sensitivity

Phylum Annelida

- Class Polychaeta (1)
- Class Hirudinea (1)
- Class Oligochaeta (2)

References

Hawking & Smith 1997, pp 18-23; Williams 1980, p 97; Gooderham & Tsyrlin 2002, pp 41-45.

6.1 Class Oligochaeta—segmented worms

Background

Aquatic oligochaetes are closely related, and quite similar, to earthworms. There are over 3100 species of terrestrial, marine and freshwater oligochaetes worldwide. Ten families of freshwater oligochaetes occur in Australia, represented by over 90 species. In South Australia, there are at least 35 known species. Fossilised burrows believed to have been constructed by worms date back to the Precambrian era, 600 million years ago. Fossils of the worms themselves are rare because of their soft bodies.

Size

Aquatic oligochaetes can range in length from less than 0.5 mm to 100 mm.

Features

Freshwater oligochaetes are thin, elongate, cylindrical animals. They vary in colour from white, yellow, pink, red, green to brown, but sometimes are colourless and translucent. Their bodies are composed of segments: an oligochaete can have as few as seven or as many as 500 segments. They also have bundles of ‘setae’, which are stiff hair-like structures, located on the top and bottom of each of the body segments; the setae provide important characteristics for the identifications to family, genus and species levels. Some oligochaetes have eyes, some have gills on the end of the body, and some have a proboscis-a trunk-like projection used for feeding.

Diet and feeding

Oligochaetes are generally detritivores, feeding on organic material and bacteria in aquatic sediments. Some are grazers and pick up food particles by protruding their pharynx onto the food and then retracting the pharynx with the attached food particle back into the body. A few species eat algae or are carnivorous.

Locomotion

Some oligochaetes swim with an undulating movement, but most crawl on the surface of aquatic substrates or burrow into them. When crawling or burrowing, oligochaetes use a combination of muscle contractions and anchoring of parts of their bodies with their setae to generate peristaltic movements and propel themselves forward. One species of worm attaches itself to the foot of snails and travels with the snail.

Gas exchange (breathing)

Oligochaetes generally exchange gases by diffusion across their skin. Some species have external gills, and others can pump water through the anus into the posterior part of the gut to aid gas exchange. The red colour of some segmented worms is caused by erythrocruorin, a respiratory pigment that aids oxygen uptake.

Life cycle and reproduction

Some oligochaetes reproduce asexually by budding from a special segment near the posterior end of their bodies, but most reproduce sexually. All oligochaetes are hermaphrodites and they generally reproduce with a partner, although some can self-fertilise. When mating, a pair of worms will exchange sperm. These sperm are stored and later released, with the eggs, into a cocoon. After reproduction, the worms will usually revert to a non-reproductive stage during which they lack reproductive organs. Juvenile oligochaetes are very similar in appearance to the adults. Breeding can occur throughout the year and some species reproduce only once. For aquatic worms, the entire life cycle occurs in the water.

Habitat

Oligochaetes live in virtually all water bodies, often associated with the sediment. Some even build tubes in the sediment. There is one species that prefers saline inland waters. Abundance of a variety of oligochaetes can indicate good water quality, although some species are very tolerant of polluted waters. Aquatic worms can be found in almost every water body in South Australia.

Critter facts: Oligochaetes can tolerate very low oxygen concentrations. They are often found in large numbers at sites with organic pollution, such as locations where sewage is discharged. It is believed that the first record of oligochaetes in polluted water was made by Aristotle, who lived between 384-322 BC. He described red threads protruding from putrefying mud at the edges of rivers.

Giant earthworms exist in Australia and other parts of the world. These worms can exceed 3 m in length.

Identification

The key starting on page 21 of *The Waterbug Book* should help you distinguish oligochaetes from other animals. They have soft, elongate, segmented bodies and may occasionally be mistaken for plant roots.

Aquatic worms look very similar to earthworms, although they are often smaller. It may be impossible to tell an aquatic oligochaete from an earthworm without a microscope. Even if you are certain you have an aquatic oligochaete, identification beyond class level is difficult as it requires microscopic scrutiny of the hairs on the body of the animal and sometimes examination of the internal features.

Classification and sensitivity

Phylum Annelida

Class Oligochaeta (2)

References

Hawking & Smith 1997, p 19; Williams 1980, p 99; Gooderham & Tsyrlin 2002, pp 44-45.

6.2 Class Hirudinea-leeches

Background

Over 500 species of leeches occur throughout the world, except in Antarctica. They can be found in marine, estuarine and fresh waters and some are also terrestrial. Five families and 27 species of Hirudinea are known from Australia. At least four species occur in South Australia.

Size

Fully grown Australian leeches range from 7 to 200 mm long, although their length can depend on how extended or contracted they are, or how full of blood they are. Juveniles can be as small as 2 mm. A giant leech found in the Amazon region of South America can reach a length of 300 mm.

Features

The bodies of all leeches have 34 segments, but they may appear to have more because many exhibit secondary segmentation. They have suckers at the anterior and posterior ends of the body. The sucker at the posterior end is usually larger and more obvious than the anterior sucker. Body shapes vary and include flattened or cylindrical as well as leaf, worm or pear shapes. Some leeches are brightly coloured with yellow or orange stripes, others have a more drab appearance and are brown, white or green. Many leeches have several eyes and the arrangement of these can be useful for identification.

Diet and feeding

The best-known leeches feed on the body fluids of other animals. They seek out prey by sensing chemicals (smells) and movement. Hosts include snails, frogs, fish, turtles, birds and mammals, including humans. Most leeches will feed on a few different types of animals but some specialise on one kind of host. One species of leech attaches itself to the outer corner of the eye of some waterbirds. Some leeches even steal: they suck blood meals from other leeches, often killing them in the process. Many leeches are predators on other aquatic invertebrates, eating them in the normal manner rather than by sucking their blood.

Locomotion

Leeches move over surfaces by anchoring their posterior sucker on the ground, reaching forward and anchoring their anterior sucker, then moving their posterior segment forward, next to the anterior one and so on, to loop along. Some leeches swim strongly through the water using undulating movements, others cannot swim. Most leeches are more active at night than during the day.

Gas exchange (breathing)

Leeches exchange gases across their skin by diffusion. They have a complex system of heart tubes that enable blood to be pumped all over the body. These heart tubes have valves and sphincters that prevent back flow of blood. Some leeches have gills in the form of extensions on the sides of the body. These gills act as accessory respiratory organs. When oxygen concentrations are low, some leeches undulate the body to improve oxygen uptake. Leeches from the family Glossiphoniidae ventilate their cocoons and develop young in this way to ensure that they have enough oxygen.

Life cycle and reproduction

Leeches are hermaphroditic and generally cross fertilise with another leech. In some species, direct internal fertilisation takes place, while in others, the sperm are placed on the surface of a special segment and then burrow through the flesh to the eggs. Some leeches carry their eggs around; others place them in a cocoon and attach it to various substrates. On hatching, the young look very similar in appearance to the adults. The entire life cycle occurs in the water.

Habitat

Leeches can be found in standing and flowing waters and they can cope with a range of salinities, oxygen concentrations and temperatures. They are probably more common in still waters where plants, stones and debris provide shelter. They can survive in temporary waters by burrowing into the sediment and constructing a mucus-lined cell where they lie dormant during dry periods. Leeches occur throughout South Australia.

Critter facts

Blood-feeding leeches have anaesthetic, anticoagulant saliva. The anaesthetic stops the prey from feeling the bite and the anticoagulant stops the blood from clotting. (You usually only notice that you have been attacked by a leech after it has fed fully and dropped off!) The weight of a leech can increase five times following a blood meal. Some species can live for more than two years between blood meals. Blood-sucking leeches have been used to help treat circulatory diseases and to reduce bruising after reconstructive plastic surgery.

Leeches have specialised tissues that can act as both liver and kidney. These tissues function in lipid metabolism, oxidation, detoxification, and the storage of lipids and pigments from the blood that they ingest.

Identification

Some leeches may be confused with oligochaetes, but leeches have a very obvious posterior sucker that is not present in oligochaetes. Specialists identify leeches to family level using characters such as arrangement of the eyespots.

Classification and sensitivity

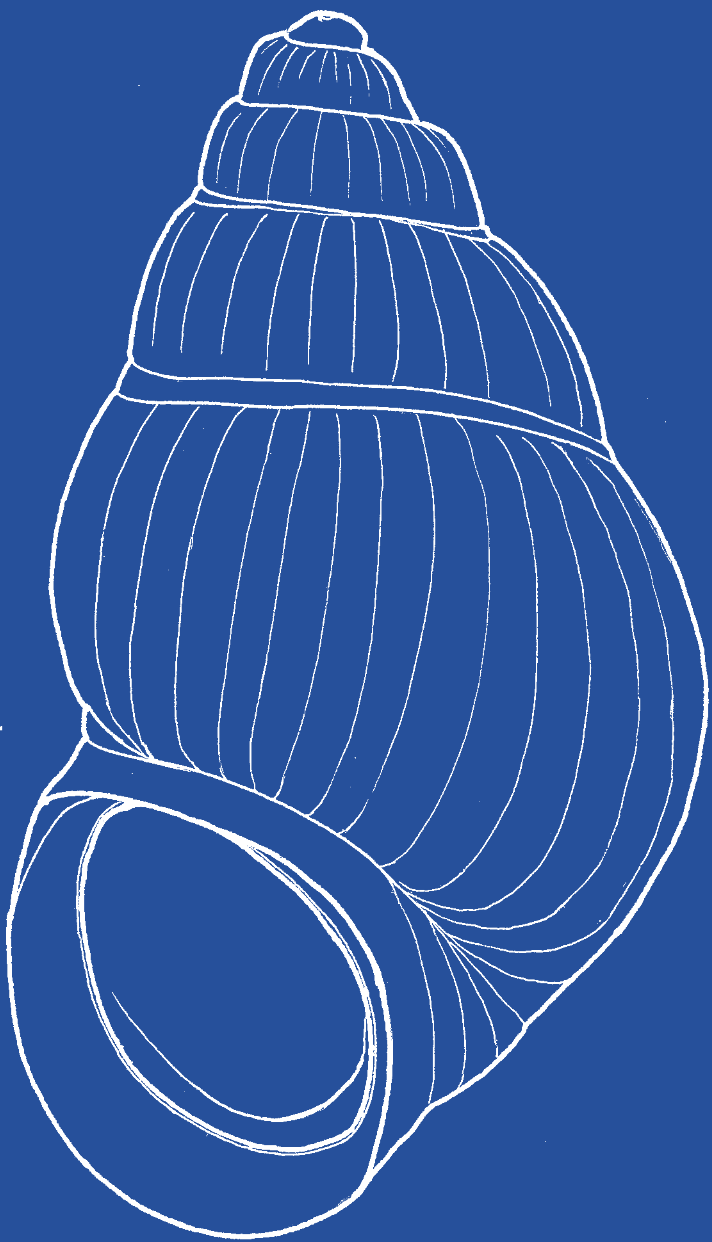
Phylum Annelida

Class Hirudinea (1)

References

Hawking & Smith 1997, pp 22-23; Williams 1980, p 104; Gooderham & Tsyrlin 2002, pp 41-43.

Snails, mussels, pea shells and basket shells



7 Phylum Mollusca—molluscs

Background

Over 100,000 species of Mollusca are described worldwide. In terms of its high number of species, Mollusca is second only to the phylum Arthropoda. Seven classes of living (extant) Mollusca are generally recognised, but only two have freshwater representatives in Australia-Gastropoda (snails) and Bivalvia (bivalves). These are discussed in more detail in individual sections below. The other five classes are marine and terrestrial. There are 15 aquatic families of gastropod and bivalve molluscs Australia-wide. Twelve families, with 40 species in total, are present in inland waters of South Australia. Molluscs are well represented in the fossil record due to their hard shells. They first appear in the Lower Cambrian period, over 500 million years ago.

Size

Molluscs range in size from very small, immature animals about 1 mm long to large freshwater mussels that can reach 150 mm long.

Features

Each mollusc has a single large foot and a soft body that is usually housed in a calcareous shell. Many have a hard, file-like feeding organ called a 'radula'. The shape and colour of mollusc shells can vary greatly. Gastropods have either a coiled or limpet-shaped shell. Bivalves have two shells that are hinged together at the rear of the animal.

Diet and feeding

Bivalves use a complex gill structure to filter the water and remove food particles, mainly microscopic plankton. Most gastropods are grazers and feed on algae and plant material.

Locomotion

Both gastropods and bivalves move along the substrate by using their muscular feet, sometimes leaving a mucous trail behind them. The mucus acts as a deterrent against predators. Bivalves do not move very often and generally bury themselves partially in the sediment.

Gas exchange (breathing)

To obtain oxygen, bivalves open their shells slightly and, using their complex gill structure, create currents that move water over the gills. Gastropods obtain oxygen either by using gills or by using the mantle cavity as a lung-like structure.

Life cycle and reproduction

The reproductive methods of molluscs are quite varied. Some species of mollusc are hermaphroditic, while others have separate sexes. Some females reproduce through parthenogenesis, others mate with male molluscs. Some molluscs bear live young, others produce eggs. The eggs of some molluscs are laid in gelatinous coatings on water plants, rocks or logs, while in others, including all bivalves, the young develop within the body of the adult. The entire life cycle is aquatic. Some gastropods can live up to 30 years.

Habitat

Molluscs can be found in most inland water bodies, including fresh, saline, flowing, standing and temporary waters. They can be found attached to stable substrates such as rocks, logs and leaves of aquatic plants. Some bury themselves in the sediment. Molluscs are common throughout South Australia.

Critter facts

Squid, octopus and cuttlefish are also molluscs, but their shells are reduced to internal deposits of calcium.

Identification

Freshwater molluscs can be recognised easily by the shapes of their shells. Gastropods have either a coiled or a limpet-shaped shell and bivalves have two shells that are joined together by a hinge-like structure. Further identification is usually based on shell features. See page 40 of *The Waterbug Book* for a key to the families of molluscs.

Classification and sensitivity

Phylum Mollusca

- Class Gastropoda (1)
- Class Bivalvia (3)

References

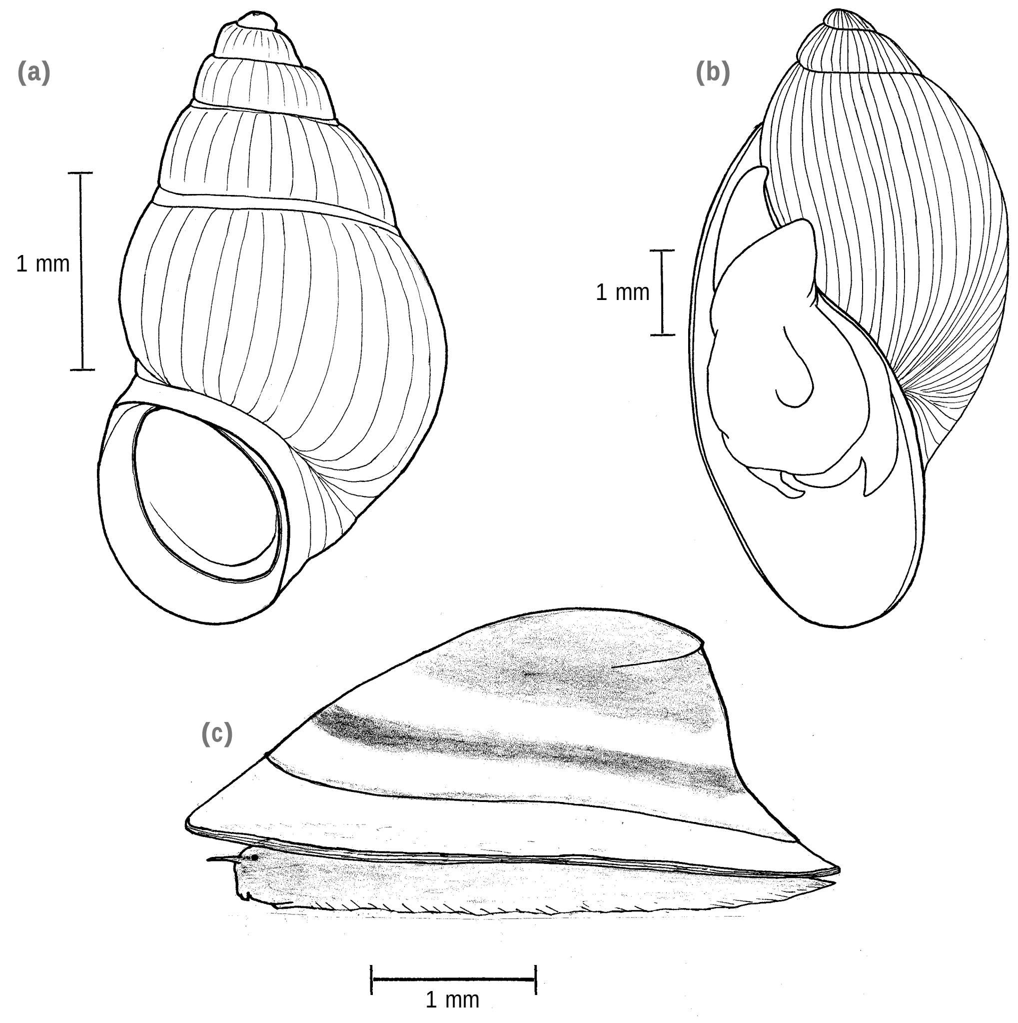
Hawking & Smith 1997, pp 24-39; Williams 1980, p 78; Gooderham & Tsyrlin 2002, pp 46-58.

7.1 Class Gastropoda-water snails

Background

About 35,000 species of gastropod have been described worldwide, among them terrestrial, marine, estuarine and freshwater species. In addition, around 15,000 fossil forms date back to the Cambrian period, over 515 million years ago. Twelve families and 203 species are known from inland waters of Australia. Eight families occur in South Australia.

Gastropoda can be divided into two subclasses: the Pulmonata (which includes the families Lymnaeidae, Ancylidae, Planorbidae and Physidae) and the Prosobranchia (which includes the families Viviparidae, Thiaridae, Hydrobiidae and Pomatiopsidae). Most of the families of gastropods found in South Australia are also present in other parts of the world.



The gastropods:

(a) *Angrobia* sp. (family Hydrobiidae)

(b) *Glyptophysa concinna* (family Planorbidae) and

(c) the freshwater limpet *Ferrissia* sp.

Size

Gastropods range in size from very small-less than 1 mm-to 65 mm in diameter, depending on the species and age of the snail.

Features

Freshwater snails can have a coiled or a limpet-like shell, which protects a soft body. A number of shell features help classify Gastropoda, such as whether they have an operculum-the hardened door to the opening of the shell-and whether the shell has a left- or right-handed spiral. The shape and decoration of the shell can also be important. Some shells are highly sculptured. Members of the subclass Prosobranchia have an operculum, while Pulmonata lack this feature.

Diet and feeding

Most freshwater snails are herbivorous and feed on vascular plants, decaying vegetation and algae. They use their radula to rasp away plant tissue and to scrape algae from the surfaces of rocks, plants and other substrates. The radula is a file-like structure made of chitin and has a numerous teeth.

Locomotion

Gastropods glide along surfaces of rocks, logs and plants using waves of muscular contractions in their feet. They secrete mucus onto their feet to make travel easier. It is thought that the mucus decreases the friction between the foot and the surface along which they are moving; it also acts as a deterrent to predators.

Gas exchange (breathing)

Gastropods respire by two different methods. Prosobranch snails have gills inside their water-filled mantle cavity and gas exchange occurs across the gill surface. Ventilation of the respiratory surface occurs as water is drawn into the mantle cavity at the front of the body by currents created by movement of tiny hairs on the gills. Some snails have haemocyanin in their blood, which aids oxygen uptake.

Pulmonate snails, as the name implies, have a respiratory system that functions in a similar way to a lung. Instead of passing water through the mantle cavity, they hold air inside it. The mantle cavity is richly supplied with blood vessels.

Most pulmonate snails regularly come to the surface to refresh their air supplies, some species do not need to do this. Such snails have hairs that are used to ventilate the respiratory surface. These hairs are also used for locomotion.

The pulmonate order Basommatophora are able to survive in waters with low dissolved-oxygen levels. To obtain air, they hang upside down in the water, with the foot just touching the water surface. They ventilate their mantle cavity by arching and flattening the body.

Life cycle and reproduction

Some species are hermaphroditic, but most have separate sexes. However, some species seem to have only females and reproduce by parthenogenesis.

Most gastropods lay eggs that are contained in a gelatinous coating, which is thought to protect the eggs from bacteria and fungi. The egg mass is attached to water plants, twigs or logs. On hatching, the young resemble the adult in some ways. However, the shell is softer than that of the adult and the juveniles have a very small, squat shell rather than an elongate spire. Some gastropod species give birth to live young.

Habitat

All types of water bodies, including fresh, saline, flowing and standing waters, contain gastropods. They can be found attached to stable substrates such as rocks, logs and leaves of aquatic plants. Many live in temporary waters and have adaptations that enable them to withstand desiccation. When the water body dries up, they seal off the opening of their shell until conditions become more favourable. Species with opercula withdraw into their shells and close their 'doors'. Species without opercula seal the shell opening by secreting calcified mucous plugs. Some arid zone species can survive without water like this for up to two years. Pulmonate molluscs are able to tolerate waters with low levels of dissolved oxygen. One particular family of gastropods prefers saline inland waters.

Critter facts

The two most common freshwater snails in South Australia are introduced species: the physid snail, *Physa acuta*, and the hydrobiid snail, *Potamopyrgus antipodarum*. These snails can be found throughout South Australia, except in the far north region of the state.

Some species of Gastropoda act as the intermediate host for flukes-parasitic platyhelminths-including the sheep liver fluke.

One species of viviparid snail that inhabits the River Murray was thought to be extinct until it was found in the early 1990s in irrigation pipelines. It was a pest in these pipes, the vast accumulation of shells blocking irrigation equipment. It seems to have disappeared again, perhaps due to measures taken to clear snails from the pipes.

Identification

Snails have a variety of shell shapes-tall spires, limpet or dome shapes, or flat coils without a spire. The limpet-shaped snails of the genus Ferrissia are easily recognisable as they resemble marine limpets. Gastropods can have very thin to thick, highly calcified shells and can be coiled either to the left or the right. Sometimes empty shells are found, and often these can still be identified from shell characteristics. See page 40 of *The Waterbug Book* for a key to the families of gastropods.

Classification and sensitivity

Phylum: Mollusca
- Class Gastropoda (1)
  - Order Architaenioglossa
    - Family Viviparidae (4)
  - Order Neotaenioglossa
    - Family Thiaridae (4)
    - Family Hydrobiidae (4)
    - Family Pomatiopsidae (1)
  - Order Basommatophora
    - Family Lymnaeidae (1)
    - Family Ancylidae (4)
    - Family Planorbidae (2)
    - Family Physidae (1)

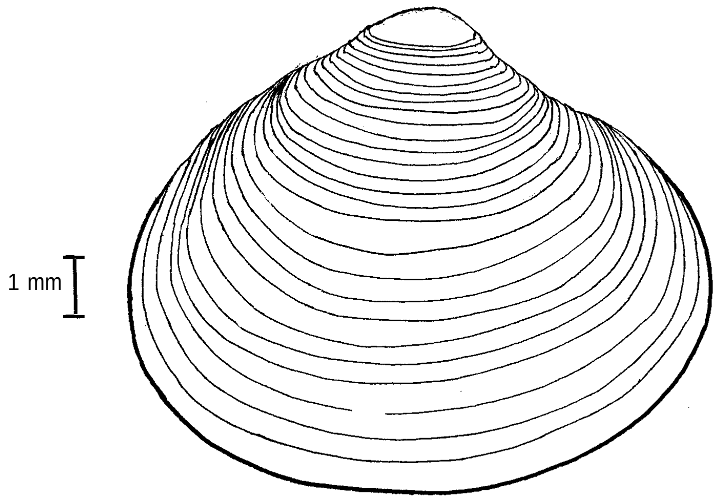
References

Hawking & Smith 1997, pp 24-35; Williams 1980, p 86; Gooderham & Tsyrlin 2002, pp 52-58.

7.2 Class Bivalvia-mussels, little basket shells and pea shells

Background

About 85% of the 25,000 bivalves that occur worldwide are marine. In Australia, representatives of three families and some 33 species of bivalves are found in inland waters. All three families occur in South Australia. Two species of freshwater mussels (family Hyriidae) occur in South Australia-the river mussel *(Alathyria jacksoni)* and the billabong mussel *(Velesunio ambiguus)*. The other two families are Corbiculidae (little basket shells) and Sphaeriidae (pea mussels). Fossil records date back to the Cambrian period, over 515 million years ago.



The little basket shell *Corbiculina australis* (family Corbiculidae)

Size

Bivalves range in size from very small to 150 mm, depending on species and maturity. Freshwater mussels are the largest. Corbiculidae and Sphaeriidae are smaller, reaching a maximum shell height of only 25 mm

Features

The shell of a freshwater mussel consists of two separate valves hinged together to enclose the animal completely. The shells often have concentric growth rings and the shell is strengthened by the incorporation of calcium. Shell colour can be white, brown or black. Bivalves have soft bodies and lack defined heads. They have two siphons that protrude from between the shells when the animal is active. Water, containing food particles, is drawn into the shell through one siphon and passes over the gills to be expelled through the second siphon.

Diet and feeding

Bivalves filter food particles such as zooplankton, phytoplankton and organic detritus from the water. The food particles are trapped in mucus on the surface of the gills and passed to the mouth. The shells do not need to be opened very wide for this process to occur.

Locomotion

Bivalves move slowly by extending their foot out between their shells, gaining a hold on the substrate, contracting the muscles in the foot and thus dragging themselves along. Most of the time, they submerge themselves, either partially or completely, in the sediments.

Gas exchange (breathing)

Bivalves pass water over their single pair of gills while filter-feeding. Water is drawn into the mantle cavity via the longer of the two siphons and is moved across the gills by the action of fine hair-like structures called cilia. The water then exits through the second siphon. The blood of bivalves lacks any respiratory pigment.

Life cycle and reproduction

Bivalves reproduce sexually. Sphaeriidae are hermaphrodites and self-fertilise, but the members of the other families have separate sexes. Males release sperm into the water column and the sperm are drawn in through the siphons of females. Female Corbiculids and Sphaeriids brood their eggs and the larvae develop between the gills inside the shell. At the completion of development, the young are shed from the gills. Hyriid larvae attach to the gills or bodies of fish for a time before they drop off and settle on the bottom. The age of a bivalve can be determined by the number of growth lines on the shell, in the same way that the age of a tree can be determined by the rings of the trunk. Freshwater mussels may reach an age of 20 or 30 years.

Habitat

Bivalves are found in a variety of inland waters: Hyriidae are common in the River Murray, Sphaeriidae live in streams and ponds, and Corbiculidae live in sandy areas in fast-flowing water of streams. They often bury themselves into soft sediment. Bivalves don’t appear to be as common as gastropods in South Australia, but can be found in a variety of water bodies throughout South Australia, including slightly saline waters.

Critter facts

Hyriidae are very resistant to desiccation. A specimen of one species survived after being left for five years in a dry box. Some bivalves can live for a very long time, one species of bivalve was recorded to have lived for 150 years.

Freshwater mussels have been used in studies of heavy metal pollution. They accumulate heavy metals within their soft tissues and in their shells. Comparing the concentration of metals in shellfish from different places and over different times can tell us about the presence and distribution of metals in the environment.

Identification

Bivalves can easily be recognised by the paired, hinged shells that completely enclose the soft-bodied animals. Little basket shells and pea shells look just like marine clams or cockles, but are slightly smaller. It is hard to distinguish between these two bivalves, but the shape of the shell at the hinge is often used. Freshwater mussels look very similar to marine mussels and can grow to be quite large. See page 40 of *The Waterbug Book* for a key to the families of bivalves.

Classification and sensitivity

Phylum Mollusca

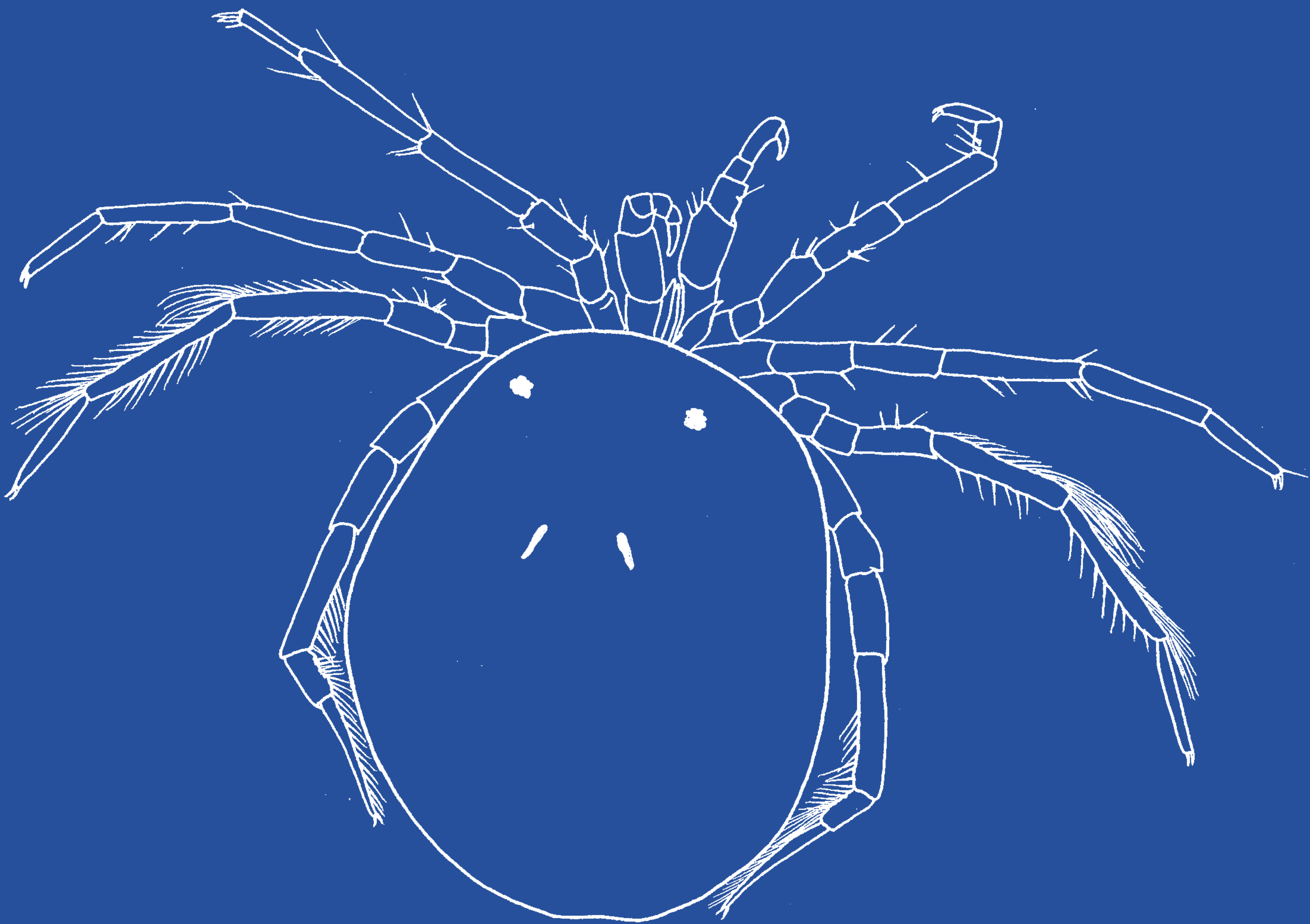
- Class Bivalvia (3)
  - Order Unionoida
    - Family Hyriidae (5)
  - Order Veneroida
    - Family Sphaeriidae (5)
    - Family Corbiculidae (4)

References

Hawking & Smith 1997, pp 36-39; Williams 1980, p 78; Gooderham & Tsyrlin 2002, pp 49-51.

ENVIRONMENT PROTECTION AUTHORITY

Mites, spiders, crustaceans and insects



8 Phylum Arthropoda—arthropods including water mites, water spiders, crustaceans, insects

Background

Phylum Arthropoda includes between 10 and 20 classes, depending on the classification adopted. There is much debate about the appropriate classification. Over 750,000 species of arthropods have been described worldwide, with more to be discovered and described. They are found in terrestrial, marine, estuarine and freshwater environments and in climates from the hottest to the coldest. They are probably the most successful and diverse phylum of all animals.

Some of the better known groups are Insecta (insects), Collembola (springtails), Crustacea (e.g. crabs, shrimps and crayfish), Arachnida (spiders, scorpions, ticks and mites), Chilopoda (centipedes), Diplopoda (millipedes) and the extinct Trilobita (trilobites). The first four of these groups include species that inhabit inland waters and these are discussed in further detail in their individual sections below.

Arthropods are believed to have evolved from annelids, or it may be that Arthropoda and Annelida evolved from a common ancestor. Fossil arthropods first appeared in sediments from the Precambrian era, about 590 million years ago.

Size

In such a diverse group of animals, size varies considerably. Freshwater arthropods range from less than 1 mm long to more than 300 mm long, in the case of large freshwater crayfish.

Features

Adult arthropods have segmented bodies with jointed appendages-legs, antennae, and mouthparts. Many have a thickened skin or cuticle that forms a rigid external skeleton, or 'exoskeleton', made of a chemical substance called 'chitin'. It provides protection for the soft tissue underneath as well as an attachment point for muscles, and reduces the amount of water that can evaporate from the body. Larvae of arthropods may lack some of these characteristics.

Diet and feeding

Arthropods are a diverse group and feed in many different ways. They may be herbivores, detritivores, scavengers, carnivores or active predators; some are filter feeders.

Locomotion

Many arthropods are good swimmers and can move swiftly through the water. Others walk on the water surface or climb and cling to plants in the water, and some crawl along the bottom of the water body. Many aquatic insects have adult life stages that are able to fly.

Gas exchange (breathing)

Respiratory systems range from diffusion of oxygen through the surface of the body to complicated gill structures supplied with blood vessels that help to transport oxygen around the entire body.

Life cycle and reproduction

Some arthropods have life cycles that are entirely aquatic; others (some insects) have larval stages and pupae that are aquatic, but adult stages that are terrestrial or, at best, semi-aquatic. Reproduction can occur through parthenogenesis or by sexual means that result in the production of eggs. Arthropods can take as little as two weeks to as much as several years to complete their life cycles.

Habitat

Arthropods can be found in every habitat, from fast-flowing to still or stagnant waters, from fresh waters to hypersaline lakes, from temporary to permanent water, and from pristine water bodies to extremely nutrient-enriched and degraded water bodies. Some like to burrow in sand and silt, others require stable substrates to which to cling, and still others skate across the surface of the water, only rarely submerging. In South Australia, the distribution of some arthropods may be limited to certain areas, either because the species are rare or because they prefer a particular altitude, water temperature or specialised habitat. Other species are very common and can be found throughout the State.

Critter facts

Trilobites were common ocean-living arthropods during the Palaeozoic era, first appearing about 540 million years ago and becoming extinct about 250 million years ago. Over 3900 species of trilobites have been described from fossils. Adults ranged in size from 0.5 mm to almost a metre in length.

Identification

As adults, arthropods have segmented bodies and jointed appendages. They vary greatly in appearance and often are difficult to identify as juveniles. Some juveniles have segmented bodies and jointed legs, but some Diptera or true flies, for example, have larvae that are maggot-like in appearance and do not have jointed appendages or distinguishable body segments.

Classification and sensitivity

A single sensitivity ranking is not given for arthropods as they are a very large group and range in sensitivity from very tolerant to very intolerant of a range of pollutants.

Phylum Arthropoda

- Class Arachnida
- Class Crustacea
- Class Collembola
- Class Insecta

References

Hawking & Smith 1997, p 40; Williams 1980, p 118; Gooderham & Tsyrlin 2002, pp 59-212.

9 Class Arachnida—water mites and water spiders

Background

The main types of arachnids are spiders, scorpions, mites and ticks. There are over 70,000 species worldwide. The orders Acariformes and Parasitiformes (mites and ticks) and the order Araneae (spiders) all have aquatic members, but aquatic mites are far more numerous and diverse than the water spiders. At least 30 families of aquatic mites are found in Australia, most of which occur in South Australia. Only one type of spider is aquatic, and this belongs to the family Pisauridae (fishing spiders). Fossil records for mites date back to the Devonian period, about 400 million years ago, but spiders appear much later, in the Carboniferous period, about 300 million years ago.

Class Arachnida also includes scorpions, but although aquatic scorpions have been found in the fossil record, in the Silurian period about 420 million years ago, all are extinct today. What we now refer to as 'water scorpions' are, in fact, insects in the bug family Nepidae.

Size

Aquatic arachnids range in size from tiny mites less than 1 mm long to water spiders that can grow up to 50 mm long.

Features

Arachnids have two main body segments: the 'prosoma' or 'cephalothorax', which is the arachnid equivalent of the insect head and thorax fused together; and the abdomen. Mites have only a single body segment as the prosoma and abdomen are fused together. Arachnids lack antennae and as adults have eight legs and two pairs of feeding appendages, the 'chelicerae' and 'pedipalps'.

Diet and feeding

Arachnids feed on the juices of their prey. They grasp their prey with pedipalps that are situated near the mouth, insert their mouthparts into the prey and suck out the body fluids.

Locomotion

Some arachnids, particularly larval mites, are parasitic and travel around with their hosts. Others are able to crawl or creep using specialised legs. Some water mites are very good swimmers and use the long hairs on their legs to propel themselves through the water.

Gas exchange (breathing)

Water mites take oxygen from the water by diffusion. They have a 'tracheal system' that transports the oxygen throughout the body through a system of tubes. Water spiders (fishing spiders) use fine hairs on their abdomens to trap a bubble of air that provides a source of oxygen when they dive under the surface of the water.

Life cycle and reproduction

Sexual reproduction occurs in both water mites and water spiders, but the life cycles of water mites and water spiders are quite different. Both water mites and water spiders lay eggs. The female mites attach their eggs to submerged water plants or inside molluscs and sponges. On hatching, the young often parasitise insect larvae. In contrast, female fishing spiders carry their eggs around with them, using their jaws. The eggs are kept in a sac until the young are ready to hatch and, for the first few juvenile stages, the spiders remain on land sheltered in vegetation. The young of both mites and spiders (spiderlings) resemble the adults, although juvenile mites have only six legs instead of eight.

Habitat

Water mites are found in almost every aquatic habitat, but are more common in still waters than they are in running water. Mites can often be found among aquatic vegetation. They tend to be absent from extremely polluted or saline waters. Water spiders, in contrast, prefer the shorelines of ponds, lakes, marshes, streams and rivers.

Critter facts

One species of terrestrial mite, commonly called a 'chigger', can cause severe dermatitis. An intense itching is caused by the secretions that it leaves as it bites. This species is also of medical importance as it acts as a vector for human pathogens, such as the Asian scrub typhus.

The largest species of aquatic scorpions, now extinct, grew to 86 cm.

Identification: The key starting on page 21 of *The Waterbug Book* should help you tell mites and spiders from other animals. Aquatic mites vary in shape and colour, but all are quite small. They have eight legs and most have spherical bodies. Large mites that are brightly coloured may be seen with the naked eye. Many others, due to their small size, may go unnoticed without the aid of a microscope, although they are far more common than water spiders.

Water spiders are light in colour, usually brown, and they have long legs. They have eight eyes arranged in two rows of four. The arrangement of the eyes is the easiest way to recognise a water spider.

Classification and sensitivity

Sensitivity not rated

Phylum: Arthropoda

- Class Arachnida
    - Order Acariformes
    - Order Parasitiformes
    - Order Araneae

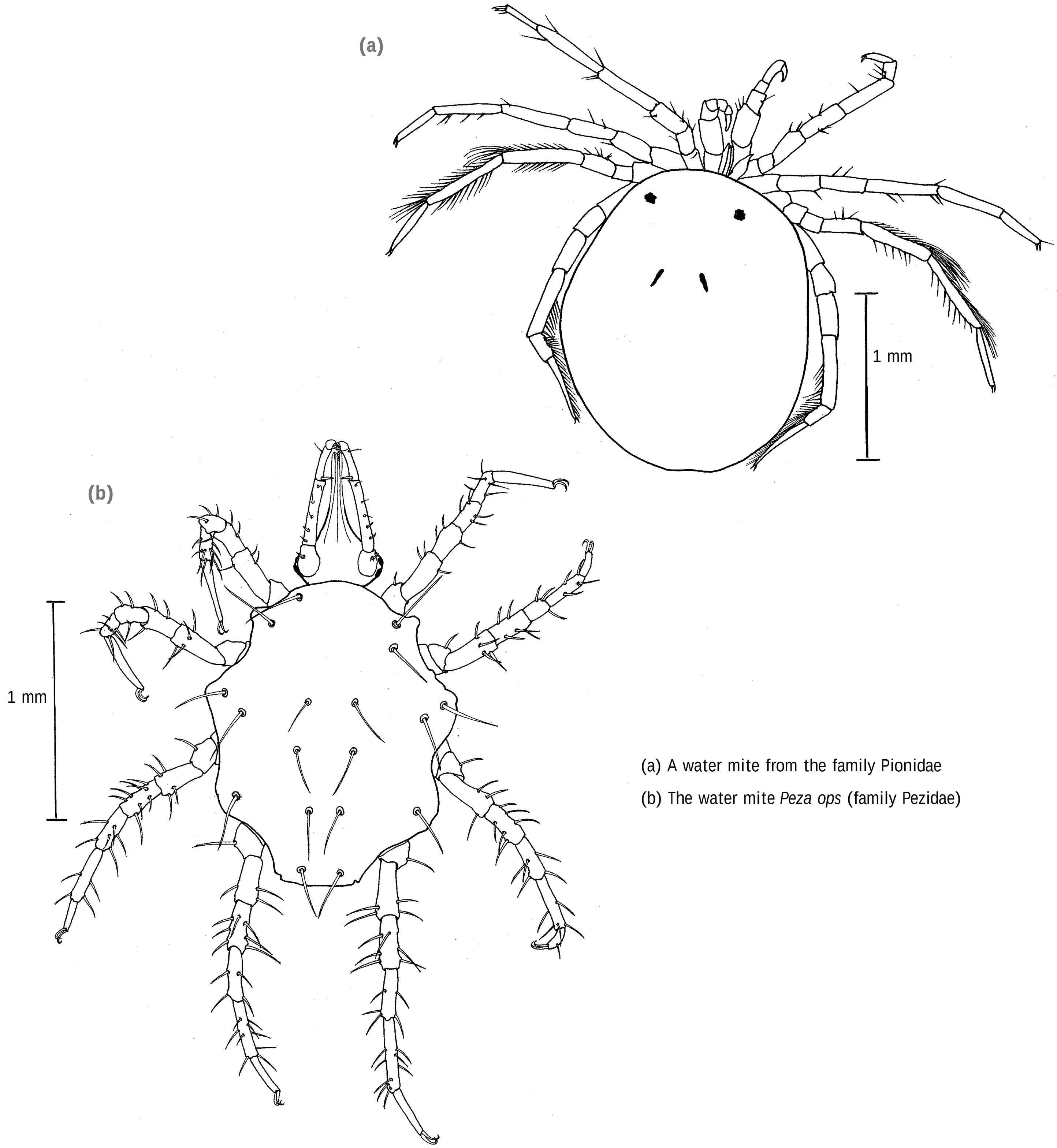
References

Hawking & Smith 1997, pp 40-46; Williams 1980, p 118; Gooderham & Tsyrlin 2002, pp 59-62.

9.1 Orders Acariformes and Parasitiformes-water mites

Background

There are over 45,000 named species of mites and ticks worldwide, including terrestrial, marine and freshwater forms. Some authors suggest that the order Acariformes, which consists of many types of mites and ticks, should be split into seven separate orders. At least 22 families of aquatic Acariformes are found in Australia. For South Australia, at least 33 species of mites are known, but that number is increasing as more species are recognised. Fossil records date back to the Early Devonian period, nearly 400 million years ago.



(a) A water mite from the family Pionidae

(b) The water mite *Peza ops* (family Pezidae)

Size

Larger aquatic mites grow to 2.5 mm long, but many species are smaller.

Features

The prosoma and abdomen are fused to form the body of a water mite, which is called the 'idiosoma'. Many of these mites are brightly coloured-sometimes red, blue or green. Some are soft bodied while others have heavily sclerotised, or hardened, bodies. They are often round in shape, but some are elongate or flattened. Adults have four pairs of legs, which are often fringed with swimming hairs. They also have one pair each of chelicerae and pedipalps, which they use for feeding.

Diet and feeding

Some aquatic mites eat detritus, but as adults most are predatory. They feed on crustaceans and larvae of aquatic insects. Mites grasp their prey with a pair of palps near the mouth. Their piercing mouthparts puncture the prey and the juices are sucked out. Most larval mites parasitise other invertebrates.

Locomotion

Some mites are strong swimmers, having long hairs on their legs that help them move swiftly through the water. Other mites crawl along the bottom of the water body and have legs modified for this purpose.

Gas exchange (breathing)

Water mites get oxygen from the water by diffusion. They have tracheae that are used to transport oxygen throughout the body.

Life cycle and reproduction

Typically, the life cycle of an aquatic mite has four stages. During mating, the male mite grasps a female and, using his third pair of legs, passes a packet of sperm from his penis to the genital pore of the female. Eggs are laid either singly or in a group and are usually attached to submerged plants. On hatching from the egg, most larvae parasitise other freshwater organisms. Larval mites have only six legs and are usually teardrop-shaped. The mature larva moults into a stage called a 'deutonymph', which looks like the adult, but lacks fully developed reproductive organs. The deutonymph eventually becomes an adult.

Habitat

Water mites are found in almost every aquatic habitat except extremely polluted or saline waters. In South Australia, they can be found in ponds, lakes, slow-flowing streams and rivers, but they are not as common in fast-flowing waters. Some mites are ectocommensal and may be found in the gill chambers of crustaceans.

Critter facts

Many mites parasitise larval or pupal insects that have terrestrial adult life stages, staying inside the insect as it pupates to the adult, and then travelling to other water bodies with the unsuspecting winged insect. This enables mites to colonise new water bodies.

Identification

Mites are small animals with eight legs and are usually rotund. They can be mistaken for spiders, but are smaller and do not have distinct body segments. Spiders by contrast have two-segmented bodies. Water mites vary in colour from white, yellow, grey and blue, to red and sometimes green. They can have either soft or hardened bodies, and generally are difficult to identify to family or genus levels.

Classification and sensitivity

Note that 'Acarina' is not a formal taxonomic group but refers to aquatic mites from a number of taxonomic groups within the Order Acariformes.

Phylum Arthropoda

- Class Arachnida
  - Order Acariformes-'Acarina' (6)
  - Order Acariformes-all other members (NR)
  - Order Parasitiformes (NR)

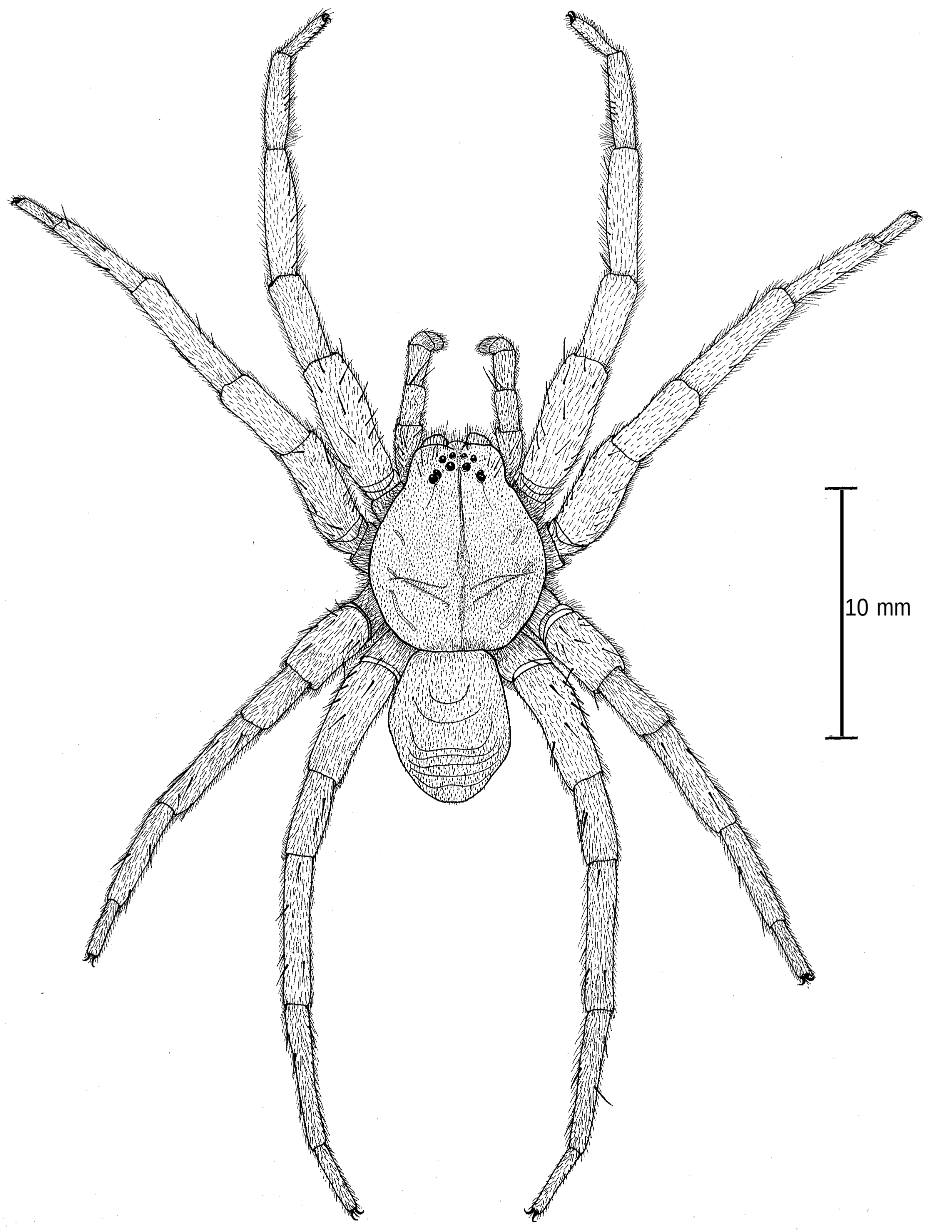
References

Hawking & Smith 1997, pp 40-46; Williams 1980, p 118; Gooderham & Tsyrlin 2002, pp 59-60.

9.2 Order Araneae-water spiders or fishing spiders

Background

There are some 35,000 species of Araneae worldwide, most of which are terrestrial. Many species of non-aquatic spiders can be found around water. However, the family Pisauridae, commonly called fishing spiders, depend upon water as a habitat. Worldwide, there are about 100 species of fishing spiders. They can be found throughout Australia, including South Australia. Fossil records of spiders date back to the Carboniferous period, about 300 million years ago.



The fishing spider *Dolomedes* sp. (family Pisauridae)

Size

Adult fishing spiders can grow up to 50 mm long, including legs. The body is about the size of a 50-cent piece. Females are slightly larger than males.

Features

All spiders have eight legs and a body of two segments, with the head and thorax combined as a single segment and abdomen as the second segment. They have no antennae and have two pairs of feeding appendages, the chelicerae and pedipalps. Fishing spiders are usually brownish in colour. They resemble wolf spiders (family Lycosidae) but have longer legs. Some wolf spiders are often found in the same habitat, on the edge of water bodies.

Diet and feeding

Fishing spiders catch semi-aquatic insects that frequent the surface of the water. They are also able to dive for food beneath the surface of the water where they can hunt aquatic insects, fish and tadpoles. They have excellent vision and can detect the slightest movement in both bright and dim light. After they have captured their prey, they feed, sitting on the bank of the water body or on a rock.

Locomotion

Aquatic spiders usually run on the surface film of a water body. The surface tension prevents them from falling into the water. When threatened or hunting for food, they are able to dive under the water, completely submerging themselves.

Gas exchange (breathing)

Fishing spiders have fine hairs on the abdomen that they use to trap air bubbles. The air bubble provides them with an oxygen supply while they are under the water. Oxygen can diffuse from the water into the bubble and carbon dioxide dissipates into the water. This system allows the spider to remain under water for more than 30 minutes.

Life cycle and reproduction

Fishing spiders produce round white eggs that the female carries in a sac in her jaws. She carries the egg sac for approximately three weeks and, just before the eggs hatch, builds a nursery web around the eggs. This web is attached to vegetation and provides a safe haven for the spiderlings during the first few stages of their lives. The spiderlings go through a series of moults. They leave the web after one or two moults and must hunt food and survive on their own. An adult female will produce two to three egg sacs in her lifetime.

Habitat

Fishing spiders live at the shorelines of ponds, lakes, marshes, streams and rivers. They are frequently found in aquatic vegetation in still waters, not often in fast flowing waters. Fishing spiders live in water bodies throughout South Australia but are not commonly seen.

Critter facts

Most spiders construct webs to capture their prey. Fishing spiders are one of the few spiders that capture their prey without using a web. They only build a web to protect their eggs.

Fishing spiders do not usually bite humans and generally the spider will retreat when a human is present. They may bite when defending young or an egg sac, but the poison produced by this spider causes only localised pain in humans.

Identification

Fishing spiders are light in colour, usually brownish. They have eight eyes, arranged in two rows of four, and long legs. They are difficult to distinguish from terrestrial spiders but the arrangement of the eyes may be helpful. Another spider family, the Tetragnathidae, often build their webs near creeks. These spiders have long thin legs like daddy-long-legs and have longer bodies than fishing spiders.

Classification and sensitivity

Phylum Arthropoda

Class Arachnida

Order Araneae (NR)

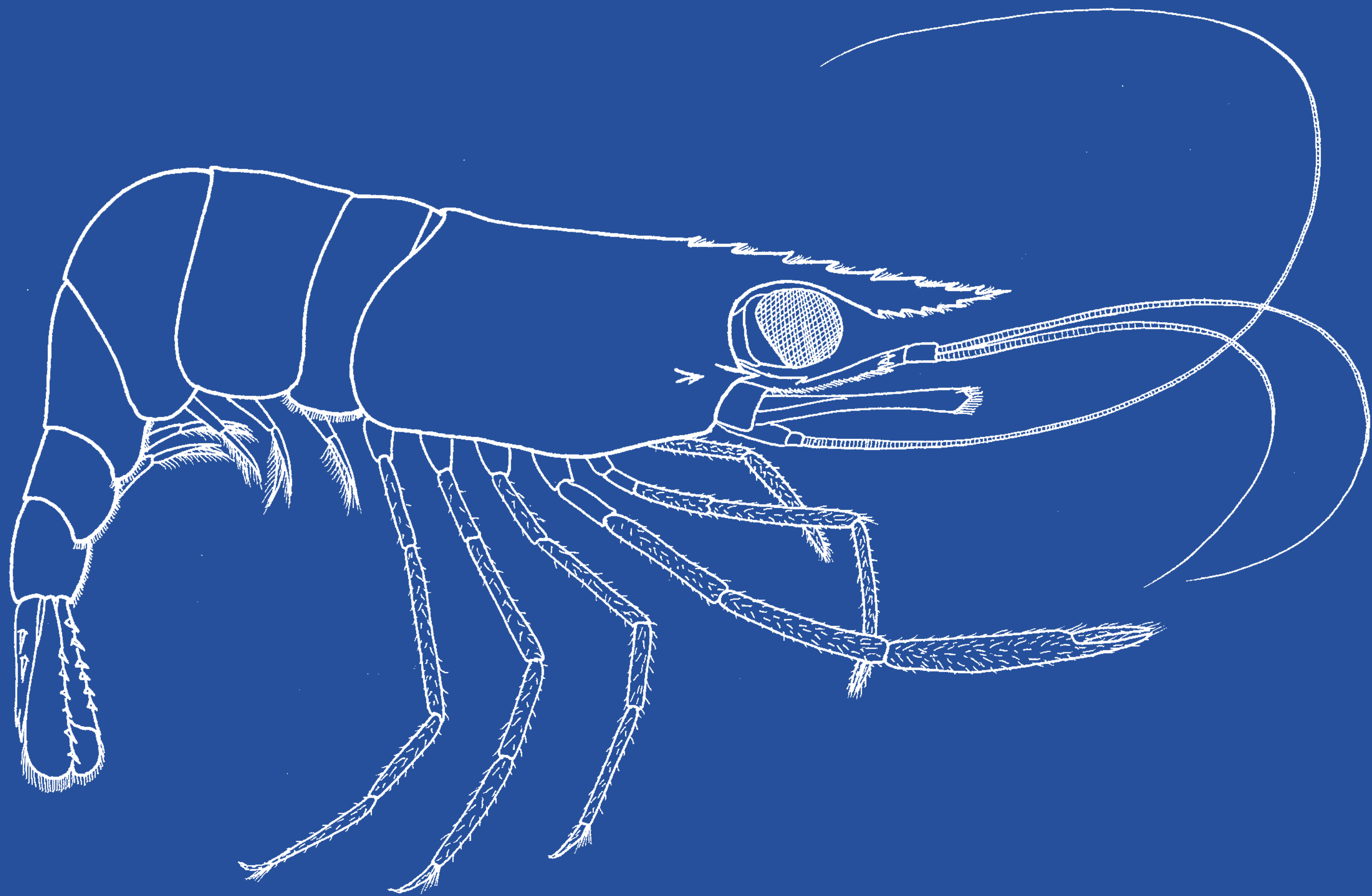
Family Pisauridae (NR)

References

Williams 1980, p 121; Gooderham & Tsyrlin 2002, pp 60-62.

ENVIRONMENT PROTECTION AUTHORITY

Crustaceans



10 Class Crustacea—crustaceans

Background

Worldwide, more than 42,000 species of Crustacea are known. They are divided between eight subclasses and include terrestrial, marine and freshwater forms. Around 500 species of freshwater crustaceans are listed for Australia. Due to the difficulty of identifying some crustaceans, it is unknown how many species occur in South Australia. Fossil records date back to the Devonian period, approximately 400 million years ago.

Freshwater biologists group crustaceans by size. Microcrustaceans, including Ostracoda (seed shrimps), Copepoda (copepods), Cladocera (water fleas) and Conchostraca (clam shrimps, an uncommon group not covered in this guide) are often small and many species from these groups tend to be planktonic, although this is not always the case.

Crustaceans from the groups Anostraca (fairy shrimps), Notostraca (shield or tadpole shrimps), Amphipoda (scuds or side-swimmers), Isopoda (water slaters or sow bugs) and Decapoda (freshwater crabs, crayfish, prawns and shrimps) are called ‘macroinvertebrates’. These animals tend to be larger and benthic, rather than planktonic.

Size

Crustaceans range in size from less than 1 mm to more than 300 mm long for large freshwater crayfish.

Features

Crustaceans are highly variable in body form but some general rules apply. All crustaceans have two pairs of antennae, one pair of mandibles, and two pairs of ‘maxillae’, on their heads. Characteristically, they also have a pair of appendages on each body segment, although sometimes these are reduced or absent from various parts of the body, depending on the species. The appendages can be modified in shape to perform tasks such as swimming, walking, feeding, respiration or copulation. Crustacean bodies are composed of between 16 and 60 segments. The first six segments form the head and the remainder make up the thorax and abdomen.

Diet and feeding

Smaller crustaceans are generally filter feeders, using specialised appendages to create a current of water that passes over the ‘filter’. The collected particles, including bacteria, algae and small plankton, are removed by special combing or brushing hairs and transported to the mouth. Larger forms feed by grabbing prey with their large front claws; they locate their prey by smell and take insects, molluscs and fish. Some larger crustaceans, including yabbies, eat plants. A number of crustaceans are parasites, often during their larval stages.

Locomotion

Smaller crustaceans are able to swim through the water using their body appendages. Larger forms tend to crawl along the bottom of the water body.

Gas exchange (breathing)

Larger crustaceans respire by use of gills; smaller crustaceans, such as members of the suborder Cladocera and subclasses Ostracoda and Copepoda, respire by diffusion through the body surface. Oxygen is then transported to the rest of the body, either dissolved in the blood or bound to haemoglobin.

Life cycle and reproduction

Most crustaceans have separate sexes. Some reproduce parthenogenetically. Eggs may be attached to certain appendages or contained within a brood pouch or in an egg sac. The most common form of larva is the 'nauplius', which is free-swimming and has only three pairs of appendages: first and second antennae, and mandibles. All crustaceans moult and additional appendages are formed as the animal grows. Many of the smaller crustaceans have resting eggs that are resistant to desiccation, but these are not found in amphipods, isopods and decapods. The life span of a crustacean can be anywhere between two weeks and 15 years, depending on the species.

Habitat

Crustaceans can be found in just about all kinds of waters-fast-flowing, still, fresh and saline. They can be found living in the water column, on the bottom of a water body, or among aquatic plants. Some are tolerant of pollution, while other species are intolerant and prefer clean water. Smaller crustaceans can be found in just about every water body in South Australia. Some of the larger ones are less common or are found only in particular areas of the state. Adult crayfish have been known to roam the banks of creeks for a period of time and to move from one water body to another if conditions become unfavourable.

Critter facts

Unlike insects, most crustaceans are aquatic, although some, including slaters, live on land.

Identification

Most crustaceans have a carapace and all have two pairs of antennae, but their appearance varies greatly. The larger freshwater forms are very similar to their marine cousins and are easily recognised. The tiny microcrustaceans are harder to recognise and it may be difficult to see their features without a microscope.

The key starting on page 21 of *The Waterbug Book* should help you tell crustaceans from other animals and separate the major groups from each other.

Classification and sensitivity

Phylum Arthropoda

- Class Crustacea
  - Suborder Cladocera (NR)
  - Suborder Copepoda (NR)
  - Suborder Ostracoda (NR)
  - Order Anostraca (1)
  - Order Notostraca (1)
  - Order Amphipoda (3)
  - Order Isopoda (2)
  - Order Decapoda (4)

References

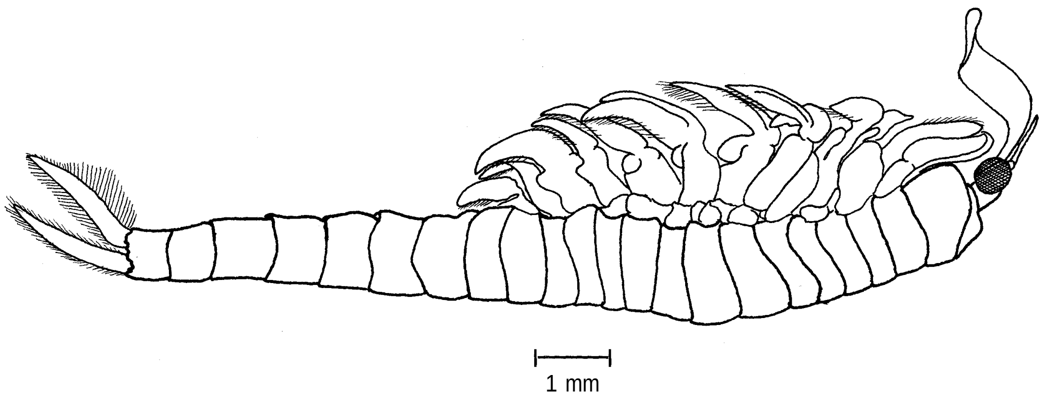
Hawking & Smith 1997, pp 47-73; Williams 1980, p 122; Gooderham & Tsyrlin 2002, pp 63-83.

10.1 Order Anostraca-fairy shrimps or brine shrimps

Background

Anostracans are among the most primitive of all living crustaceans. They occur worldwide, and at least three families, each containing one genus, occur in inland waters Australia. Two genera of brine shrimp live in highly saline waters, the native *Parartemia* (with eight described species) and the introduced *Artemia salina*. The fairy shrimp genus *Branchiella* (nineteen described species) lives in wetlands and temporary ponds of lower salinity. All three of these genera are found in South Australia.

Fossil records of this Order date back to the Miocene epoch of the Caerozoic era, nearly 25 million years ago.



The Anostraca *Parartemia* sp. (family Branchipodidae)

Size

Anostracans can grow up to 50 mm in length, but usually are much smaller.

Features

Anostracans have a clearly defined head and a thorax that lacks a carapace. The eyes are stalked. They have two pairs of antennae; the first pair is small, the second pair is more prominent. The abdomen is made up of eight segments. Anostraca may be either white or a reddish-orange colour.

Diet and feeding

Fairy shrimps feed mainly on micro-organisms such as bacteria, protozoa, rotifers and algae, and also on bits of detritus that they filter from the water. By beating their thoracic appendages they produce a current over their gills. As the water is moved across the gills, it is filtered, the food particles settling along a groove between the bases of the thoracic appendages. Setae on the ventral, or abdominal, groove transport the food to the mouth.

Locomotion

Fairy shrimps swim through the water column on their backs with their ventral side oriented to the light. They feed and take up oxygen as they swim. If they stop moving their thoracic appendages, fairy shrimps sink to the bottom.

Gas exchange (breathing)

Anostracans lack true gills; instead, they have leaf-like extensions on the ends of their appendages. They move the thoracic appendages through the water to produce a current that flows over these extensions. Some anostracans have haemoglobin, which is used to transport oxygen throughout the body, and gives the shrimp a red colour.

Life cycle and reproduction

The sexes are separate, and males and females differ in the structure of the second antennae. Male antennae are longer and adapted for grasping the females, and the mating shrimps often swim around attached to one another for hours. Once mating has finished the male dies.

Females carry their eggs in a brood sac on the abdomen, and the eggs are deposited in the sediment. When an egg-carrying female dies the eggs often end up in the sediment as well. A female can have between 10 and 150 eggs in each brood and can produce many broods in her lifetime. In one species, under optimum conditions, the female can live for three months and produce around 300 young every four days.

Anostracan eggs are resistant to desiccation and can survive in the sediment if a water body dries up. When the pool fills with water again, some of these eggs will hatch. The time between hatching and adulthood is very short. The young are born as nauplii and go through 15 moulting stages or ‘instars’. At each instar, they grow more segments on the body until they reach the adult stage.

Habitat

Anostracans may be seen swimming in the water column in both fresh and saline waters. They prefer the still waters of pools and ponds. They have been recorded in the South East region of South Australia, in the Far North and arid regions, as well as in solar salt ponds.

Critter facts

‘Brine’ describes water containing a high concentration of salt, and some species of brine shrimps are able to survive in very saline waters by regulating their osmotic pressure. Some can even survive at salinities around 300 grams/litre, about 8 1/2 times as salty as seawater.

'Sea monkeys' are species of *Artemia* sold as 'pets', often in a kit complete with dried algae for food and a small tank in which to keep the shrimps. Also, *Artemia* are often used as fish food. The dehydrated eggs of these brine shrimps can be bought from aquarium shops. When placed in brine solution, the eggs hatch. Resting eggs have been hatched under laboratory conditions after 15 years of dehydration.

One species of fairy shrimp is on the endangered species list in the United States of America.

Identification

These animals are quite unusual in appearance. Because they do not have a carapace, their many thoracic appendages are clearly visible. They have stalked eyes and two pairs of antennae, and the elongate abdomen is divided into eight segments. The key starting on page 21 of *The Waterbug Book* should help you tell anostracans from other animals.

Fairy shrimps are not easy to identify to genus level. However, in saline waters you will get native *Parartemia* species and the introduced *Artemia salina*. In fresher waters you are likely to get *Branchiella*.

Classification and sensitivity

Phylum Arthropoda

Class Crustacea

Order Anostraca (1)

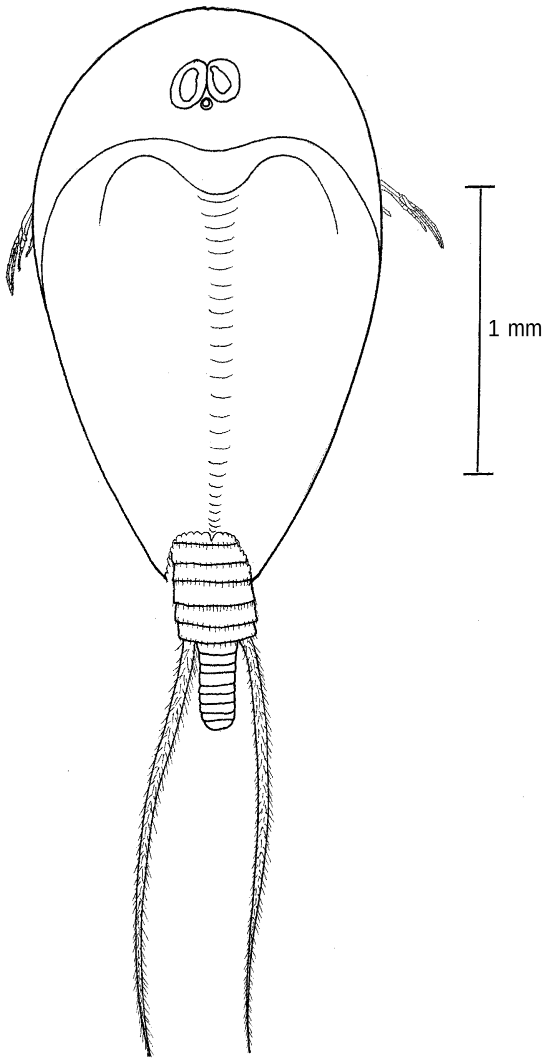
References

Hawking & Smith 1997, p 48; Williams 1980, p 126; Gooderham & Tsyrlin 2002, pp 75.

10.2 Order Notostraca—shield or tadpole shrimps

Background

Notostraca have been recorded from as early as the Carboniferous period and have not changed physically in almost 300 million years. The 220-million-year-old *Triops cancriformis* is thought to be the oldest animal species living on earth. Notostracans evolved before freshwater fish and appear never to have adapted to fish predation. Typically, they are found in temporary pools that do not contain fish. They have been found on every continent except Antarctica, but there are only 15 species worldwide, all in one family. Two genera of shield shrimps (also known as tadpole shrimps) are found in Australia, and members of both can be found in South Australia.



The Notostraca *Lepidurus apus viridis* (family Triopsidae)

Size

First instar larvae of the shield shrimp are approximately 0.5 mm long, but adults can grow to 35 mm in length.

Features

Shield shrimps have a prominent, hardened shield that covers the head and thorax of the animal. The last segment of the abdomen bears two slender 'tails'. From underneath they have a mass of feathery legs, sometimes as many as 60 pairs. They are usually brown or white in colour on the upper side, while their underside can be a fleshy pink colour.

Diet and feeding

Shield shrimps are omnivorous, feeding on algae, bacteria, protozoa, rotifers, aquatic worms, fairy shrimp, frog eggs, tadpoles, rotting leaves and other detritus. Some of this food is filtered from the water using the thoracic appendages that are situated under the shield. The food settles in a groove on the underside of the animal and is then passed along to the mouth. Notostracans sometimes cannibalise others of their kind that have just moulted.

Locomotion

Shield shrimps tend to rest on the bottom of the pool, sometimes partially submerging themselves in the mud or sand. Like most aquatic animals, but unlike anostracans, they swim with their back facing towards the light; lack of oxygen, however, can force them to swim upside down with their gill-like appendages close to the surface of the water.

Gas exchange (breathing)

All of the appendages beneath the shield have leaf-like gills at their bases. The beating appendages create a current of water that flows over the gills.

Life cycle and reproduction

Some species are hermaphroditic and reproduce sexually either through cross-fertilisation or self-fertilisation. They are also able to reproduce by parthenogenesis. Desiccation-resistant resting eggs are often produced and are an important method of survival for the species over periods of drought. The eggs can survive in the dried mud long after the adult shrimps have died; they are quite small and may be carried by wind to other water bodies.

For one species, a period of dry conditions is necessary for the development of all their eggs. Once immersed in water (as the temporary pools are filled), eggs may take as long as two weeks to hatch, but usually take between one and three days. Larvae go through a series of moults and, in less than 24 hours, resemble the adults. Within seven to ten days of hatching, a female shrimp can produce her first brood of eggs. Resting eggs as old as 27 years have hatched successfully.

Habitat

Notostracans have been found in freshwater lakes and ponds, and in slightly saline waters, particularly temporary pools. Members of the two genera prefer different climates: *Triops* species are found in warmer parts and arid areas of South Australia, and *Lepidurus* species are found in cooler regions, such as the South East of South Australia. They are not very common animals and are usually found in temporary water bodies, even puddles.

Critter facts

Overseas, shield shrimps have been known to cause extensive damage to rice crops. They chew off the roots and leaves of the seedlings or uproot the seedlings with their digging. They also stir up mud as they dig, and reduce the amount of light penetrating to the rice seedlings.

If a shield shrimp is placed in a petri dish with a light shining underneath it, the animal will flip over to swim on its back.

One species of tadpole shrimp is on the endangered species list in United States of America.

Identification

Shield shrimps are easy to identify, but are not often seen. They have very obvious hardened shields that cover the head and thorax so that only the eyes are visible. The abdomen has two 'tails' attached at the end. The key starting on page 21 of *The Waterbug Book* should help you tell notostracans from other animals.

Classification and sensitivity

Phylum Arthropoda

Class Crustacea

Order Notostraca (1)

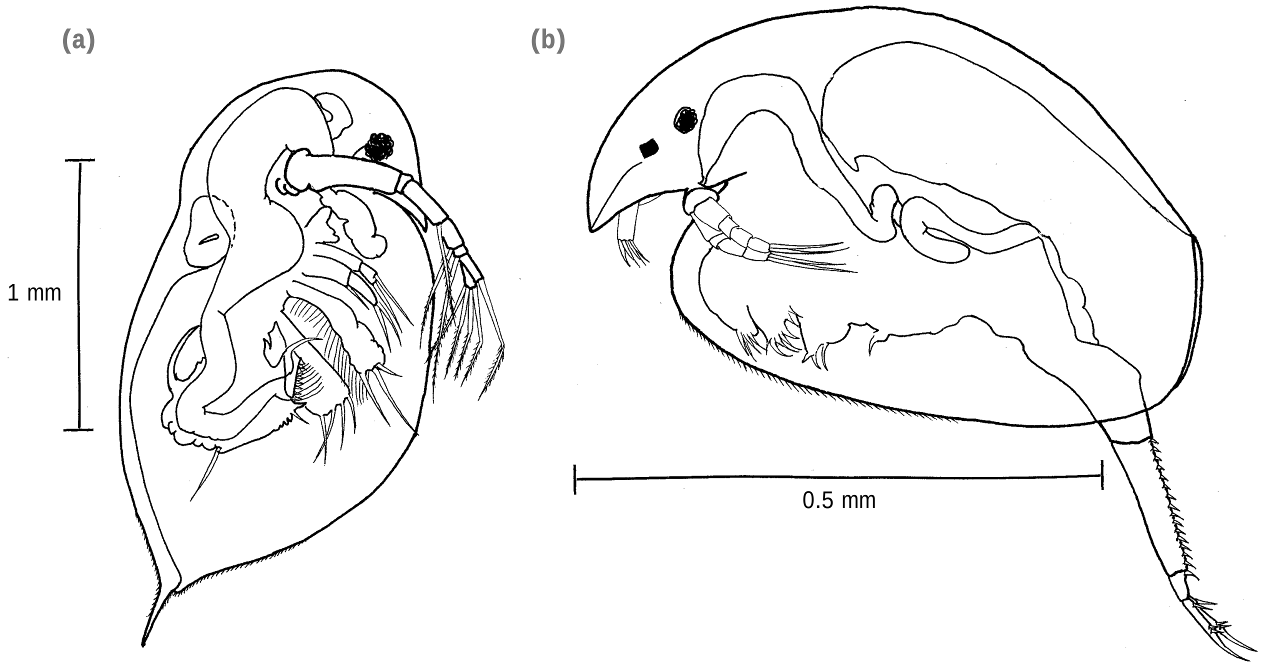
References

Hawking & Smith 1997, p 49; Williams 1980, p 129; Gooderham & Tsyrlin 2002, pp 76.

10.3 Suborder Cladocera-water fleas

Background

Cladocerans occur throughout the world, even in Antarctica. Most are freshwater animals, but some species are estuarine and marine. Eight families (Daphniidae, Moinidae, Macrothricidae, Chydoridae, Sididae, Bosminidae, Sayciidae and Ilyocryptidae) and over 170 species of Cladocera are known from Australian inland waters. *Daphnia* is the most commonly known genus in this group. The exoskeletons of some cladocerans fossilise well in the mud of water bodies and can be used to look at changes in water bodies over hundreds of years. Fossil Cladocera have been identified from the Mesozoic era; the group is thought to have existed since the Devonian period, about 400 million years ago.



The water fleas: (a) *Daphnia* sp. (family Daphniidae) and (b) a member of the Chydoridae family

Size

Most cladocerans are less than 1 mm long, but some grow to 7 mm. Males of some species are smaller than the females.

Features

Cladocerans have a bivalved carapace that is usually transparent. The carapace encloses the body and legs, but not the head or antennae. Cladocerans have one compound eye and sometimes another smaller eye called an ‘ocellus’. Females sometimes carry dark-coloured eggs under the carapace.

Diet and feeding

Most cladocerans are filter feeders. They do not feed selectively, but will take any small organism or organic particle within an appropriate size range, including small items of detritus, and algae, bacteria and rotifers. Food is filtered from the water by fine hairs on the thoracic appendages.

Locomotion

Cladocerans swim using their second pair of antennae for propulsion. Some swim on their backs through the water and move through the water column with a jerky motion. Others crawl around on plant surfaces or in the mud.

Gas exchange (breathing)

Cladocerans gain oxygen from the water by diffusion. They have blood that is pumped through the body by a heart. The blood of some cladocerans contains haemoglobin, which helps transport oxygen through the body.

Life cycle and reproduction

Male cladocerans are rarely found as most cladocerans reproduce parthenogenetically. When reproducing parthenogenetically, the females carry their young around in a brood pouch for a few days before they are released.

Cladocera reproduce sexually when environmental conditions deteriorate, due to pollution, food shortages, overcrowding, or water bodies drying up. Two thick-shelled resting eggs are formed that are enclosed in a dark capsule, carried around on the back of the female. Eventually, the capsule containing the resting eggs is shed and falls into the sediment. The eggs are resistant to desiccation and hatch when conditions improve.

Under laboratory conditions, it has been noted that when an adult female is about to die, she moults one last time and sheds the juveniles growing in her brood chamber, even if they are premature. This process is a survival technique to keep the population going.

Like other crustaceans, cladocerans moult; each time a new carapace grows under the old one before it is shed. When the old carapace is shed, the cladoceran absorbs large amounts of water to expand the new carapace. This water is slowly released as animal tissue takes its place. When an adult female moults, she releases the juveniles from her brood pouch. It can take one to two weeks for a juvenile to become an adult. The whole life cycle may last for several weeks and an adult female will produce at least six broods.

Habitat

Cladocerans live in standing and flowing waters. Members of some families are ‘benthic’, which means that they are found living on or close to the bottom of the water body. Others are ‘planktonic’, that is, found in the water column, usually in surface waters. Cladocerans can tolerate a range of salinities and are often found in saline lakes. Some are very tolerant of sewage effluent and thrive in nutrient-enriched waters, but most are quite sensitive to pollutants such as heavy metals and pesticides. Cladocerans can be found in most water bodies throughout South Australia.

Critter facts

Cladocerans are able to alter the shape of their carapace if they are being preyed upon. Some species are able to enlarge their head capsule and, sometimes, to lengthen their tail spine, which makes them less palatable to their predators.

Some cladocerans are grown as fish food for the aquarium trade and aquaculture industry.

Identification

These crustaceans are usually quite small. They have transparent carapaces, and sometimes the eggs can be seen inside the females. Cladocerans have very long antennae, which often protrude from the side of the animal, looking like arms. With the aid of some magnification you should be able to distinguish a cladoceran from other crustaceans using the key starting on page 21 of *The Waterbug Book*. Be careful though-the young larval stages of other crustaceans may be confused with cladocerans.

With specialist keys, cladocerans can be identified to family level with the aid of a dissecting microscope or a very strong hand lens. Identification to species level is quite difficult and may require dissection of the tiny creatures.

Classification and sensitivity

Phylum Arthropoda

Class Crustacea

Suborder Cladocera (NR)

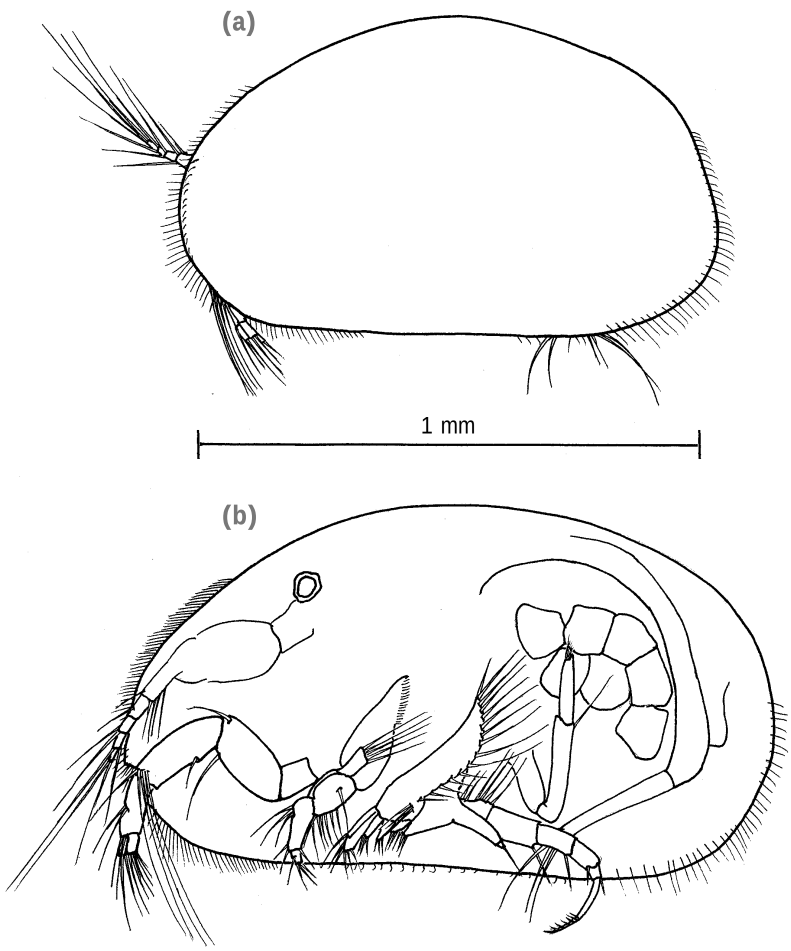
References

Hawking & Smith 1997, pp 50-52; Williams 1980, p 131; Gooderham & Tsyrlin 2002, pp 63-64.

10.4 Subclass Ostracoda-seed shrimps

Background

Worldwide, there are about 5700 species of living Ostracoda and over 10,000 fossil species. The group has a continuous fossil record stretching from the Cambrian period to the present, a period of about 515 million years. Most species are marine, but there are a substantial number of freshwater species and even a few terrestrial species (in New Zealand and South Africa) that live in leaf litter on forest floors. Eleven families and 37 genera of Ostracoda have been recorded from inland waters in Australia.



(a) external view and (b) internal features of an ostracod

Size

In Australian inland waters, adult ostracods range from 0.25 to 6 mm long. The largest marine ostracods are 30 mm long.

Features

Ostracods have a bivalved carapace that generally encloses the entire animal and looks a bit like the shell of a mussel. The carapace is strengthened with calcium carbonate and can be smooth, pitted or ornately sculptured; some have large wing-like projections; sensory hairs can also be present. Ostracods can be green, white, brown, grey or pink, and some are striped or spotted.

Compared with other crustaceans, an ostracod's head is very large, but its body trunk is reduced and has a maximum of two pairs of appendages. When the carapace is open, two pairs of antennae extend out, but if the animal is threatened it retracts all appendages and closes its carapace. The antennae have long setae and are modified for locomotion and feeding. Some ostracods are blind, others have one or two eyes.

Diet and feeding

Ostracods display a range of feeding preferences. They are filter feeders, scavengers, detritivores, herbivores and carnivores. Some marine species parasitise crustaceans, polychaete worms and even sharks. Many freshwater species use their antennae to draw water through the carapace and filter out small food particles. They feed on algae, bacteria and detritus.

Locomotion

Ostracods use their antennae for propulsion and swim actively through the water column, although they only swim short distances. Most also burrow into or skip along the surface of the substrate, using their hinged legs.

Gas exchange (breathing)

Ostracods obtain oxygen from the water by diffusion. Oxygen uptake is enhanced by the currents that the antennae and other appendages create, drawing water through the carapace.

Life cycle and reproduction

Some species lack males and the females reproduce by parthenogenesis. In other species, males range from rare to abundant. Males use their antennae to grasp the female during mating. Some species retain their eggs within the carapace where they are brooded until hatching, but most deposit the eggs onto the substrate.

Ostracod eggs are resistant to desiccation and can lie dormant for a number of years until conditions are favourable. Dry eggs have remained viable for 20 years in laboratory storage. The eggs hatch into small nauplius larvae that have bivalved carapaces like those of adults. The larvae moult eight times before reaching adulthood.

Habitat

Ostracods are found in all types of aquatic habitats-still and flowing, permanent and temporary, fresh and saline waters. Most species are benthic, but some are planktonic; many prefer to shelter in aquatic vegetation. Ostracods are tolerant of pollution and many species can live in waters with low oxygen levels. They are found in most water bodies throughout South Australia.

Critter facts

Ostracods fossilise very well and their fossils are used by geologists to help determine the age of sediments. Some marine species are 'bioluminescent', producing flashes of light. Ostracods have very long sperm. The genus *Pontocyprus* has sperm that are 6 mm long, which is remarkable for an animal that is only 0.3 mm in length. The Australian species, *Heterocypris sydnei*, is even more remarkable. At 10 mm long, this species has the largest sperm known for any animal.

Identification

The key starting on page 21 of *The Waterbug Book* should help you tell ostracods from other animals. In live samples, ostracods scurry about and, without closer observation, can easily be mistaken for mites. Ostracods are often mistaken for tiny bivalves, but the presence of jointed appendages, which are absent in molluscs, helps in identification. Conchostracans, or clam shrimps, also have bivalved carapaces, but they are usually much larger, have growth lines on the carapace and have between 10 and 30 appendages on the trunk. This is unlike ostracods, which have a maximum of two.

It is very difficult to identify ostracods to family or genus level as the internal structures of the animal need to be examined. This job is best left to the experts.

Classification and sensitivity

Phylum Arthropoda

    Class Crustacea

        Subclass Ostracoda (NR)

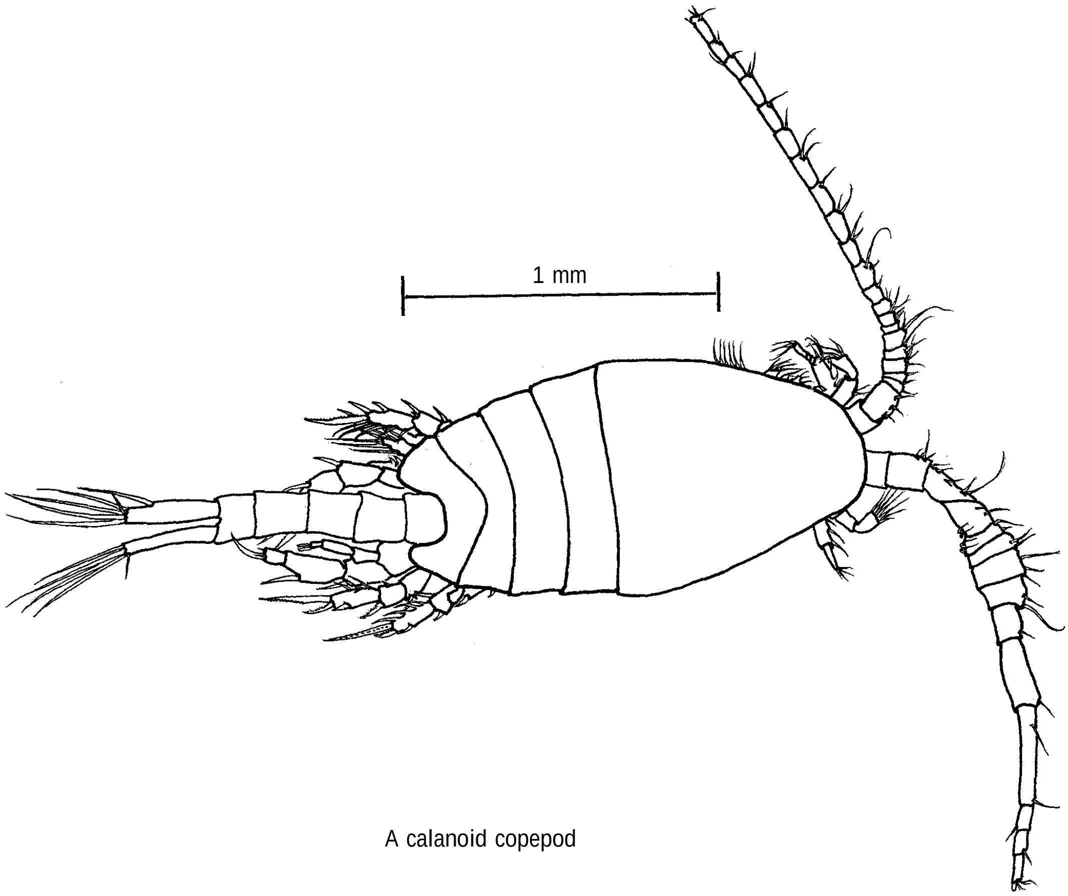
References

Hawking & Smith 1997, p 54; Williams 1980, p 135; Gooderham & Tsyrlin 2002, p 67.

10.5 Subclass Copepoda-copepods

Background

Copepods are found in marine, estuarine and freshwater environments. They are among the most abundant animals on earth. Worldwide, the group comprises ten orders, approximately 210 described families, 2280 genera, and over 14,000 species. Copepods are found in waters from alpine areas to subterranean caves, from fresh water bodies to hypersaline lakes, from shallow coastal waters to deep ocean trenches and as parasites of fish. Members of three orders of Copepoda-Cyclopoida, Harpacticoida and Calanoida-occur in the inland waters of South Australia. Fossil records of Copepoda date back to the Lower Cretaceous period, more than 100 million years ago.



A calanoid copepod

Size

Freshwater copepods grow up to 4 mm long, but usually are much smaller. Harpacticoids are the smallest, at about 1 mm long. The early life stages are very tiny and can be as small as 0.05 mm. Males are smaller than females.

Features

Copepods are small pear- or torpedo-shaped animals with obvious antennae that can be as long as their body. Attached to the thorax they have five pairs of legs that help them swim and grasp food. They usually have a single eye on the head. Copepods are often a pale green colour or translucent in appearance. Females frequently carry around their egg sacs, attached to the end of the abdomen, and this feature can be a useful guide to their identification.

Diet and feeding

Most freshwater species are filter feeders and eat detritus, bacteria and algae. A few are predatory, feeding on small copepods, rotifers and small cladocerans. Some copepods have sensors on their appendages that help them detect their prey. Strong mandibles are used to tear pieces from animals.

Locomotion

Copepods are strong swimmers, propelling themselves by beating their antennae in a rowing manner. They do not swim smoothly through the water, but instead swim in a jerky motion.

Gas exchange (breathing)

Copepods obtain oxygen from the water by diffusion through the body surface. A few species have a heart that pumps oxygenated fluids around the body, but many circulate these fluids by pulsing their digestive systems.

Life cycle and reproduction

Reproduction is thought to be mainly sexual. The male attaches a packet of sperm to the female and these fertilise the eggs as they are released. In some species, mating takes place after the female has undergone her final moult. A few dozen eggs can be produced in one brood and females often carry the eggs, attached to the end of the abdomen. The eggs are released anywhere from a few hours to a few days after mating has occurred and some species can produce eggs that are resistant to desiccation.

After a few days, the larvae, called nauplii, hatch from the eggs. The younger copepods are quite difficult to recognise as they look nothing like the adults. They are triangular and have only three appendages, which they use for feeding and swimming. Larvae go through several moults before reaching adulthood. After the fifth moult, the copepod is sexually mature and can reproduce. Copepods can undergo 11-12 moults in a lifetime.

Habitat

Like ostracods, copepods occur in still and flowing, permanent and temporary, fresh and saline waters. Some are benthic and others planktonic, and many prefer the shelter of aquatic vegetation. Some copepods are parasitic and can be found attached to fish and gastropods. Copepods are common and often abundant, and are found in most water bodies throughout South Australia.

Critter facts

The largest free-living copepods are marine and grow to 17 mm in length, but these are tiny compared to the largest parasitic types, which reach 32 cm long.

Identification

These crustaceans are quite small; close observation is necessary to see them without a microscope. The easiest way to recognise planktonic copepods without a microscope is by looking for small jerking 'Y'-shapes: these are the adult females with clusters of eggs attached to their tails. The key starting on page 21 of *The Waterbug Boo*k should help you tell copepods from other animals.

Identification of freshwater copepods to genus or species levels requires removal of the legs and scrutiny under a compound microscope. This requires a great deal of patience.

Classification and sensitivity

Phylum Arthropoda

Class Crustacea

Subclass Copepoda (NR)

References

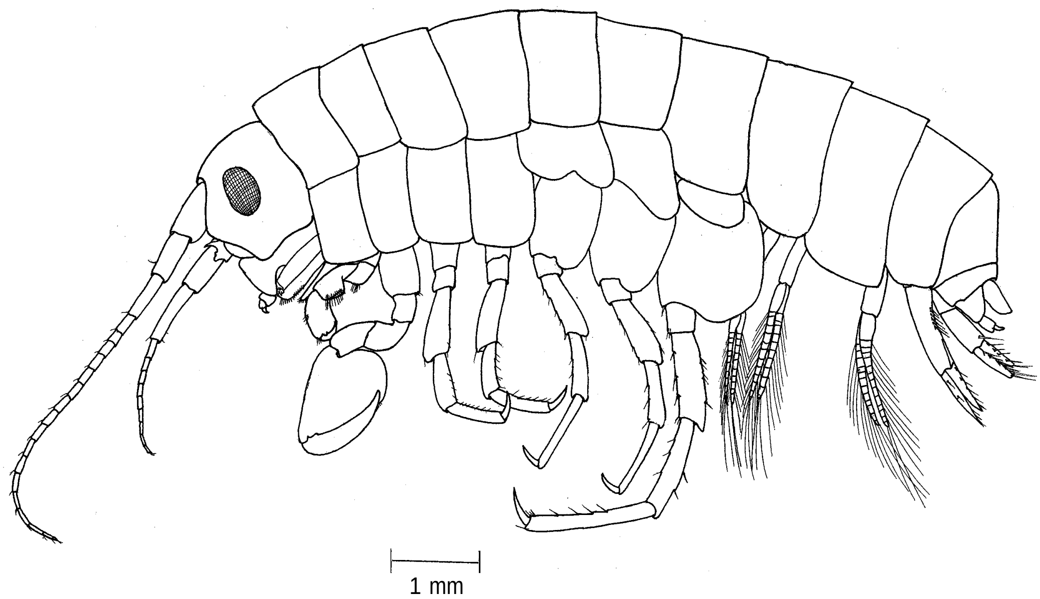
Hawking & Smith 1997, pp 55-59; Williams 1980, p 142; Gooderham & Tsyrlin 2002, p 65.

10.6 Order Amphipoda-scuds or side-swimmers

Background

Over 6000 species of Amphipoda have been found worldwide in marine, freshwater and terrestrial habitats. Nine families of aquatic Amphipoda occur in the inland waters of Australia and seven families are known to occur in South Australia. Beware that amphipods from the terrestrial family Talitridae sometimes slips into aquatic samples.

Amphipods are almost totally absent from the fossil records.



The side-swimmer *Austrochiltonia australis* (family Ceinidae)

Size

Amphipods range in length from 1 mm to 25 mm.

Features

Amphipods are flattened sideways and have a distinctive head and 13 body segments. They have two pairs of antennae and seven pairs of legs, the first two modified to grasp food. Gills are present on the thoracic segments, which are not covered by a carapace. They have three tail appendages, or 'uropods', at the end of the abdomen.

Amphipods have a heart with an open circulatory system. Glands on the antennae regulate the intake and excretion of salts.

Diet and feeding

Most amphipods are detritivores or scavengers. Some have been known to eat their own exoskeleton after a moult. They feed by grasping their prey with the modified front pair of legs. Their diet includes algae, detritus, small crustaceans and small insects.

Locomotion

Most freshwater amphipods can swim very strongly. They can also walk on and burrow into the sediments. Some of them swim sideways-hence the common name, 'side-swimmers'.

Gas exchange (breathing)

Amphipods have ventral gills on the thorax for gas exchange. Their blood contains the respiratory pigment haemocyanin, which aids in distributing oxygen throughout the body.

Life cycle and reproduction

Reproduction is sexual. Females are often seen carrying the smaller males around and have been observed to do so for a number of days. The female releases the eggs into thoracic brood chamber where they are fertilised. Females have broods of about 15-30 eggs at a time. There is no larval stage: the adult form develops directly from the eggs. After hatching, the juveniles are carried around by the adult female for only a few days. The young start to moult very soon after hatching and, in some species, may moult as soon as two days after hatching. Sexual maturity is usually reached around the sixth moult. As the female ages, the number of eggs that she lays after each moult increases. Not all eggs hatch; the mortality rate of eggs is 25-50%. Some amphipods have been known to live through 13 moults.

Habitat

Amphipods are found in still and flowing water and generally live on the sediment or in aquatic vegetation and organic debris. They have been found in waters ranging from fresh to twice the salinity of the sea. One species of amphipod, *Austrochiltonia australis* (Family Ceinidae), is tolerant of high salinity levels and is found in most streams and lakes of South Australia.

One species of Corophiidae was discovered recently in water bodies of South Australia, primarily in streams that are slightly saline to saline, as well as in estuaries. The family Perthiidae has also been found recently in the Onkaparinga catchment and in the Murray River at Woods Point. Previously, this family was known only from Western Australia.

Critter facts

One blind amphipod species, *Brachina invasa* (Family Melitidae), lives in interstitial spaces a metre below the gravel stream beds of the Flinders Ranges.

The largest amphipod was thought to be a marine species that reaches 14 cm in length; however, in 1968, a 28-cm-long benthic amphipod was discovered in the Pacific Ocean. It was detected in an aerial photograph taken from 5300 metres!

Identification

Amphipods may occasionally be confused with isopods, but in South Australia amphipods are flattened sideways (laterally), while isopods are dorso-ventrally flattened. In addition, amphipods have gills on the thoracic segments whereas isopods have gills on the abdominal segments. Another way to distinguish an amphipod from an isopod is to determine if it has three pairs of tail appendages (uropods) since isopods only have one. The most common amphipod in South Australia has a very small third uropod.

The key starting on page 21 of *The Waterbug Book* should help you tell amphipods from other animals; however, identification to family is tricky. If you have some spare time and a microscope you can try the key on page 71 of *The Waterbug Book*.

Classification and sensitivity

Phylum Arthropoda

- Class Crustacea
  - Order Amphipoda (3)
    - Family Ceinidae (2)
    - Family Melitidae (NR)
    - Family Eusiridae (7)
    - Family Corophiidae (4)
    - Family Perthiidae (NR)
    - Family Paramelitidae (4)
    - Family Neoniphargidae (4)

References

Hawking & Smith 1997, pp 60-61; Williams 1980, p 158; Gooderham & Tsyrlin 2002, pp 69-71.

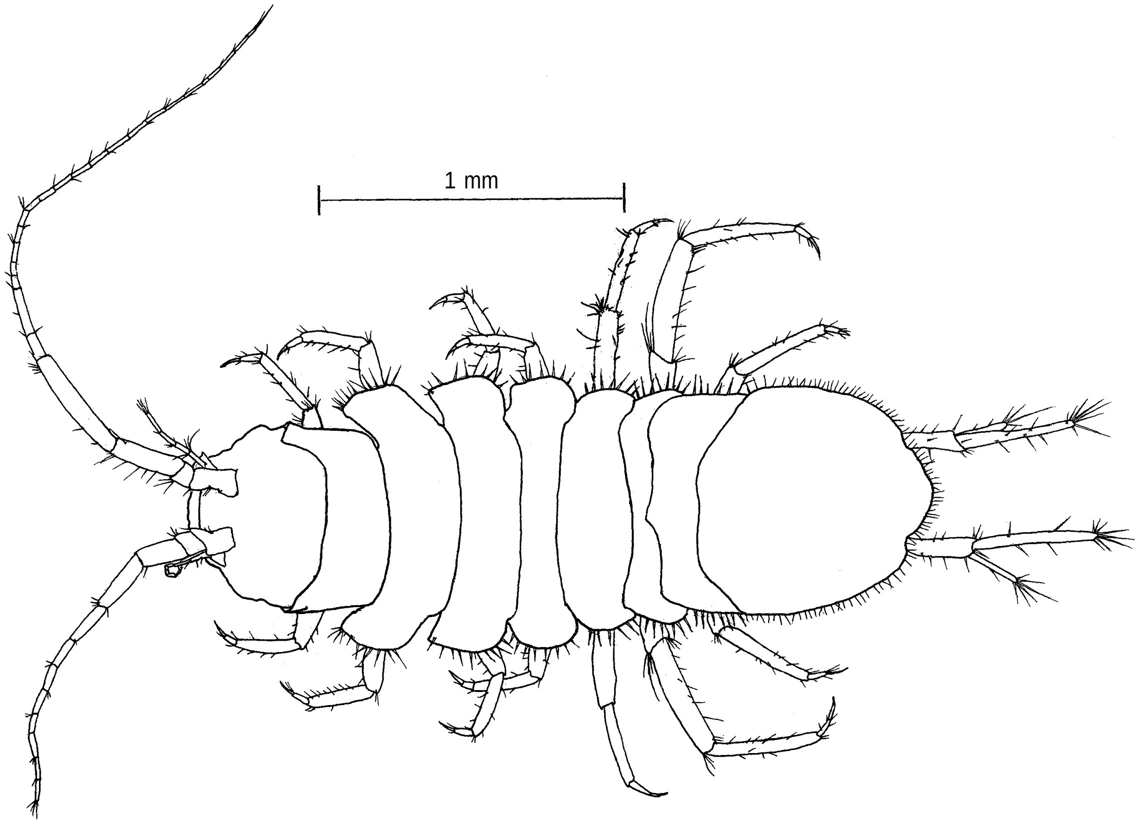
10.7 Order Isopoda-water slaters and sow bugs

Background

There are over 10,000 species of Isopoda worldwide. Most are marine and terrestrial but approximately 500 species have been found in freshwater systems. Isopods have been particularly successful in adapting to deep sea conditions. Their greatest diversity is seen in the ocean depths.

Twelve families are known to occur in inland waters of Australia, with four in South Australia. Three genera commonly found in South Australia are *Heterias* (Family Janiridae), *Haloniscus* (Family Oniscidae) and Austroargathona (Family Cirolanidae). A fourth genus, *Phreatomerus,* is found only in the mound springs of the Far North region of the state.

Fossil records of isopods date back to the Carboniferous period, 325 million years ago. Isopods have been living in fresh waters since the Triassic period and species present today are very little different from Triassic forms.



The isopod *Heteria pusilla* (family Janiridae)

Size

Isopods range from 2 mm to 12 mm in length.

Features

Isopods are usually strongly dorso-ventrally flattened, although some can be laterally flattened. They have a distinct head, which may or may not have eyes. They do not have a carapace. They have seven pairs of walking legs. The first two pairs of legs on the abdomen are different in males and females: in males, they are modified to transfer sperm to the female. Gills are present on the abdominal segments. Isopods have two pairs of antennae, the first of which are usually chemical sensors. Isopods have a circulatory system with a large heart.

Diet and feeding

Isopods are mainly herbivorous, feeding on small pieces of dead and decomposing plants, although some also feed on animals. In some species the first pair of legs on the thorax is modified for grasping prey.

Locomotion

Some of the legs of isopods are adapted for crawling while others are adapted for swimming. They often burrow into submerged root mats and gravel. The more primitive short-tailed forms are clumsy movers, but long-tailed isopod species are highly mobile and frequently leave their benthic shelter to swim short distances through the water. Their elongate tails and broad uropods assist in swimming.

Gas exchange (breathing)

Isopods obtain oxygen across the surface of gills that are associated with the abdominal appendages. Like amphipods, isopod blood (haemolymph) contains the respiratory pigment haemocyanin. Most excretion occurs by diffusion through the body wall.

Life cycle and reproduction

Reproduction is sexual and fertilisation occurs inside the female. The eggs are incubated in a brood pouch inside the female. Like amphipods, isopods have no larval stage, adults developing directly from the egg through several moults. Isopods are unable to produce resting eggs, but some species are able to burrow into the sediments to wait out unfavourable conditions.

Habitat

Isopods generally crawl around on the bottom of water bodies. They inhabit streams, pools and lakes, ranging from fresh to very saline waters. Some prefer spring-fed streams.

The genus *Haloniscus* resembles the terrestrial slater and is often found in saline waters; other members of this family are terrestrial. The other two genera commonly found in South Australia prefer freshwater systems. *Austroargathona* is restricted to the Murray River; in their juvenile stages, species of *Austroargathona* are parasitic on the decapods, *Paratya* and *Macrobrachium*, which are very common in the River Murray. *Heteria*s can be found in many water bodies throughout South Australia, even those that are slightly polluted.

Critter facts

The largest isopod is a marine species that reaches a length of 42 cm and width of 15 cm. Some marine isopods bore into wood and can cause damage to boats, jetties and other structures.

The fossil record indicates that the earliest isopods (and the most primitive living species) are members of the suborder Phreatoicidea. Today, phreatoicids are freshwater crustaceans that are restricted to the southern hemisphere: most species occur in the rivers and lakes of Australia. The species that occur in the mound springs of the Far North region of South Australia are part of this group.

Identification

In South Australia aquatic isopods are flattened dorso-ventrally and can be recognised quite easily-some species look like terrestrial slaters. In comparison, amphipods are flattened sideways. Isopods can also be separated from amphipods by the presence of gills on the abdominal segments, rather than thoracic segments. See the key starting on page 21 of *The Waterbug Book* for further guidance.

The three commonly found genera in South Australia, *Heterias* (Family Janiridae), *Haloniscus* (Family Oniscidae) and **Austroargathona** (Family Cirolanidae), are quite easy to tell apart. Comparison with the photographs on pages 62-64 of the *Colour Guide to Invertebrates of Australian Inland Waters* should result in a correct identification.

Classification and sensitivity

Phylum Arthropoda

- Class Crustacea
  - Order Isopoda (2)
    - Family Janiridae (3)
    - Family Oniscidae (2)
    - Family Cirolanidae (2)
    - Family Sphaeromatidae (NR)

References

Hawking & Smith 1997, pp 62-65; Williams 1980, p 155; Gooderham & Tsyrlin 2002, pp 72-73.

10.8 Order Decapoda-crabs, crayfish, yabbies, freshwater prawns and freshwater shrimps

Background

Decapods are well known to most people as a tasty food. Crabs, crayfish, prawns and shrimps all command high prices at fish markets. Worldwide, there are over 10,000 species of Decapoda, which figure represents about a quarter of the total number of described crustacean species. The majority of these species are marine, but many others occur in inland waters. There are six families of freshwater decapods that occur in the inland waters of Australia, four of which occur in South Australia. Fossil records date back to the Jurassic period, about 150 million years ago.

Size

Decapods range in size from small juveniles about 2 mm long to large crayfish that can grow to lengths of more than 300 mm.

Features

Decapods have a prominent carapace that covers all the thoracic segments. The first three appendages on the thorax are modified to assist with feeding. They have five pairs of thoracic legs, from which feature the name is derived-Decapoda means ‘ten legs’. The first or second pair of legs (depending on the species) is enlarged and modified for feeding and grasping prey. The eyes are on stalks. Some decapods have a prominent ‘rostrum’, a projection that is oftern serrated, extending from the front of the head. The abdomen of decapods often has a tail fan. The freshwater crab is the exception, with only a small rostrum and no tail fan.

Diet and feeding

Decapods use either their first or second pair of legs for feeding. The legs have pincers at the end to help grasp prey. The decapod diet includes insect larvae and adults, other crustaceans, snails and fish. Some species feed on plant material and are able to scrape algae off rocks and submerged vegetation.

Locomotion

Decapods are not very able swimmers; they prefer to climb among submerged water plants and walk along the bottom of the water body. Many are able to get out of dangerous situations quickly by flicking their tail fans and darting backwards.

Gas exchange (breathing)

Decapods obtain oxygen by diffusion, using gills at the base of their thoracic segments. Thoracic appendages beat to produce a current of water across the gills. As water flows over the surface of the gills, oxygen is extracted. The blood of decapods contains haemocyanin, which aids in the transport of oxygen throughout the body of the animal.

Life cycle and reproduction

The sexes of decapods are separate, and mating usually occurs after a moult. Pheromones are released to attract the opposite sex to initiate mating. All decapods lay eggs. The eggs are carried around by the female, attached to the underside of her body. When the juveniles hatch, they often remain attached to the female for a few days. Juveniles look similar to the adults, but are smaller. The juvenile goes through numerous moulting stages when young, but the animal moults less frequently as it ages. As the juvenile grows, the number of appendages increases and gradually it becomes more like the adult. These moulting stages are vital for the growth of appendages, even in the adult stage. It is not uncommon for a decapod to lose an appendage such as a leg or claw, and this can be regrown over a few moults.

Habitat

The Parastacidae can be found in burrows along the bottom and sides of a water body, and in waters with clay or sandy sediments. Members of other decapod families can be found among water plants, usually clinging to the leaves or stems that are underwater. Sometimes they can be found in the undercutting of banks. They are usually found in fresh water, but are tolerant of slightly saline waters. Decapods are common throughout South Australia, living mainly in vegetated, still or slow-flowing waters.

Critter facts

Marron, a member of the family Parastacidae and native to Western Australia, has been introduced into South Australia. It resembles the South Australian yabbie. It is farmed on Kangaroo Island and can be eaten at some of the cafes on the island. Unfortunately, it is not restricted just to the farming dams but can be found in many of the streams on Kangaroo Island as well as on the Fleurieu Peninsula.

Identification

Freshwater decapods are quite similar to marine decapods in appearance. Freshwater shrimps and prawns are usually translucent when alive; they have a thin carapace and long rostrum, usually with spikes or teeth along the upper and lower surfaces. Freshwater crayfish and yabbies have a hardened carapace and are usually brownish in colour; they have very large claws on the first pair of legs.

Freshwater crabs are usually quite small and white or yellow in colour; they have a carapace that covers the whole body except the legs, and a small rostrum that appears as a bump between the eyes. See page 78 of The Waterbug Book for a key to the families of Decapoda.

Classification and sensitivity

Phylum Arthropoda
- Class Crustacea
  - Order Decapoda (4)
    - Family Atyidae (3)
    - Family Palaemonidae (4)
    - Family Hymenosomatidae (3)
    - Family Parastacidae (4)

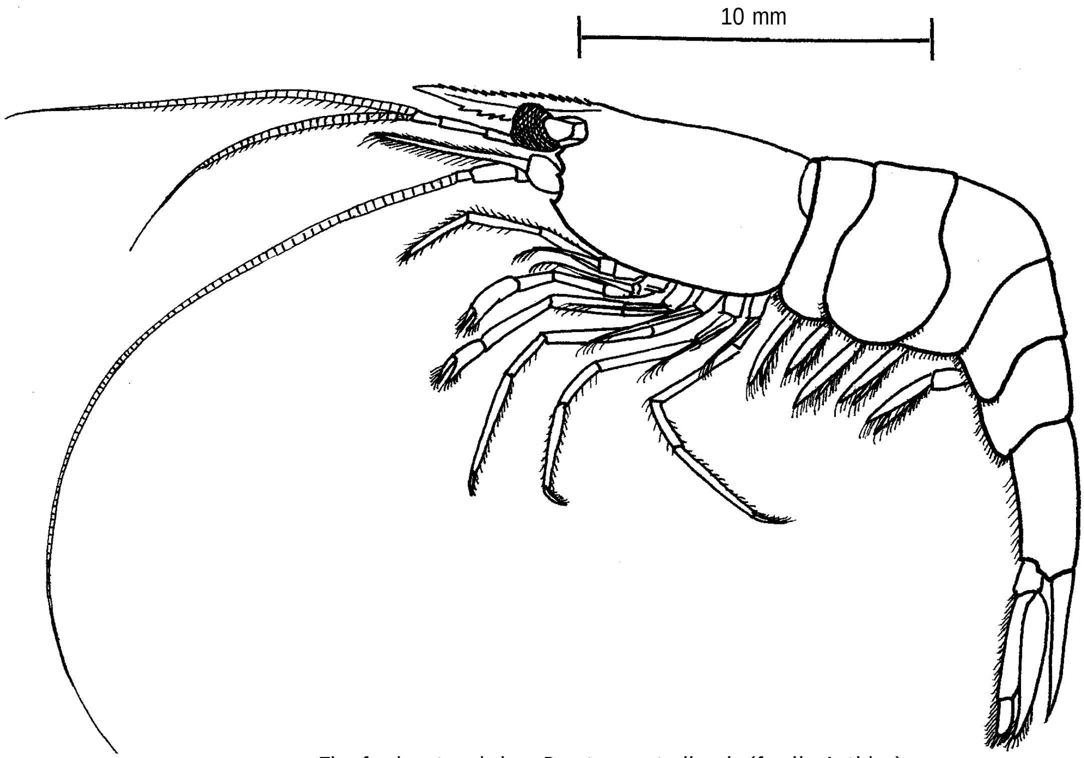
References

Hawking & Smith 1997, pp 66-73; Williams 1980, p 161; Gooderham & Tsyrlin 2002, pp 77-83.

Family Atyidae-freshwater shrimps

Background

This family is found throughout the world. Members of eight genera can be found in inland waters of Australia and at least two genera are found in South Australia. The most common species is *Paratya australiensis*, but species of the genus *Caridina* are also found in South Australia.



The freshwater shrimp *Paratya australiensis* (family Aytidae)

Size

Atyids can grow to about 35 mm long. The males are slightly smaller than the females.

Features

Freshwater shrimps have a prominent rostrum that has teeth or spikes along the upper and lower rostrum ridges. The first two pairs of legs are similar, with pincers on the ends. These pincers are tipped with tufts of long hairs. The atyid body is flattened sideways and the end of the tail resembles a fan. These shrimps are usually transparent and can camouflage well.

Diet and feeding

Freshwater shrimps feed on animal and plant material. They scrape algae and detritus from rocks and water plants, which they pick up with their pincers. They are also able to filter food particles from the water.

Locomotion

Freshwater shrimps walk well, grasping the substrate with their pincers. They also cling and climb up the stems of submerged water plants. Shrimps are able to escape danger by beating the tail fan and shooting quickly backwards. They can also swim by beating the abdominal appendages.

Gas exchange (breathing)

Atyids obtain oxygen by diffusion from the water, using gills at the bases of thoracic appendages. The appendages beat to produce a flow of water over the gills.

Life cycle and reproduction

The sexes are separate, although some species develop as males first and then transform into females. When shrimps mate, they are usually oriented at right angles to each other. In summer, females produce 50-200 eggs, which they attach to their abdominal appendages. The larvae are planktonic and, with high flow, may be swept downstream to develop in an estuary until they are big enough to swim upstream. The larval stage can last up to 45 days. Females sometimes produce two broods of young in a season. Freshwater shrimps live for up to two years.

Habitat

Freshwater shrimps are widespread and can usually be found in the ponded sections of lowland rivers and streams. They mostly shelter among aquatic plants, but have also been found in open waters. Members of the genus *Paratya* are found throughout South Australia in many still waters and are very common in the River Murray. The genus *Caridina* is not as widespread, but has been found in the River Murray as well as in streams in the Flinders Ranges. One species of *Caridina* lives in thermal pools in central Australia. Some atyids are moderately tolerant of water pollution, particularly of increased nutrients.

Critter facts

Freshwater shrimps can be kept in home aquaria. They feed on fish food and apparently have a liking for soft-boiled zucchini.

Identification

Atyids can easily be confused with members of the family Palaemonidae (freshwater prawns). Palaemonids have larger spines on the rostrum and much longer chelae (claws or 'nippers'). Atyids have a very obvious tuft of hair on both the first and second pair of legs that is absent in palaemonids. Juvenile atyids are indistinguishable from juvenile palaemonids. See page 78 of *The Waterbug Book* for a key to the families of Decapoda.

Classification and sensitivity

Phylum Arthropoda

- Class Crustacea
  - Order Decapoda
    - Family Atyidae (3)

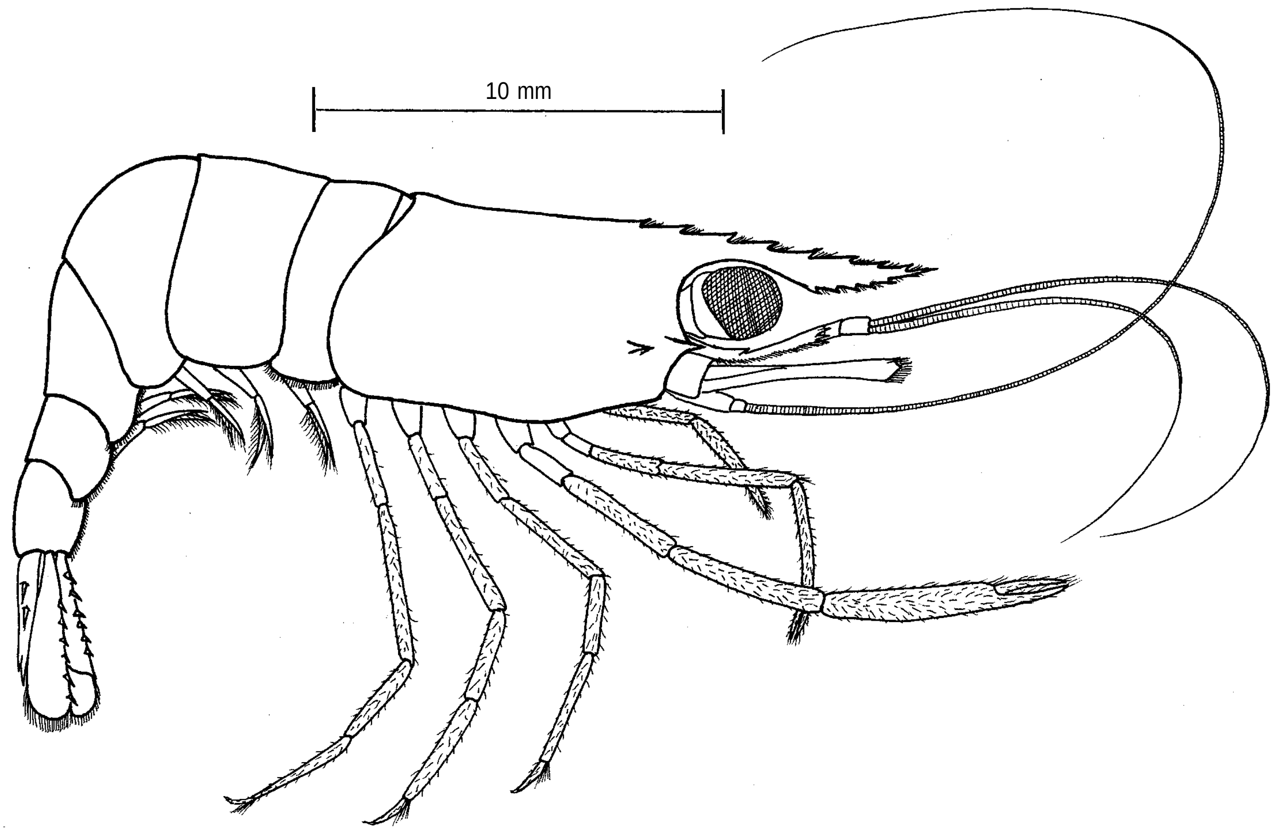
References

Hawking & Smith 1997, pp 66-68; Williams 1980, p 164; Gooderham & Tsyrlin 2002, p 80.

Family Palaemonidae-freshwater prawns

Background

Palaemonids occur worldwide; in some countries they are economically important and are cultured as a food source and as aquarium pets. All members of this family occur in fresh waters. There are four genera of freshwater prawns in Australia, but only one genus, *Macrobrachium*, occurs in South Australia.



The freshwater prawn *Macrobrachium australiense* (family Palaemonidae)

Size

Adults can grow up to 65 mm long. Juvenile palaemonids can be around 2 mm long. Adult males are larger than adult females.

Features

Freshwater prawns have a prominent rostrum that protrudes from between their eyes. The carapace covers their head and thorax, and the eyes are on stalks. Palaemonids are translucent when young and turn to a bluish-brown as they grow older. They have long thin legs; the first pair is longer than the second and has larger pincers.

Diet and feeding

Freshwater prawns are omnivores. They feed on algae and detritus, which they scrape from rocks and stems of water plants; using their long pincers, they are also able to catch prey. These crustaceans feed on larval and adult insects, algae, worms, molluscs, fish and faeces of fish. They tend to eat animals smaller than themselves. At high densities, or when there is a shortage of other food, freshwater prawns become cannibalistic.

Locomotion

Freshwater prawns are able to crawl along the bottom of a water body or cling to water plants, using the pincers on their legs. They are also able to swim by flicking through the water.

Gas exchange (breathing)

Palaemonids have gills at the base of their thoracic appendages. The appendages beat the water and produce a current over the gills.

Life cycle and reproduction

The sexes are separate and mating occurs between a hard-shelled male and a soft-shelled female, the female mating shortly after she has moulted. Females reach reproductive maturity at about six months of age. The male deposits a jelly coated sperm sac in between the female’s fourth pair of walking legs. Eggs are laid a few hours after mating and are fertilised after they are laid. A female can lay 30,000 eggs in a lifetime.

Once fertilised, the eggs are transferred to the brood chamber of the female, which is situated under the abdomen or tail of the animal. There, they are kept aerated and clean by the swimming appendages on the tail. The eggs remain attached to the female until they hatch, approximately 20 days after being laid. The young are similar in appearance to the adults and feed almost continuously on zooplankton, worms and small insect larvae. They go through 11 moulting stages, which can take up to 40 days. The juveniles spend all their time suspended in the water column but, with maturity, become bottom-dwelling organisms.

Habitat

Palaemonids are quite common in the larger rivers of South Australia, such as the River Murray, and Cooper Creek in the Far North region of the state. They can be found among submerged water plants in larger slow-flowing rivers and still waters, and they tolerate elevated salinity. All their life stages are vulnerable to desiccation and so they tend to be more common in permanent waters.

Critter facts

Freshwater prawns have been known to respond to the presence of people in the River Murray. People who have waded into the water with bare legs have felt the prawns crawling on their skin and, on occasions, have felt a prawn nip them.

Identification

Palaemonids can be confused easily with atyids (freshwater shrimps). Palaemonids have larger spines on the rostrum and much longer pincers; atyids have a very obvious tuft of hair on both the first and second pair of legs that is not present in palaemonids. However, juvenile palaemonids are very difficult to distinguish from juvenile atyids. See page 78 of *The Waterbug Book* for a key to the families of Decapoda.

Classification and sensitivity

Phylum Arthropoda

Class Crustacea

Order Decapoda

Family Palaemonidae (4)

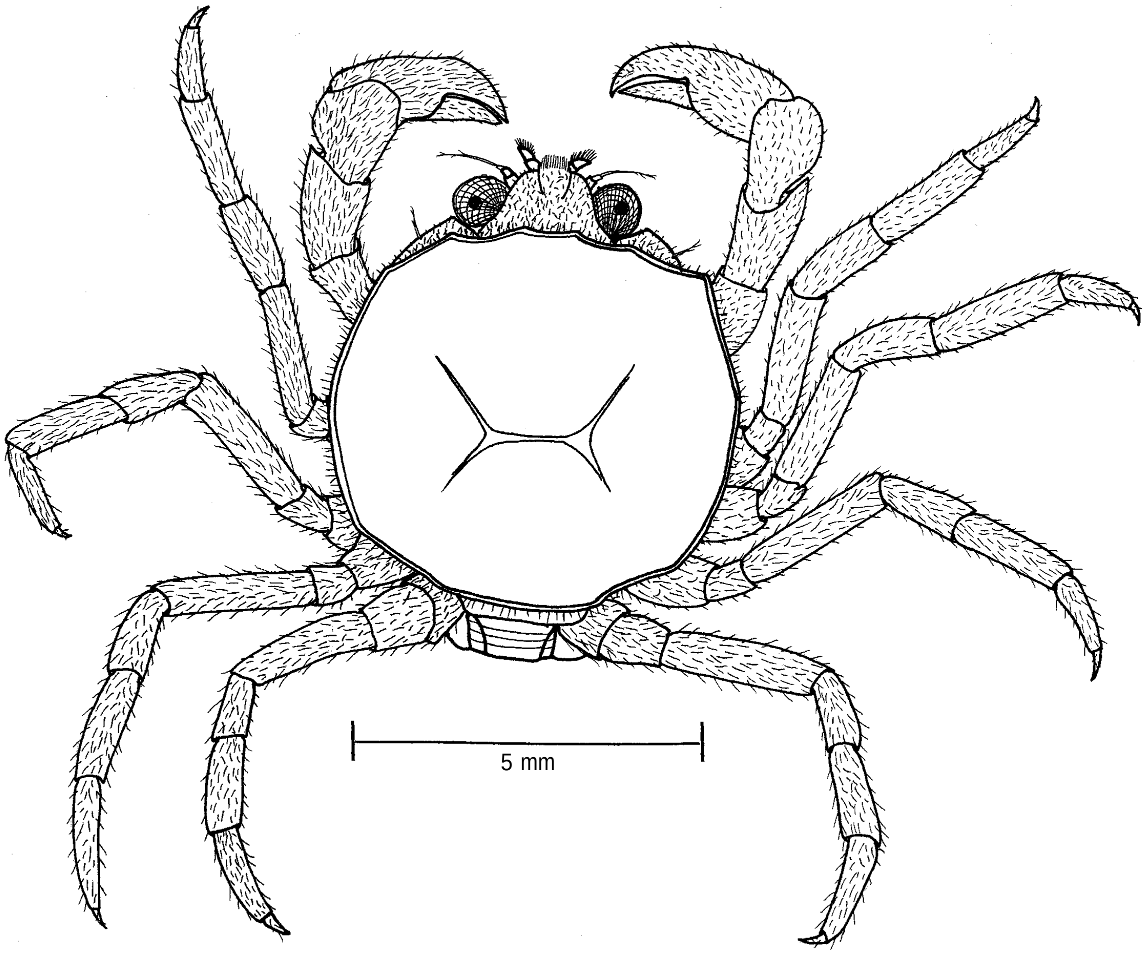
References

Hawking & Smith 1997, pp 66-68; Williams 1980, p 166; Gooderham & Tsyrlin 2002, p 81.

Family Hymenosomatidae-small spider crabs

Background

Throughout the world, there are only 50 species in the family Hymenosomatidae, and 46 of these are either marine or estuarine. One genus, Amarinus, occurs in South Australia. Fossil records of these crabs date back to the Palaeocene epoch of the Caenozoic era, up to 65 million years ago.



The freshwater crab *Amarinus lacustris* (family Hymenosomatidae)

Size

Members of *Amarinus* grow to 8 mm wide.

Features

Freshwater crabs are rounded and dorso-ventrally flattened. They have a very reduced rostrum, compared with those of shrimps and crayfish, that appears as just a slight bump between the eyes. Freshwater crabs have eight legs and two large claws. Their abdominal segments are reduced, tucked up under the body, and lack appendages. The front of the carapace is somewhat pointed, not rounded as in other freshwater crabs.

Diet and feeding

Freshwater crabs are omnivores, feeding on algae, roots and submerged plants as well as amphipods and microcrustaceans.

Locomotion

Crabs walk well and can burrow. Some can swim sideways quite quickly.

Gas exchange (breathing)

Members of the genus *Amarinus* obtain oxygen across the surface of their gills. Haemocyanin, a respiratory pigment, present in the blood, aids in transporting oxygen throughout the body.

Life cycle and reproduction

Freshwater crabs usually mate face to face: the female is pinned on her back by the male. Unlike marine crabs, young of *Amarinus* hatch directly from eggs carried under the folded tail of the mother. Hatching takes place after about 55 days. Females can produce up to three broods per season. The young go through a series of moulting stages, growing in spurts rather than continuously. Crabs are very vulnerable when they have just moulted because the new carapace is soft and usually take a few days to harden. Through the moulting stages, they are able to regrow a claw if one is lost.

Habitat

Freshwater crabs can be found in both flowing and standing waters. The genus *Amarinus* is often found in slightly saline to saline waters, in association with rocks or submerged water plants. These spider crabs have also been found where the water plant, *Cotula coronopifolia* (known as ‘water buttons’), is growing. In South Australia, this plant is not very common, but it occurs in coastal drains of the South East region and also in the River Murray.

Critter facts

Some freshwater crabs are important vectors of the deadly disease Paragonimiasis, which affects about 20 million people worldwide. This disease is caused by a lung fluke that lives in the crab.

The Japanese spider crab has a four-metre leg span, the largest of any crustacean.

Identification

Freshwater crabs resemble marine crabs, all having ten legs and a hardened shell covering the entire body. The first pair of legs are modified for feeding: they have claws to grasp prey. Crabs are easy to separate from other decapods. If you are having trouble, see page 78 of *The Waterbug Book* for a key to the families of Decapoda.

Only the genus *Amarinus,* family Hymenosomatidae, occurs in South Australia, but in the northern parts Australia, these crabs may be confused with members of another family of freshwater crabs, the Sundathelphusidae. Sundathelphusids have a square body and lack the small rostrum between the eyes.

Classification and sensitivity

Phylum Arthropoda

Class Crustacea

Order Decapoda

Family Hymenosomatidae (3)

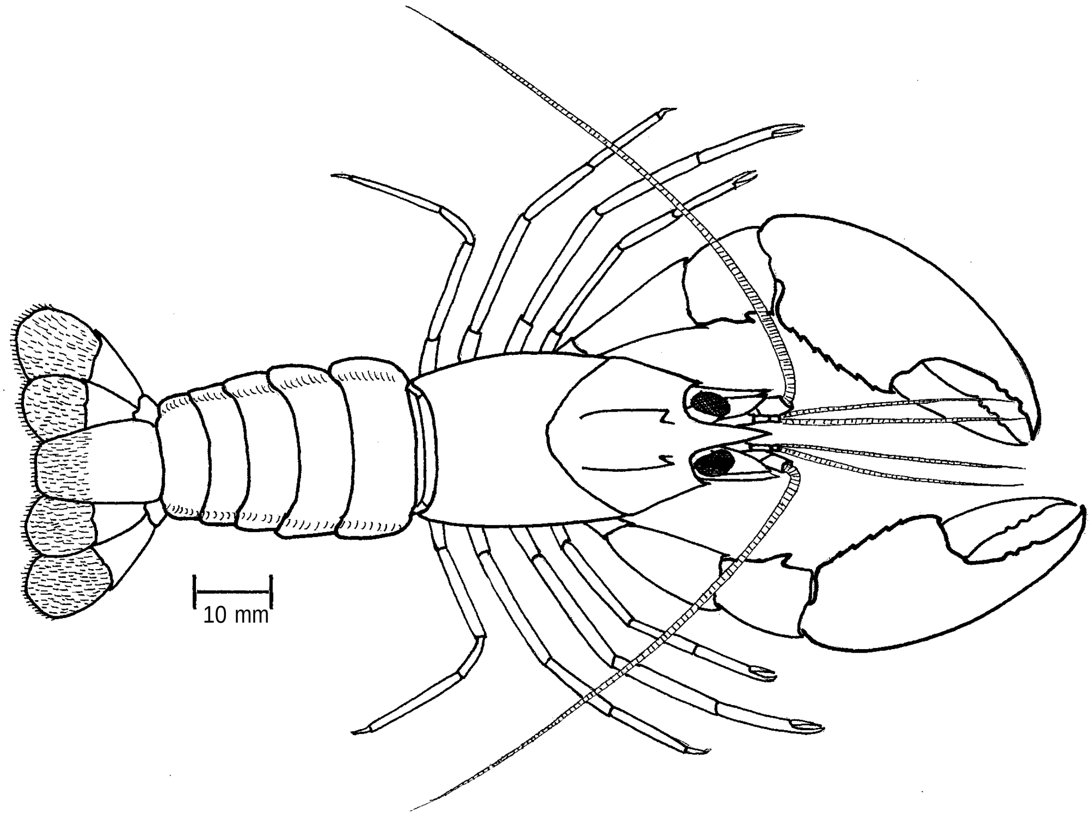
References

Hawking & Smith 1997, pp 69-70; Williams 1980, p 172; Gooderham & Tsyrlin 2002, pp 81-82.

Family Parastacidae-freshwater crayfish and yabbies

Background

There are 500 species of Parastacidae throughout the world; all members of this family occur in fresh water. Nine genera are found in Australia. In South Australia, the yabbie, *Cherax destructor,* is the most common species. In addition, an introduced species of the genus *Cherax* can be found in some parts. The large Murray crayfish, *Euastacus armatus*, which used to be quite common, is now quite rare.



The yabby *Cherax destructor* (family Parastacidae)

Size

Adults of the Murray crayfish grow to more than 300 mm long: it is the second-largest freshwater crustacean in the world. Yabbies grow to 200 mm in length.

Features

Freshwater crayfish have a prominent dorso-ventrally flattened rostrum projecting from the front of the head. The abdomen has a tail fan, and the legs are well developed, the first pair having large claws. The crayfish and yabbie are usually brown in colour, but may also be bluish, and their shells are thickened and hardened by the deposition of lime salts.

Diet and feeding

Freshwater crayfish feed on both plant and animal matter, including molluscs and fish, and adult and larval aquatic insects. They are predatory, but also scavenge on dead animals if they are available.

Locomotion

Parastacids do not swim, but prefer to walk along the stream or river bottom. They are strong walkers and burrowers. Yabbies can burrow in sediments, usually clay, to a depth of 50 cm- often yabbie burrows can be seen in the beds of streams and ponds. Yabbies and crayfish are able to escape rapidly from danger by flicking the tail and darting backwards. Adult crayfish have been known to roam the banks of creeks for a period of time and to move from one water body to another if conditions become unfavourable.

Gas exchange (breathing)

The gills are covered by the carapace, which forms a branchial chamber along the side of the body. Each gill has a stem that gives rise to numerous filaments, across the surfaces of which oxygen diffuses from the water. Parastacids have colourless blood that is drawn into the heart, which then pumps it out along arteries to parts of the body. It then passes into an open system of sinuses before returning to the heart. The blood contains haemocyanin, which aids in the transportation of oxygen.

Life cycle and reproduction

Freshwater crayfish reach sexual maturity when they are between five and eight years old; freshwater yabbies, however, start to reproduce at a much younger age. Mating in crayfish and yabbies usually occurs face to face: the male turns the female on her back and pins her down with his claws. Females can carry a large number of eggs, sometimes as many as 1200. Crayfish females carry the young under the tail for up to five months, between May and October. Yabbie females carry their young from October to March. The young hatch from eggs as miniature adults while still attached to the female and can remain attached for several days. Juveniles moult several times and grow in spurts. After moulting, for the few days during which the new carapace is still soft, the animal absorbs a lot of water and increases in size. Many juveniles fail to reach adulthood as they are consumed by birds and fish.

Habitat

Freshwater crayfish and yabbies live in most types of aquatic systems. They prefer water bodies with softer sediments into which they can burrow. They can survive over dry periods in these burrows. Crayfish prefer faster flowing waters that are well oxygenated. Yabbies can survive in either temporary or permanent still waters and in waters with low oxygen levels. Yabbies are found quite commonly throughout South Australia. The marron, which is similar to the yabbie, but a native of Western Australia, has been introduced to the waters of Kangaroo Island and some streams on the Fleurieu Peninsula. Murray crayfish numbers are declining in South Australia; they are now only rarely found downstream of Mildura.

Critter facts

Some crayfish live on land for long periods of time. They have been known to burrow into people's lawns. It has been said that the world's smallest and largest crayfish occur in Australia: a species in Queensland reaches a maximum length of 25 mm, while a Tasmanian species reaches 400 mm.

The largest freshwater crayfish in the world is the giant Tasmanian freshwater crayfish, *Astacopsis gouldi,* which grows to at least 400 mm in length and 3.6 kg in weight, and has even been recorded at over 6 kg. It used to be fished but, due to its declining numbers, sensitivity to habitat disturbance, and very long life cycle, it is now a protected species. Females mature after 14 years and the smaller males after about 7-9 years. They are thought to live for up to 60 years.

Some species of crayfish are burrowers and are often referred to as terrestrial or land crayfish. These crayfish occupy an amazing variety of habitats, usually in areas with relatively high rainfalls. The burrows sometimes have a 'chimney' of pelleted soil at the opening.

If a crayfish or yabbie looses a claw it can grow back. It will slowly increase in size over a few moults, eventually returning to its appropriate size.

Fishers who catch freshwater crayfish in Australia should remember that some species are protected and there may be bag and size limits. Small specimens should be put back, and females that have eggs under their tails are likely to be protected and must be returned to the water. Make sure you are familiar with the laws in your state before you go fishing.

Identification

Parastacids are similar to atyids and palaemonids in structure, but are much larger and more robust looking. The first pair of legs in parastacids have large claws. The exoskeletons of parastacids are much harder and darker in colour than the exoskeletons of atyids and palaemonids. See page 78 of *The Waterbug Book* for a key to the families of Decapoda.

Classification and sensitivity

Phylum Arthropoda

    Class Crustacea

        Order Decapoda

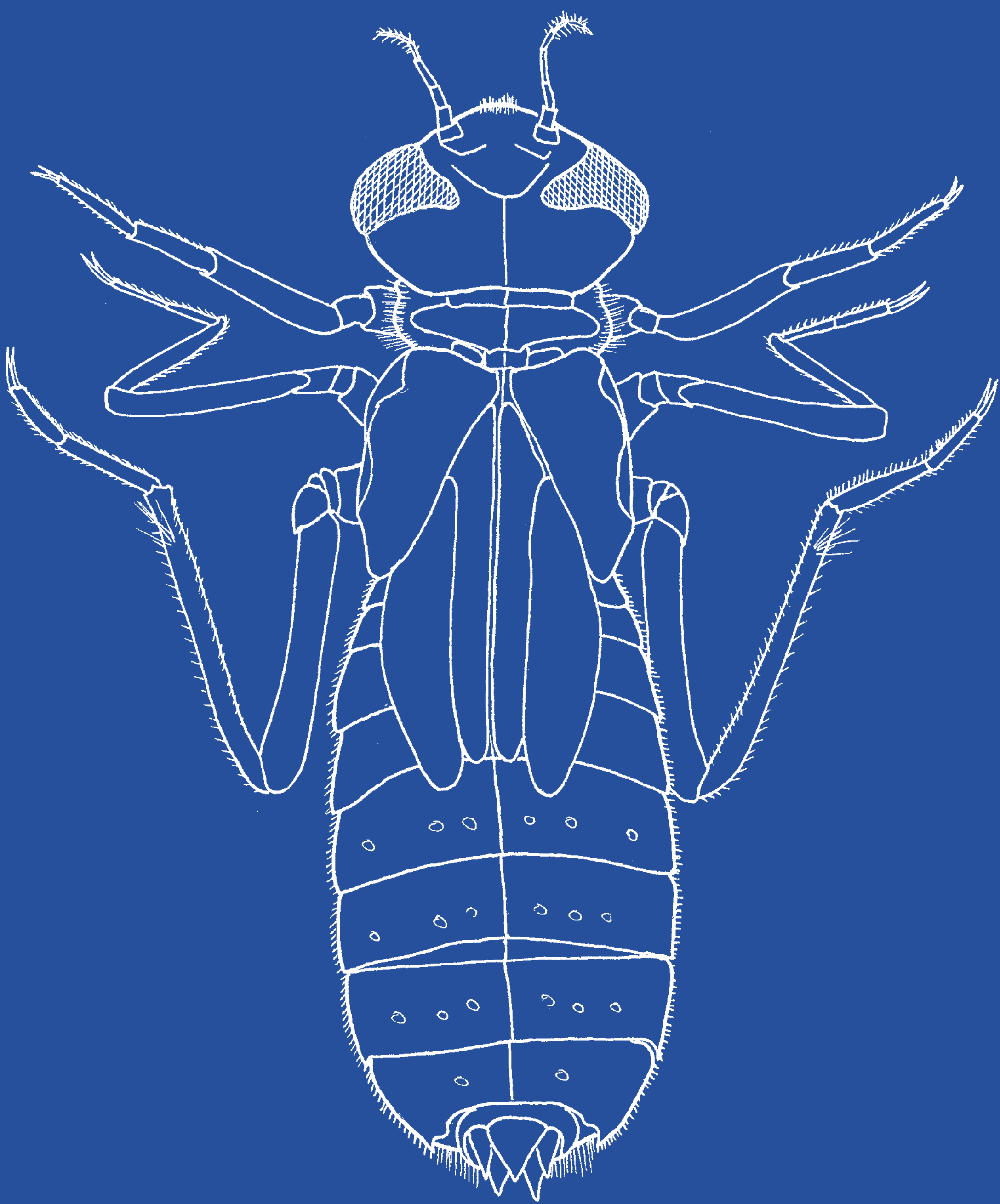
            Family Parastacidae (4)

References

Hawking & Smith 1997, pp 71-73; Williams 1980, p 167; Gooderham & Tsyrlin 2002, pp 82-83.

ENVIRONMENT PROTECTION AUTHORITY

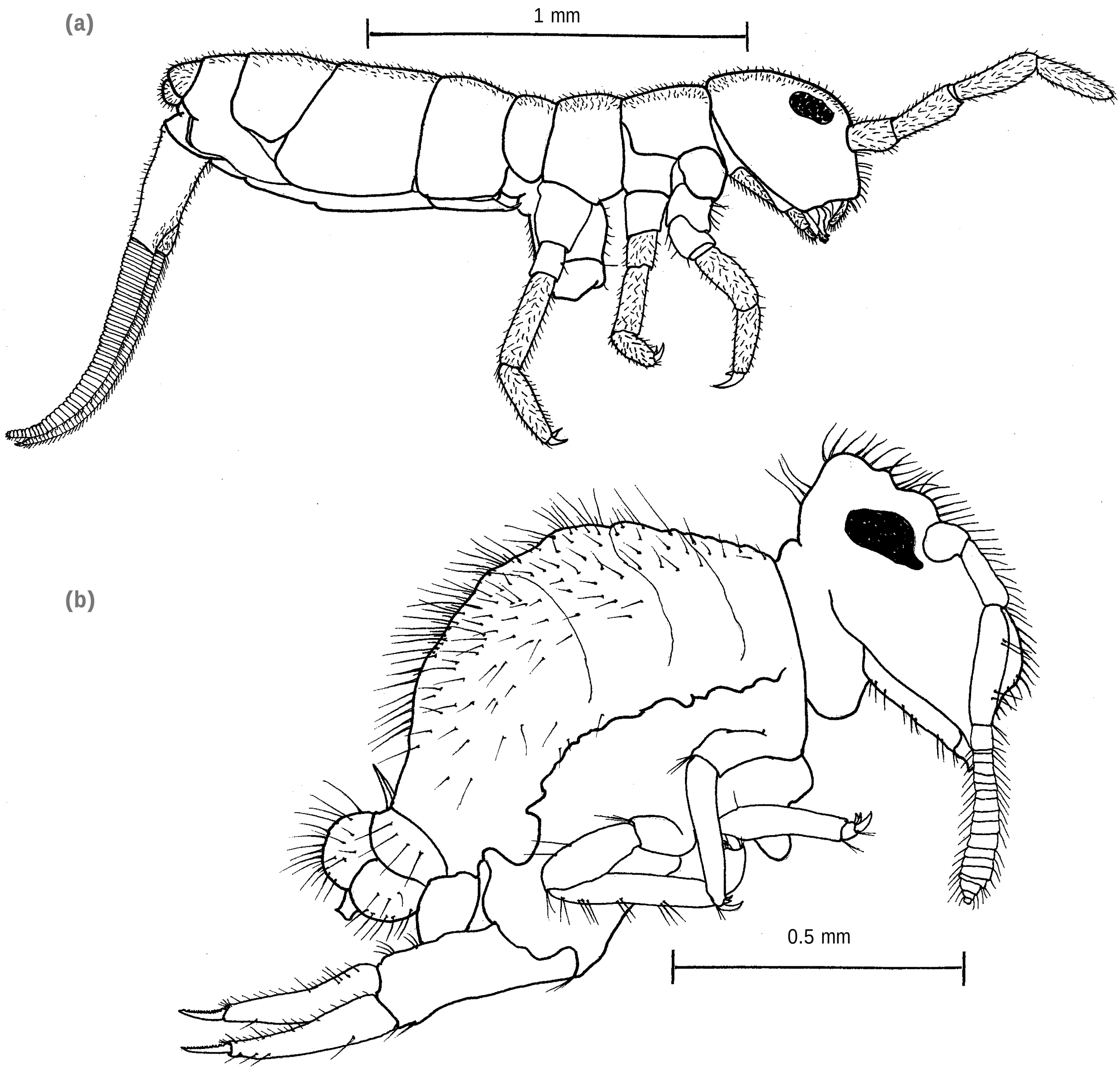
Insects and springtails



11 Class Collembola-springtails

Background

Over 6000 species of Collembola are known worldwide, and 1630 species are known from Australia. Most of these live in soil, vegetation and leaf litter. There are fourteen families in Australia and almost all of these may end up in aquatic samples; however, the vast majority of these are not aquatic. Five families appear to contain aquatic species and all of these occur in South Australia. Collembolans are not fully aquatic as they live on the surface of the water and do not swim under the water. The earliest known fossil Collembola are from the Lower Devonian period, about 370 million years ago.



Members of the springtail families: (a) Isotomidae and (b) Sminthuridae

Size

Adults are rarely more than 3 mm long.

Features: Springtails are small, wingless arthropods. Their body shape ranges from elongate to globular. They have six legs and one pair of antennae. Their small size and 'hydrophobic' (water-repellent) hairs and scales keep them afloat on the water surface. Their most interesting feature is a spring-loaded tail, called a 'furcula', extending from the rear of their abdomens. The furcula is used in jumping. Collembolans have a ventral tube called a 'collophore' on the underside of the first abdominal segment. It is believed that this tube has a number of functions, including to help maintain salt and water balance in the animal. Collembola range in colour from purple, pink, black to white.

Diet and feeding

Most springtails feed on micro-organisms associated with decaying plant matter. Some aquatic species feed on plankton and algae trapped in the surface film of water. Most are collectors and gatherers. They have primitive chewing mouthparts; in some species these are modified for piercing and sucking.

Locomotion

When disturbed, springtails can use their furcula to jump considerable distances relative to their small size. They have been known to jump over 30 cm into the air at an initial velocity of 1.4 metres per second.

Gas exchange (breathing)

Only a few species of springtails have tracheal systems and 'spiracles'-that is, external respiration orifices. Most exchange gases through their skins by diffusion.

Life cycle and reproduction

Depending on the species and the temperature, springtails can take from one week to two years to reach adult size. However, most springtails live for a year or less.

Some springtails reproduce asexually by parthenogenesis. Most reproduce sexually: the male deposits a stalked package of sperm on the ground and the female collects the sperm to fertilise her eggs. Collembola usually go through four or five moults before they reach sexual maturity. Mating takes place after moulting; when she moults, the female loses any sperm that she has had stored. A female lays 90-150 eggs in a lifetime and the eggs hatch about one month after laying. At hatching, juveniles resemble the adults. Up to 50 moults can take place during the life of a collembolan.

Habitat

Aquatic springtails live around the edges of water bodies or on the surface film of water, where they appear as masses of small purple spots. Their hydrophobic skin keeps them afloat. They are also found among emergent and floating vegetation. Springtails are quite common and can be found in most water bodies around South Australia. They are able to live in areas that are polluted.

Critter facts

Collembola can even be found in cave pools and in Antarctica. One Antarctic species reproduces only once every four years.

Identification

Springtails are very small animals and aquatic species may be mistaken for terrestrial species. They are often visible on the surface of some waters, especially after rain. They are soft-bodied, lack wings and have segmented abdomens.

When a springtail is viewed through a microscope, the furcula near the end of the abdomen is easily seen. The ventral tube, or collophore, on the first abdominal segment is also easy to see in most species. See page 21 of *The Waterbug Book* for a key to help you tell springtails from other animals.

Classification and sensitivity

Phylum Arthropoda

- Class Collembola (1)
  - Family Hypogasturidae (NR)
  - Family Onychiuridae (NR)
  - Family Isotomidae (NR)
  - Family Entomobryidae (NR)
  - Family Sminthuridae (NR)

References

Hawking & Smith 1997, pp 74-75; Williams 1980, p 188; Gooderham & Tsyrlin 2002, pp 84-85.

12 Class Insecta-insects

Background

Of the more than one million species of multicellular animals known to science, over three quarters are insects. They are found from the Arctic to the Antarctic and most places in between, including most aquatic environments. Of all the insects known, only around 5% are found in or near water bodies.

In Australia, there are 11 orders of insects with freshwater representatives. These orders include Mecoptera (scorpionflies), Ephemeroptera (mayflies), Odonata (damselflies and dragonflies), Plecoptera (stoneflies), Megaloptera (alderflies/dobsonflies), Hemiptera (true bugs), Neuroptera (lacewings), Coleoptera (beetles), Diptera (true flies), Trichoptera (caddis flies) and Lepidoptera (moths/butterflies). All groups except Megaloptera occur in South Australia.

Many fossilised insects have been discovered throughout the world. The insect fossil record is almost continuous, starting from about 400 million years ago. However, the first 75 million years of this record is represented by only two orders of wingless insects that occur as rare fossils in three Early and Middle Devonian deposits.

Size

Insects range in length from less than 1 mm to 75 mm.

Features

Adults have a clearly defined head, three-segmented thorax and, usually, an abdomen of 10-11 segments. They have one or two pairs of wings, six legs, and one pair of antennae. Larvae range from maggot-like organisms to more complex forms that resemble the adult stages.

Diet and feeding

Insect diets vary and each species has mouthparts specific to its mode of feeding. They range from the biting and chewing mouthparts of herbivores and more generalist feeders, to piercing and sucking mouth parts of other herbivores, some predators and parasites. It is quite common for a larva to have mouthparts that differ completely from those of the adult, reflecting the different diets of the two stages in the life cycle.

Locomotion

Some insects are very good swimmers and swim swiftly through the water, while some tend to jerk through the water, creating undulating motions of the body. Some can skip over the water, dive under the water, or crawl along the waterbed, while others sit on the surface of the water relying on the surface tension to prevent them from sinking into the water.

Gas exchange (breathing)

A major challenge for insects is getting oxygen from water. The oxygen concentration in air is about 21%, but even under ideal conditions in water, it is only about 1.5% and often much lower. Insects first evolved on land with a network of internal air-filled tubes that form the tracheal (respiratory) system. These tubes usually open at the body surface through pores known as spiracles. Most terrestrial insects have 8-10 pairs of spiracles. Some aquatic animals have fewer spiracles, while in some groups spiracles are absent and the tracheal system is closed.

Air breathing or bubble-carrying insects often have ‘open’ tracheal systems. Spiracles are sometimes surrounded by fine hairs or closed by fleshy lobes to prevent water from entering the tracheal system when the animal is submerged. Some invertebrates have a tube called a ‘respiratory siphon’ which allows contact with the air above the surface while they are submerged. Other species pierce plant stems to obtain gases from air in the hollow sections of the plants.

In animals with a ‘closed’ tracheal system, oxygen usually diffuses through the outer body surface-the cuticle, or epidermis; sometimes the body surface has outgrowths—gills—that increase the surface area for gas exchange. Small animals often do not have extra gills; simple diffusion through the body surface is adequate for their needs. Some insects have respiratory pigments, such as haemoglobin, that have a high affinity for oxygen and enable them to survive in oxygen-poor waters.

Life cycle and reproduction

Sexual reproduction is typical in insects, although some, mainly terrestrial insects, can reproduce asexually. Fertilisation in insects occurs as the egg is passing through the oviduct of the female at the time of egg deposition. At each mating, the male releases a large amount of sperm, which is enough to fertilise several batches of eggs. Many insects mate only once in their lifetime. Some mate only once a year and during a particular season. Others can mate several times a year, depending on environmental conditions.

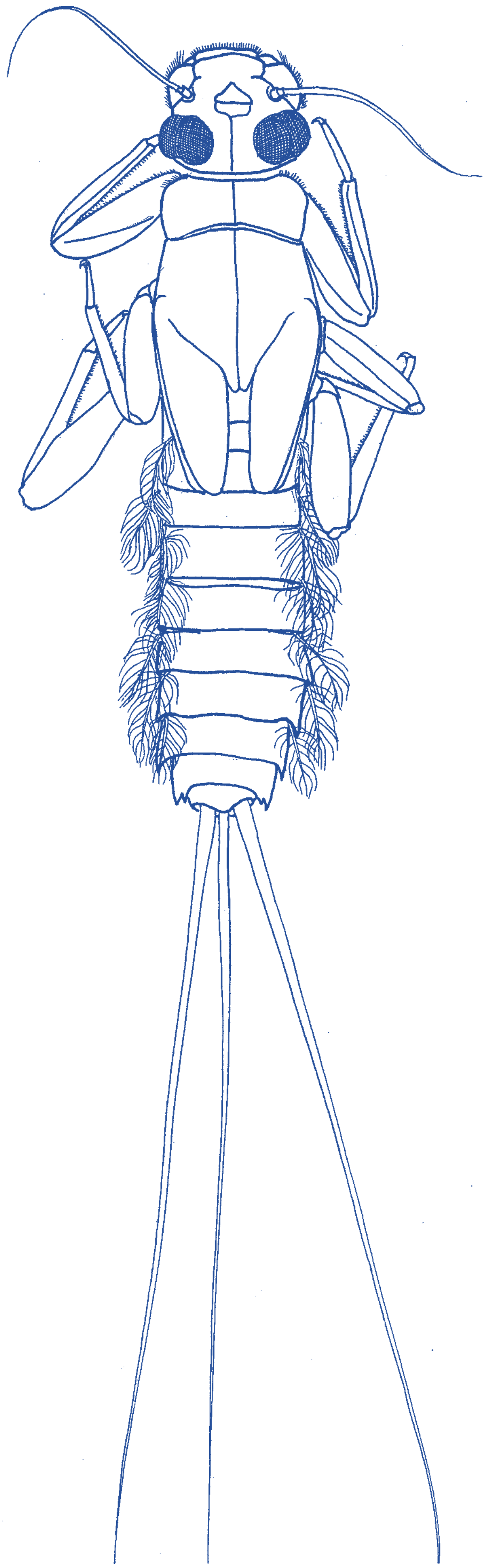
Some insects have a three-stage life cycle (undergo a complete metamorphosis), and the stages are called ‘larvae’, ‘pupae’ and ‘adult’. Others have just a two-stage cycle (incomplete metamorphosis), the stages known as ‘nymph’ and ‘adult’.

Aquatic insects have a life cycle that occurs either entirely in the water or only partially in water, the larval stage being aquatic and the adult stage terrestrial. All insects moult between successive larval stages, usually growing larger at each moult. The shedding of the outer cuticle leaves a softer, more sensitive outer surface that can take hours to harden and can leave the insect vulnerable to pollutants. Some larval stages of insects resemble their adult stage, but others undergo metamorphosis, having a pupal stage between the larval and adult stages. Adults can be either terrestrial or aquatic.

Habitat

Insects are found in a wide variety of water bodies. Some prefer fast-flowing waters, others, slow-flowing waters, and some are opportunists and will live wherever there is water. Insects can be found living on or near the water surface, underneath the surface in the water column, and on the sediment at the bottom of the water body. Some animals prefer to live in or on the open waters, while others tend to live in sheltered parts by the stream bank or among water plants. Insects vary in sensitivity to, and tolerance of, pollutants and salinity. They are distributed widely throughout the Australia; if you don’t find any insects in a water body in South Australia it is likely that you haven’t sampled well enough.

Mayflies, stoneflies, caddisflies, dragonflies and damselflies



Critter facts

Insects communicate with one another using chemical, visual or auditory signals.

Identification

Insects vary greatly in appearance. Each adult insect has a distinct head, thorax and abdomen. Adults of aquatic forms have either one or two pairs of wings and antennae, although in some the wings may be reduced in size. Most larvae also have a distinct head, thorax and abdominal segments, but some look very worm-like.

The key starting on page 21 of *The Waterbug Book* should help you tell insects from other animals and separate the major orders of insects from each other.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Ephemeroptera	9
Order Odonata	3
Order Plecoptera	10
Order Hemiptera	2
Order Coleoptera	5
Order Diptera	3
Order Trichoptera	8

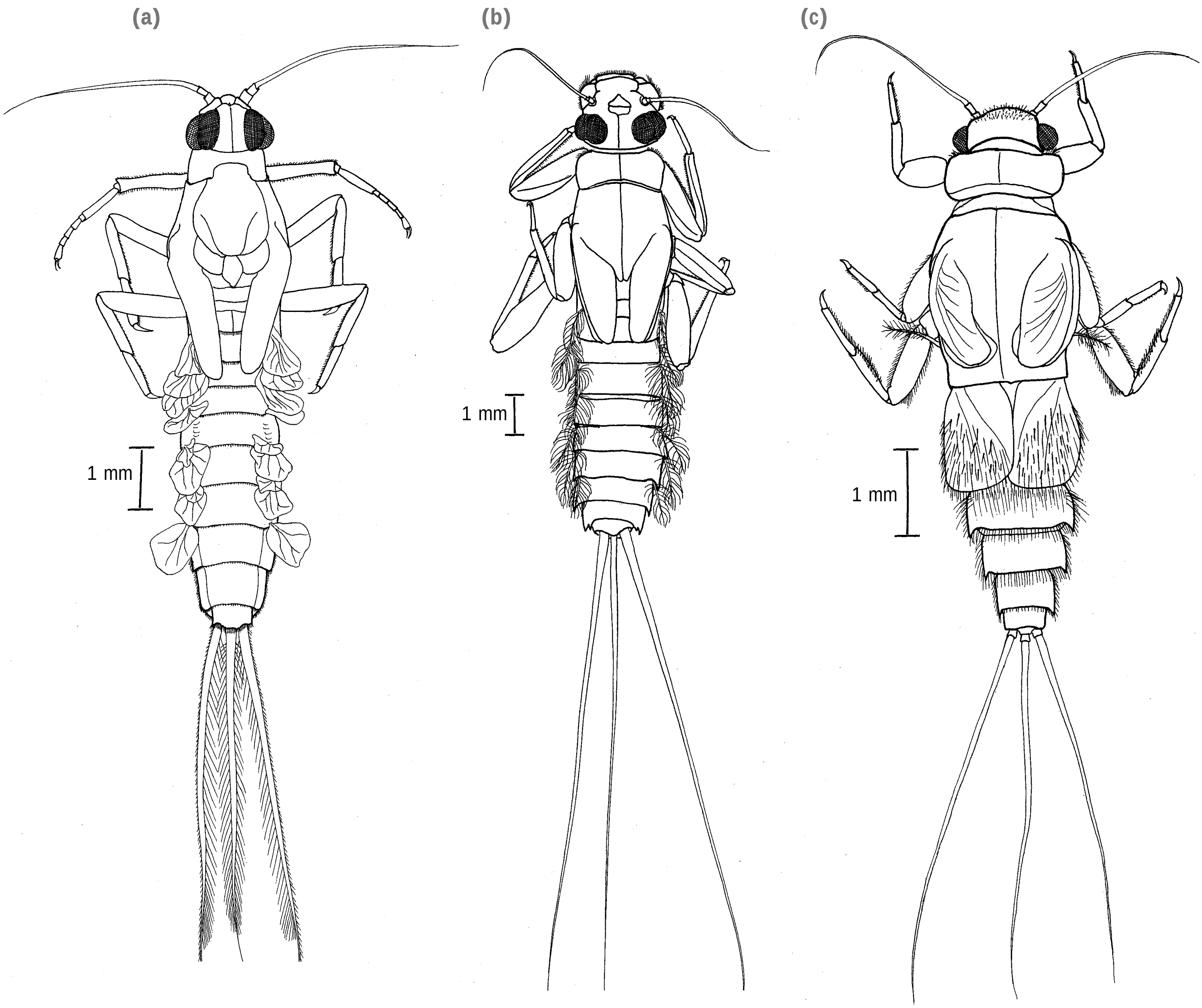
References

Hawking & Smith 1997, p 76; Williams 1980, p 185; Gooderham & Tsyrlin 2002, pp 86-212.

12.1 Order Ephemeroptera-mayflies

Background

Ephemeroptera are commonly called mayflies because in the northern hemisphere adults emerge in large groups in spring, in the month of May. They have an aquatic larval or nymphal stage and a terrestrial adult stage. About 2200 species of Ephemeroptera are described worldwide. They are the most primitive living winged insects: their fossils date to as far back as the Late Carboniferous period, about 300 million years ago. Nine families and at least 84 species of Ephemeroptera occur in Australia. Four families-Baetidae, Oniscigastridae, Leptophlebiidae, and Caenidae-and 15 species are known to occur in South Australia.



The mayfly species:
(a) *Cloeon* sp. (family Baetidae) (b) *Atalophlebia australasica* (family Leptophlebiidae) and (c) *Tasmanocoenis tillyardi* (family Caenidae)

Size

South Australian mayfly nymphs may grow up to 15 mm long, while immature nymphs can be less than 2 mm.

Features

Mayfly nymphs have three long cerci (tails) protruding from the end of their abdomen. They also have feathery, filamentous or plate-like gills on the abdomen. The nymphs usually range from light to dark brown in colour, but smaller specimens can be very pale. Most have prominent mouthparts and two large compound eyes, with three smaller eyespots, or 'ocelli'. The terrestrial adults also have three long cerci. Some species have two pairs of wings, the second pair smaller than the first; in some groups the second pair of wings is absent.

Diet and feeding

Nymphs of South Australian mayflies eat detritus and algae. They scrape and collect material from underwater surfaces such as rocks and submerged water plants. Some can filter particles from the water. Adults do not have a functioning digestive tract; they have reduced mouthparts and do not feed.

Locomotion

Using their well-developed legs, mayfly nymphs can crawl along the bottoms of streams and lakes. They are also able to swim by flicking the abdomen. When mayflies swim their cerci act like fins; some species are very rapid swimmers for their size. Adults are strong fliers, but their legs are only useful for perching, not walking.

Gas exchange (breathing)

Mayfly nymphs exchange gases by diffusion through the outer body surface and across the gills. Some species sit on cobbles and boulders in fast-flowing streams, positioned to allow the current of water to pass over their gills. Others move their gills in the water, ventilating them. A closed tracheal system that lacks spiracles assists in movement of oxygen around the body. Mayflies do not like turbid water as the suspended sediment clogs their gills and prevents oxygen getting to their tissues.

Life cycle and reproduction

Most mayfly species reproduce sexually. However, some 50 species, including a few Australian ones, reproduce by parthenogenesis. Adult males fly in swarms above the water surface and the females fly into the swarms and mate on the wing. The female then lays between 100 and 12,000 eggs. Adult life is very short.

Mayflies show great variation in the method of laying eggs. Some females fly near the water surface and dip their abdomens into the water to release eggs; others crawl under the surface and attach their eggs to rocks. Some females emerge, mate, lay eggs and die in as short a time as two minutes, while others may take several weeks, depending on species and temperature. Some lay eggs about three weeks after copulation and the nymphs hatch as soon as the eggs touch the water. The development time of nymphs ranges from about two weeks to three years, and they moult 12-50 times.

In South Australia, the range is much narrower: nymphs take between two weeks and less than a year to reach adult size. Nymphs move to the surface to pupate, and the skin splits so that the adult can emerge. This emergence usually occurs around dawn or dusk, minimising the risk of being taken by predators. Unique among aquatic insects, mayflies have a fully winged terrestrial stage, a 'sub-imago', before final moult to the sexually mature adult stage. The sub-imago is dull in appearance in contrast to the clear-winged adult. Adults do not feed and their main functions are reproduction and dispersal. Some species have desiccation-resistant eggs, which allow them to colonise temporary water bodies. Species from colder areas are known to over-winter in the egg stage and hatch in spring, thus avoiding the colder conditions.

Habitat

Mayfly nymphs live in a wide range of water bodies including streams, rivers, ponds, lakes, wetlands, ditches and bogs. They occur in permanent and temporary waters, from alpine to arid regions, living under many different flow conditions, from standing water to rapids. Some cling to the undersides of rocks in fast flows, while other species burrow into the fine sediment of slow-flowing parts of streams. Australian species are not tolerant of saline waters. Most mayfly species in South Australia occur in cooler waters in the southern parts of the state, particularly in the Mount Lofty Ranges and Fleurieu Peninsula. They are not very tolerant of pollution and will be absent from water bodies with poor quality water. One family, Caenidae, can be found throughout South Australia, and two genera from this family have been found in the Far North region of the state.

Critter facts

The first written record of mayflies was by Aristotle, who lived between 384 and 322 BC. He noticed the emergence of adult mayflies from the water surface and commented on the adults' short lives.

Due to their mainly herbivorous habits and high abundance, mayflies have been called the 'rabbits' or 'cattle' of aquatic systems. Ephemeroptera nymphs can be very abundant; they have been recorded at densities of 10,000 per square metre.

Adult mayflies often emerge together and form huge clouds along the edges of water bodies. In the Sepik River region of Papua New Guinea, locals take advantage of this simultaneous emergence and make cakes from adult mayflies.

Burrowing mayflies are abundant in the Mississippi River in the United States of America. When they emerge, driving can become difficult due to the slippery film of dying adult mayflies that accumulate on the roads.

In Sweden, a species of mayfly over-winters under the ice of frozen ponds. It survives the very low oxygen concentrations due to the effect of extreme cold, which slows metabolism.

Identification

The three spine-like cerci of mayfly nymphs help distinguish them from other animals and they often have prominent gills on the sides or backs of their abdomens. They may be mistaken for small damselfly (zygopteran) nymphs, which have three leaf-shaped gills at the end of the abdomen and much larger eyes. If one of the mayfly's cerci breaks off, it can be mistaken for a stonefly.

The key starting on page 21 of *The Waterbug Book* should help you tell mayflies from other insects. For the more adventurous reader, page 135 has a key to the families of mayflies-magnification make identification easier.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Ephemeroptera (9)

Family Baetidae (5)

Family Oniscigastridae (8)

Family Leptophlebiidae (8)

Family Caenidae (4)

References

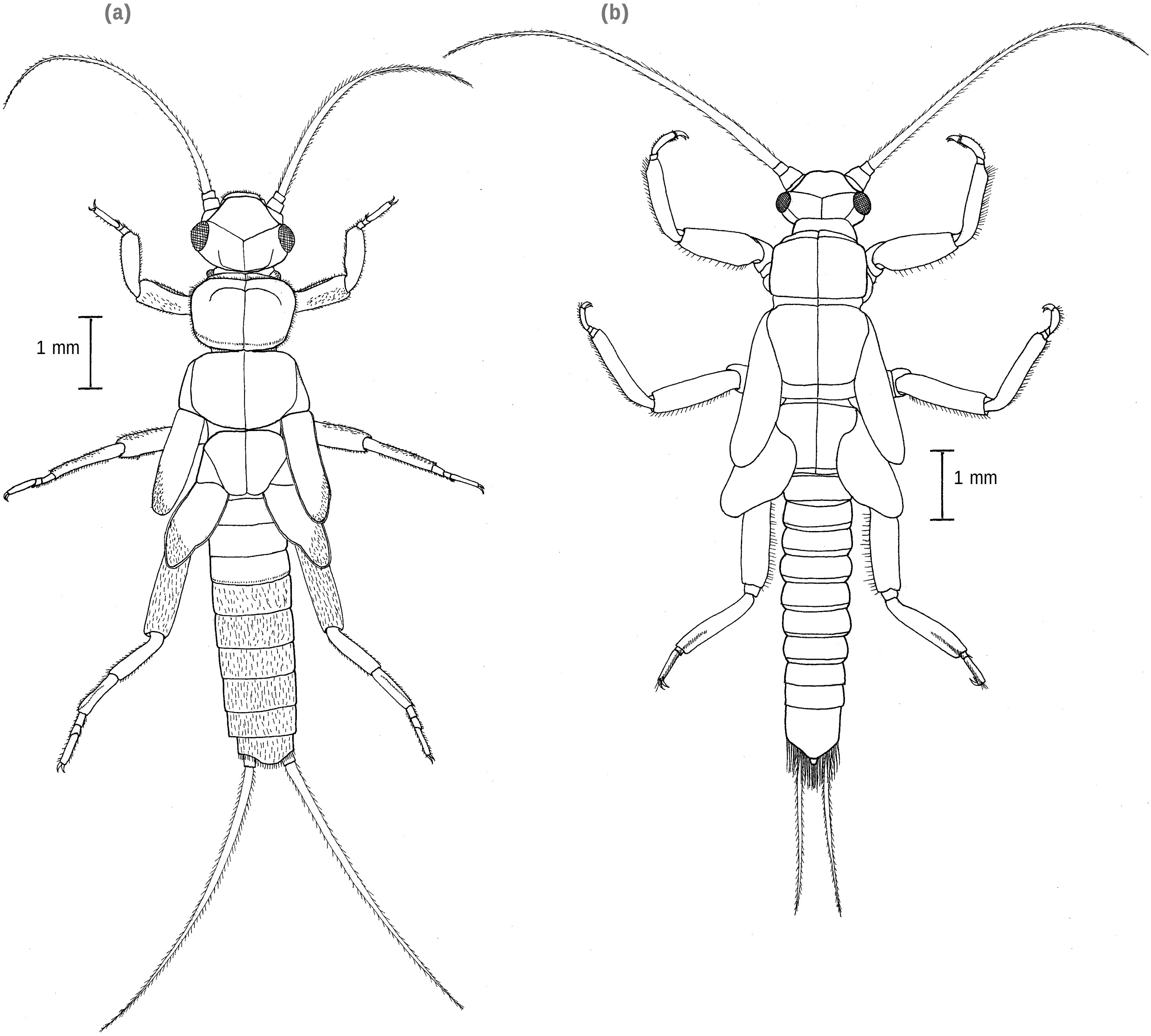
Hawking & Smith 1997, pp 78-87; Williams 1980, p 196; Gooderham & Tsyrlin 2002, pp 131-143.

12.2 Order Plecoptera-stoneflies

Background

Worldwide, there are about 2000 species of stonefly. Four families and 196 species are known from Australia, but only two families, Gripopterygidae and Notonemouridae, and nine species are recorded from South Australia. Stoneflies have an aquatic nymph stage and a terrestrial adult stage. Plecoptera is an ancient group: fossil specimens belonging to the Australian family Eustheniidae have been found in sediments from the Upper Permian period, deposited about 250 million years ago.

(a) (b)



The stoneflies: (a) *Austrocerca tasmanica* (family Notonemouridae) and (b) *Dinotoperla evansi* (family Gripopterygidae)

Size

Mature nymphs can grow up to 13 mm long, although juvenile nymphs can be as small as 2 mm.

Features

Stonefly nymphs have three pairs of well-developed legs, long antennae and two long cerci (tails) at the end of the abdomen. One family that is found in South Australia, Gripopterygidae, has a tuft of gills at end of the abdomen, while the other family, Notonemouridae, lacks these gills. The more mature nymphs have two pairs of developing wings, known as 'wingpads', on the thorax.

Diet and feeding

Some stonefly nymphs from the eastern states are predators, but all species that occur in South Australia are detritivores, feeding on plant material and decaying organic material. They use strong, blunt mandibles to grind their food. As adults, some do not require food; others feed on plant material including algae, lichen and rotting wood.

Locomotion

Stonefly nymphs can walk on, and cling to, the substrate with their strong legs. They also swim by wriggling the abdomen from side to side. Stonefly adults are able to fly, but with varying degrees of ability. Many are only able to skim the water surface, where their weight is borne by the water. In these species, the wings just propel the stonefly forwards.

Gas exchange (breathing)

Stonefly nymphs exchange gases through their body surfaces and some have gills at the tip of the abdomen that they can poke onto the water surface. The nymphs are usually found in flowing waters that are well aerated. Some do 'push-ups' that enhance water flow over the body, improving gas exchange.

Life cycle and reproduction

Stoneflies usually mate on the ground. The female generally lays her eggs by dipping her abdomen into the water, but some species crawl under the water to attach the eggs to a submerged surface. In South Australia, eggs usually hatch between April and November, which is the time when water is most suitable for the growth and development of the nymphs. Nymphs take from several months to two years to develop to the emergent stage. Then they crawl out of the water onto the bank and emerge as adults. Adults live from a few days to 12 weeks.

Habitat

In Australia, stonefly nymphs live in a range of habitats, from fast-flowing alpine streams to slow lowland rivers, and at the edges of both bare and vegetated wetlands and lakes. Generally, they live on the sediments, beneath stones or rocks or among aquatic vegetation. They are usually intolerant of pollution and salinity. Stoneflies are typically found in the cooler, flowing waters of South Australia, mainly in the Mount Lofty Ranges and on the Fleurieu Peninsula. They do not occur any further north than Willochra Creek in the Flinders Ranges. Some of the species of Gripopterygidae are rare in South Australia.

Critter facts

During drought, eggs from some Australian stonefly species can remain dormant for up to 18 months before hatching.

A South Australian species, *Riekoperla naso,* is adapted to living in seasonal or temporary streams that flow only in winter and spring. It is rarely found in permanent streams.

One species of Plecoptera has aquatic adults that have been collected at depths of 60-80 metres in a lake in the United States of America.

Stoneflies are used as model organisms to investigate the evolution of insect flight. Flying ability varies greatly between species. One species can fly only if it is unusually warm and, even then, only very weakly. Another cannot flap its wings at all, but raises them in response to wind in order to sail across water surfaces.

Identification

Stonefly nymphs may be confused with mayflies, but stoneflies have only two cerci at the end of the abdomen, instead of three. Some species of stoneflies have gills along the sides of their abdomens, while those present in South Australia do not. In contrast mayflies generally have gills on the back or sides of their abdomen although they can be knocked off. Check the key on page 20 of *The Waterbug Book* if you are unsure you have a stonefly.

Distinguishing the two families of stonefly in South Australia is easy. Gripopterygidae have a tuft of gills at the end of their abdomen while Notonemouridae do not.

Classification and sensitivity

Phylum Arthropoda

- Class Insecta
  - Order Plecoptera (10)
    - Family Notonemouridae (6)
    - Family Gripopterygidae (8)

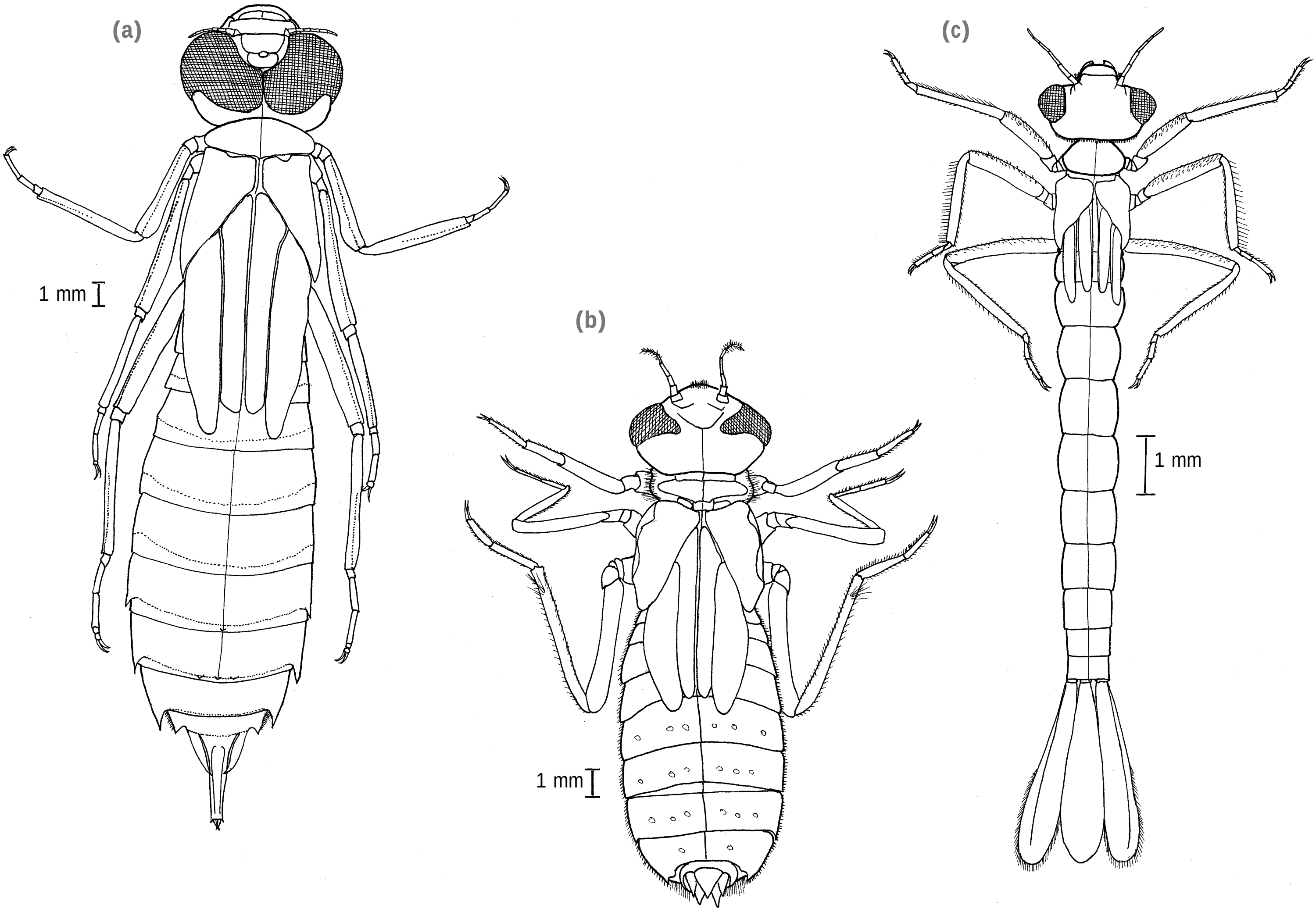
References

Hawking & Smith 1997, pp 107-112; Williams 1980, p 190; Gooderham & Tsyrlin 2002, pp 180-186.

12.3 Order Odonata-damselflies and dragonflies

Background

Odonata are divided into two suborders-Zygoptera (damselflies) and Anisoptera (dragonflies, now known as Epiproctophora). There are well over 5000 odonate species worldwide. Eleven families and 107 species of Zygoptera occur in Australia, and among these, three families and ten species are recorded for South Australia. Six families and 198 species of Anisoptera occur in Australia, seven families and 16 species in South Australia. All Odonata larvae are predators and, except for a few species that have terrestrial larvae, they are aquatic. All adults are terrestrial. Odonata are known to have a very long history. The oldest recognisable fossils of the group belong to the Protodonata, an ancient group that is now extinct. The earliest fossils so far discovered come from Upper Carboniferous sediments in Europe, formed about 325 million years ago.



The dragonfly species:
(a) *Hemianax papuensis* (family Aeschnidae), (b) *Hemicordulia tau* (family Hemicordulidae) and (c) *Ischnura heterosticta* (family Coenagrionidae)

Size

Damselfly larvae in South Australia grow to about 35 mm, including gills, and mature dragonfly larvae grow up to 50 mm long.

Features

The body of the damselfly larvae is long and slender, with three leaf-like gills at the end of the abdomen and large prominent eyes on the head. The dragonfly larva has a stout body without external gills. At the end of the abdomen is a pointed anal pyramid that opens into an internal chamber called the 'rectal gill'. Both damselfly and dragonfly larvae capture prey using an extendable 'labium', a ladle-shaped mouth structure that covers the underside of the head.

Diet and feeding

All Odonata larvae are predators that usually lie in wait to ambush prey, although they do sometimes actively stalk their prey. The large eyes of odonates help them to spot prey easily. They eat other aquatic invertebrates, including insects and crustaceans, and even eat some vertebrates such as tadpoles and small fish. The labium of the larval odonate is usually equipped with spines and teeth and these hold the prey while the larva uses its large mandibles to eat it.

Adults also have a 'labial mask' and strong legs used to grasp their prey. They hunt other insects on the wing using their excellent eyesight to find prey. Some large adults even feed on honey bees.

Locomotion

Dragonfly larvae can move rapidly by contracting their rectal chamber and shooting along with jet propulsion. Damselfly larvae swim by wriggling sideways, their leaf-like gills acting like fish tails, propelling them forward. Both groups have strong legs and can walk along or cling to surfaces such as rocks, logs and the stems of submerged plants. Adult Odonata all have wings and are able fliers.

Gas exchange (breathing)

Damselflies wave their leaf-like gills to increase oxygen uptake. Dragonfly larvae have an entirely different system, pumping water in and out of the rectal gill where exchange of gases takes place. In the last instar (when they are 'prepupae'), the larvae come to the surface to replenish their oxygen supplies.

Life cycle and reproduction

Adult males can be territorial, patrolling their own section of stream or wetland and chasing other males away. When odonates mate, copulation can last for some time. Before insemination, a male may repeatedly carry out a pumping action, using his penis to remove other males' sperm from the female, thus enhancing his chance of reproductive success. The male may also remain joined with the female until she lays her eggs, preventing other males from mating with her. It is quite common to see paired dragonfly and damselfly adults flying near water in spring. A male will attach itself to the neck of a female, using his anal appendages; when mating, the female curves the end of her abdomen beneath her to contact the genitalia of the male.

The eggs are laid in fresh water by being dropped on the surface of the water or onto the tissue of submerged water plants, rocks, logs or twigs. The female may be completely submerged in the water while she is laying eggs. In other species, the female flies over water and dips into it repeatedly to lay eggs. Males often fly vigorously while still attached to the female, shaking all the eggs from her abdomen. After laying her eggs, a female must wait between one and five days before the next batch of eggs become ready for fertilisation, when the mating procedure can start again.

Larvae hatch about three weeks after the eggs are laid. There are 10-12 larval stages and each stage is separated by moulting of the exoskeleton. The first stage is called a ‘pronymph’ and is often fish-like in appearance. Some species will develop from a pronymph into a larvae almost immediately after hatching, others may take a few hours. The larval stage may last from several months up to several years: in Sweden there is a species in which the larva lives for 20 years, yet the adult lives for only a few days.

In the last instar, the larvae crawl to a suitable stable area out of the water, usually a surface that is horizontal. This surface provides support, allowing them to emerge easily from the larval exoskeleton. The adults go through a pre-reproductive phase followed by a reproductive phase. In total, an adult may live for anywhere between two weeks and several months. It is in the pre-reproductive stage that an adult odonate will disperse and fly to other water bodies. However, not all adults disperse. Quite often odonates lay eggs in the water body in which they developed. One South Australian damselfly species, *Ischnura aurora*, mates almost as soon as it emerges. The males emerge first, the females later. A female is captured by a male while she is on her maiden flight and mating begins.

Habitat

Odonata larvae can be found in most aquatic habitats, from fresh to brackish water, still to fast-flowing, and in both permanent and temporary water bodies. They are not often found in badly polluted waters. Some dragonfly larvae burrow, leaving the tips of their abdomens protruding above the surface of the substrate so that they can respire; others cling to vegetation, leaf litter or rocks. Odonates can be found in many water bodies throughout South Australia. Some species are rare and can only be found in certain areas of the state, while others are widespread.

Critter facts

Dragonfly larvae sometimes become pests in aquaculture ponds, eating larval fish.

Some fossil adult dragonflies from the Carboniferous period had wingspans of 600 mm, which makes them the largest insects ever.

Adults dragonflies can fly backwards as well as forwards at speeds of 25-35 km/h. They have been recorded, however, at speeds of up to 56 km/h.

In Europe, mass migrations of dragonfly adults have been reported, covering areas over 800 kilometres, from Spain to Ireland.

Some people believe that adult dragonflies can deliver a dangerous sting or bite, possibly due to their large size and impressive appearance. Such a belief is unfounded since dragonfly adults neither bite nor sting.

Dragonfly larvae are popular bait for catching freshwater fish. They are known as 'mud-eyes' to freshwater fishers.

Identification

Odonata larvae are very distinctive so it is difficult to mistake them for any other animal. They range in colour from yellowish-white, through brown to black, often have large eyes, and all have a large labial structure on the underside of their head, used to catch prey. Damselfly larvae tend to have long abdomens while dragonfly larvae are more squat.

Magnification will help when using the key to the families of dragonfly larvae on page 166 of The Waterbug book.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order: Odonata

Sub order Zygoptera

Family Hemicorduliidae	5
Family Libellulidae	4
Family Aeschnidae	4
Family Telephlebiidae	9

Sub order Anisoptera

Family Coenagrionidae	2
Family Lestidae	1
Family Protoneuridae	4

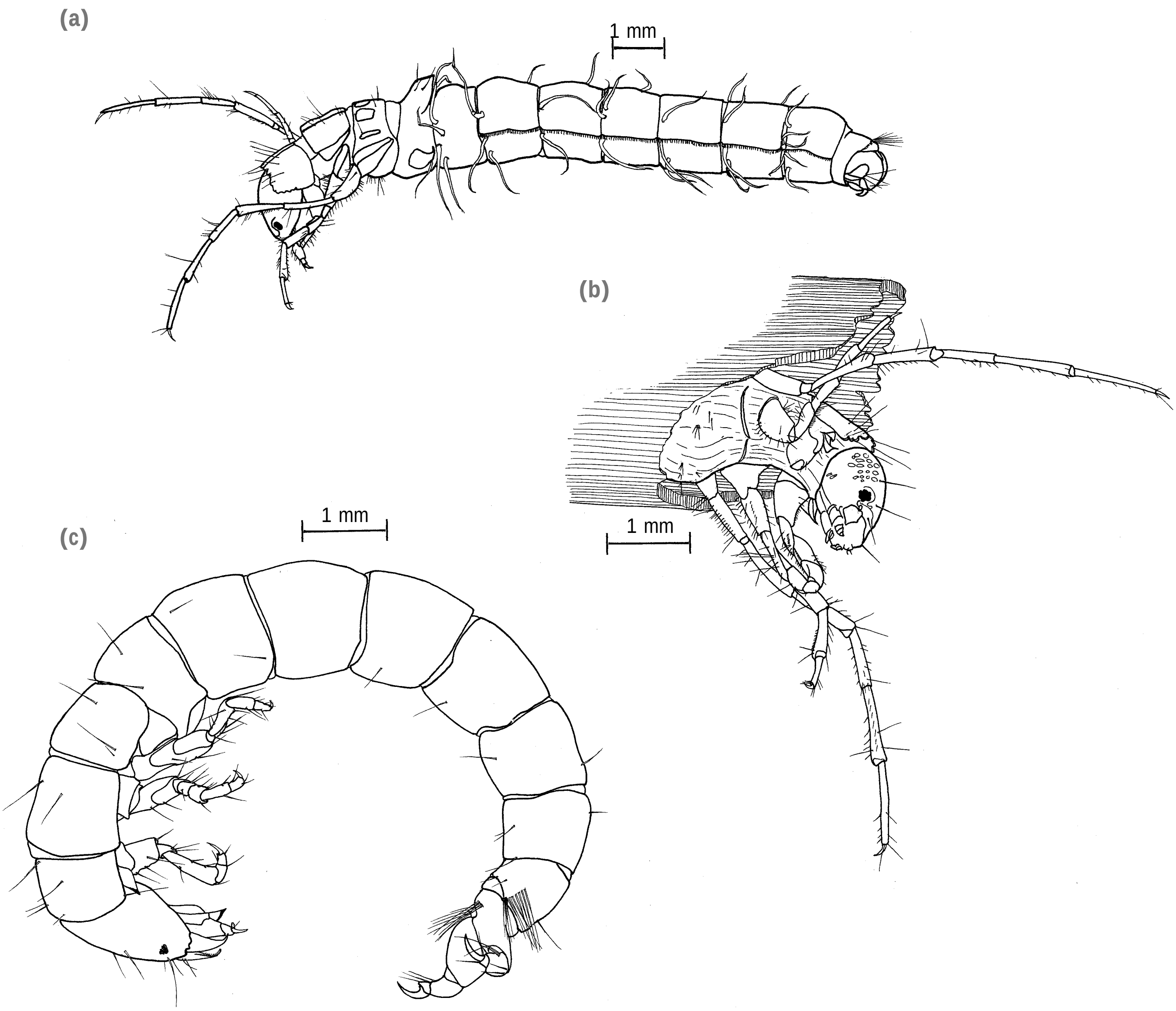
References

Hawking & Smith 1997, pp 88-106; Williams 1980, p 203; Gooderham & Tsyrlin 2002, pp 161-179.

12.4 Order Trichoptera-caddis flies

Background

Over 10,000 species and 40 families of Trichoptera have been described worldwide. In Australia, 479 species have been found, assigned to 26 families. At least nine families are known to occur in South Australia: Ecnomidae, Hydropsychidae, Hydrobiosidae, Leptoceridae, Hydroptilidae, Tasimiidae, Calamoceratidae, Atriplectididae and Conoesucidae. Adult trichopterans are terrestrial, but larvae and pupae are aquatic. Functionally, trichopteran families can be split into three groups: those that have free-living larvae, those that build and live in portable cases, and those that build fixed retreats, although these are not clear taxonomic divisions. Trichoptera first appear in the fossil record in the Permian period, 250 million years ago.



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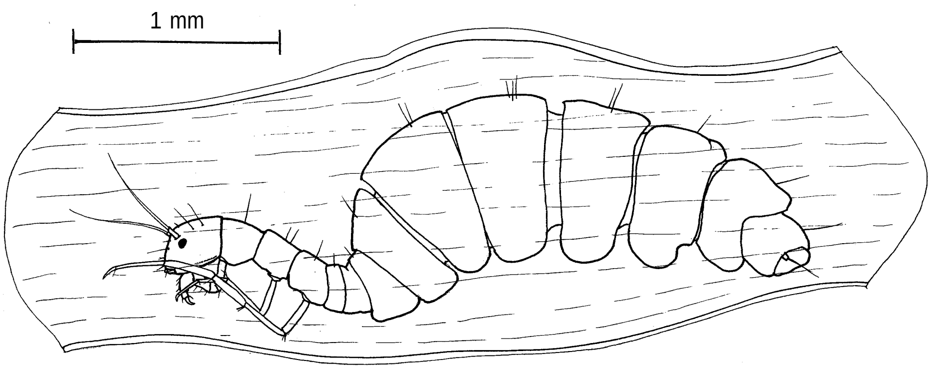

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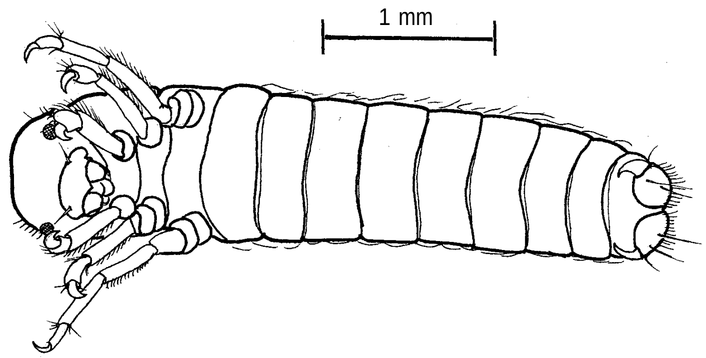

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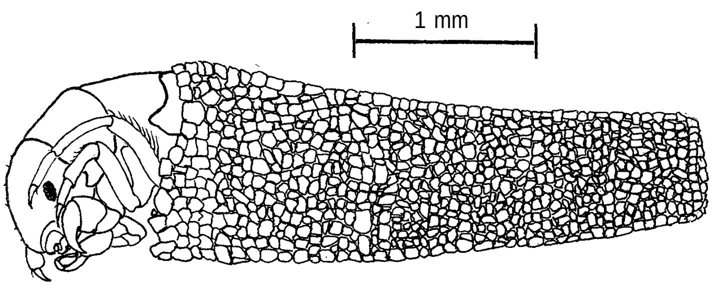


The caddis fly larvae:

(a) *Triplectides ciuskas*

(b) *Triplectides ciuskas* (family Leptoceridae) inside a stick case,

(c) *Ecnomus pansus* (family Ecnomidae)

(d) *Hellyethira malleoforma* (family Hydroptilidae)

(e) *Lingora sp.* without a case and

(f) *Lingora sp.* with case (family Conoesucidae)

Size

Trichoptera larvae range from 1.5 mm to 40 mm in length, depending on the species and maturity of the larvae. Adults are about the same size, ranging from 2 mm to 40 mm.

Features: Trichoptera larvae have three pairs of legs on the thorax and one pair of anal prolegs on the final segment; the anal prolegs often end in large hooks. The larval head and often part or all of the thorax are well sclerotised. The abdomen is usually soft and sometimes has respiratory gills attached to it. Larvae spin silk from a gland on their mouthparts and many construct cases that they live in and usually carry around. Adults are moth-like and usually quite drab in colour. They have two pairs of wings and some have long antennae.

Diet and feeding

Larval Trichoptera are not selective about what they eat, but often have specialised feeding techniques. Some larvae scrape algae from the surface of surrounding rocks. Others construct conical webs to filter material from the current or are active predators of insects and crustaceans. Adults have weak mouthparts and feed only on liquids. The Trichoptera larvae found in South Australia can be divided into five different functional feeding groups that cut across families:

- shredders/chewers-these include the families Hydroptilidae, Leptoceridae and Calamoceratidae; they are herbivores and detritivores that feed on vascular plants and filamentous algae.
- collectors/gatherers-these include the families Conoesucidae, Hydroptilidae, Atriplectidae and Leptoceridae; they are filter and suspension feeders that feed on fine organic particles.
- scrapers-these include the families Hydroptilidae, Tasimiidae and Leptoceridae; they are herbivores that feed on ‘periphyton’ and fine organic particles.
- piercers-these include some of the species in the family Hydroptilidae; they suck the fluids from living plant tissue.
- predators-these include the families Ecnomidae, Hydrobiosidae, Hydropsychidae, Hydroptilidae and Leptoceridae; they are carnivores that feed on either whole invertebrates or parts of animals, fish and insect eggs.

Larval diets may change from the early instars to later instars as well as from season to season, depending on the availability of food.

Locomotion

Trichopteran larvae are not very good swimmers and generally crawl along the bottom of water bodies. Some of the case carriers, however, do swim through the water effectively by flicking their bodies. Adult trichopterans are active by day and/or night, depending on species.

Gas exchange (breathing)

Larvae of many species have respiratory gills along their abdomens, although they also exchange gases through the body surface by diffusion from the water. They are all able to obtain oxygen underwater. The tube-case-makers undulate their body inside the case for ventilation. Species with respiratory gills on the abdomen generally live in flowing water and use the flow of water over their gills to ventilate the gills.

Life cycle and reproduction

For most Trichoptera species, mating begins around dusk. The adults mate in flight, on the ground, or on vegetation. The eggs are deposited on or near the water shortly after mating. Some females may actually enter the water to deposit their eggs. Eggs can be laid singly, as strings, or in masses. The egg masses contain between 20 and several hundred eggs. Eggs hatch within 3-25 days. Larvae go through five larval instars. In the final instar, larvae either construct a case in which to pupate or modify their larval case. Pupation occurs in the water. The larva stops eating and seals itself inside the case. At the end of the pupal period, the mature pupa breaks free of the case using hook-bearing abdominal plates. It swims to the surface of the water using the long hairs on its middle legs. The final moult to adult usually occurs above water. The pupal stage can take between 15 and 25 days. Once the adult has emerged, its wings must expand to full length and harden before the animal can take flight. The entire life cycle can take up to three years, depending on the species.

Habitat

Trichoptera larvae are quite diverse and can live just about anywhere in a water body, including in the sediment, on rocks or branches, among algae, and on aquatic plants. Some can also be found in crevices in the rocks on waterfalls. Trichopterans can be found in both flowing and still waters. They are commonly found in most water bodies in South Australia, including fast-flowing streams and rivers, non-flowing permanent and temporary water bodies, and fresh and saline waters.

Critter facts

One family of marine Trichoptera lays eggs in the gut cavity of a particular starfish species. The eggs hatch and the larvae live in the starfish for a period of time before emerging to live in the intertidal zone.

A species in the caddis fly genus *Symphitoneuria* is found in saline inland waters of South Australia. It has been found on the Eyre Peninsula and in the brackish lakes of the South East of South Australia.

Identification

Due to the wide variety of body types of the larvae in this order, it is difficult to mention characteristics that can be consistently used to identify trichopterans. Larvae can be identified mainly by the cases that they construct. Most case forms are specific to a family or genus, although some trichopterans are lazy, taking old, discarded cases and making slight modifications to them. They may often be identified as ‘walking sticks’. The larvae have a completely sclerotised head and often the thorax of the animal is sclerotised as well. The abdomen is fleshy, usually pale in colour, and may bear gills. These larvae may be confused with lepidopteran (moth) larvae. Lepidopterans have prolegs on the third to sixth abdominal segments, while trichopteran larvae have them on only the last abdominal segment.

The general key on page 20 of *The Waterbug Book* should get you started on caddis fly identification, while the key on page 190 will help you get to family.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Trichoptera (8)

Family Ecnomidae (4)

Family Hydropsychidae (6)

Family Hydrobiosidae (8)

Family Leptoceridae (6)

Family Hydroptilidae (4)

Family Tasimiidae (8)

Family Calamoceratidae (7)

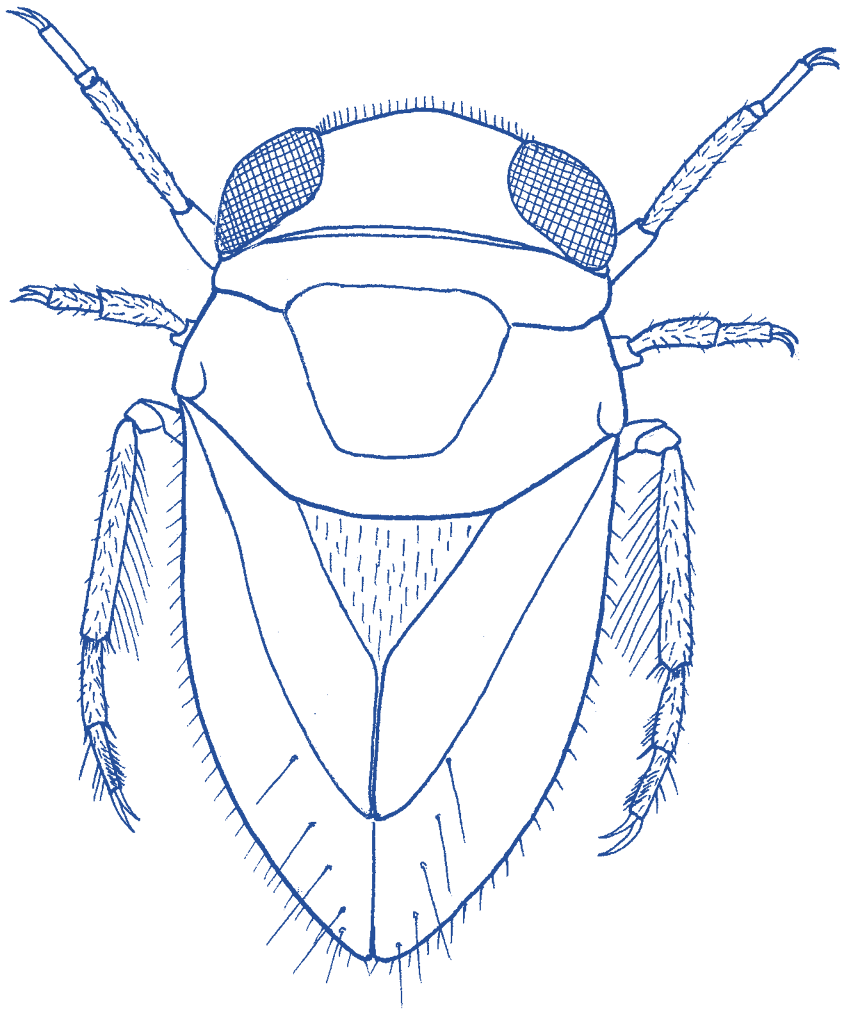
Family Atriplectididae (7)

Family Conoesucidae (7)

References

Hawking & Smith 1997, pp 176-194; Williams 1980, p 255; Gooderham & Tsyrlin 2002, pp 187-212.

True Bugs



12.5 Order Hemiptera-true bugs

Background

Hemipterans are also known as true bugs. They number about 35,000 species worldwide. Ninety-nine families and 5650 species of Hemiptera are recorded for Australia, but most of these are terrestrial and feed on plants. Common examples of these include aphids, cicadas and shield bugs. In Australia fifteen families and some 222 species are aquatic.

Twelve aquatic families are reported from South Australia: Naucoridae (creeping water bugs), Pleidae (pygmy back swimmers), Gerridae (water striders), Notonectidae (back swimmers), Corixidae (water boatmen), Hydrometridae (water measurers), Belostomatidae (giant water bugs), Nepidae (water scorpions and needle bugs) and Veliidae (small water striders or riffle bugs) are covered in this guide. Hebridae (velvet water bugs), Saldidae (shore bugs) and Mesoveliidae (water treaders) are not.

Fossil records date back to Late Silurian period, nearly 430 million years ago. Fossil evidence indicates that major lineages of Hemiptera probably diverged between the Lower Permian and Lower Triassic periods (about 260 to 220 million years ago).

Size

Hemipterans range in length from 1 mm to 75 mm.

Features

Hemipterans have modified mouthparts that enable them to pierce plant tissues or animal prey. Adults usually have two pairs of wings; at least part of their forewings are hardened compared with the more membranous hind wings. All juvenile and some adult hemipterans are wingless, especially those that live on the surface film. Most aquatic hemipterans have legs modified for feeding, swimming or standing on the surface of the water.

Diet and feeding

Hemipteran mouthparts are modified for piercing and sucking. They have two feeding tubes or stylets; one pumps out digestive juices from the salivary glands and one sucks up the partially digested food. The digestive juices cause the tissues of the prey or plant material to dissolve. Most aquatic Hemiptera are predators, but some Corixidae (water boatmen) feed on detritus.

Locomotion

Many hemipterans are strong fliers and can either skate on the water surface or swim strongly beneath it. Some swim on their backs.

Gas exchange (breathing)

Hemipterans have a well-developed tracheal system. Some species take an air bubble on their abdomen or beneath their wings when they swim underwater. Most must periodically come to the surface to renew their air supply.

Life cycle and reproduction

Hemipterans have separate sexes. In some groups, calling is an important part of the mating process. Sound designed to attract a female is produced by the male, using what is called a 'stridulatory organ'. This organ is rubbed against another part of the body or a twig to produce a sound.

Adults of aquatic Hemiptera lay their eggs in or on aquatic plants or on firm substrate. After hatching, five larval instars occur before the animal reaches the adult stage. There is no pupal stage-the nymphs all look very similar to the adults, but are smaller and wingless.

Habitat

Hemipterans can be found in a variety of water types. They can be separated into three main groups according to their habitat. There are shore-dwelling semi-aquatic bugs, surface film bugs, and fully aquatic bugs. They can live in flowing or standing, saline or fresh waters. Hemipterans can be found in almost all water bodies in South Australia. Some species are tolerant of pollution.

Critter facts

Many aquatic Hemiptera produce sounds by rubbing their legs on various parts of their bodies. These sounds include mating, defensive and alarm calls, some of which are within the hearing range of humans.

Some hemipterans have glands that release chemicals that deter predators, such as fish. The chemicals released taste bad and they make the bug less palatable.

The Corixidae (water boatmen) and Notonectidae (back swimmers) are the most active bugs. These families are very common in South Australian waters. Members of both groups can often be seen swimming quite rapidly through the water, often in large groups.

Identification

If you look closely, most hemipterans are easily distinguished from other invertebrates by their piercing mouthparts, which are long and slender and, in some bugs, can be almost half as long as the body. On larger specimens the mouthparts are easily visible on the underside of the animal. Smaller animals may require magnification. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda
- Class Insecta
  - Order Hemiptera (2)
    - Family Naucoridae (2)
    - Family Pleidae (2)
    - Family Gerridae (4)
    - Family Notonectidae (1)
    - Family Corixidae (2)
    - Family Hydrometridae (3)
    - Family Belostomatidae (1)
    - Family Nepidae (3)
    - Family Veliidae (3)
    - Family Hebridae (3)
    - Family Saldidae (NR)
    - Family Mesoveliidae (2)

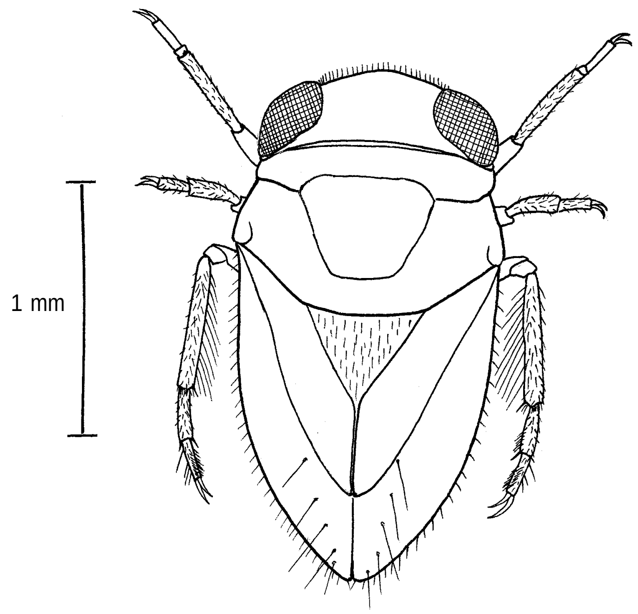
References

Hawking & Smith 1997, pp 115-132; Williams 1980, p 211; Gooderham & Tsyrlin 2002, pp 144-160.

Family Pleidae-pygmy back swimmers

Background

Worldwide, there is only one genus of Pleidae, with at least five species. Four species have been found in Australia. These bugs are small and not commonly found in South Australia. They spend most of their life in the water, but some species have been observed to sit on the bank to clean themselves.



The pygmy back swimmer *Paraplea* sp. (family Pleidae)

Size

They do not reach more than 2.5 mm in length.

Features

Pygmy back swimmers are small animals with arched bodies. They are usually brownish in colour. Both antennae and beak (the piercing mouthpart or rostrum) have three segments. All their legs are equal in length and they have small swimming hairs on the hind pair.

Diet and feeding

Pleids are predatory and use their long sharp mouthparts to suck out the juices of their prey, which are usually ostracods and other small crustaceans. They grasp the prey with the front pair of legs and roll the animal around to find a vulnerable spot to pierce with their beaks.

Locomotion

Pygmy back swimmers are poor swimmers, preferring to climb up or crawl across submerged vegetation. When they do swim, they swim upside down in smooth motions.

Gas exchange (breathing)

Pleids obtain oxygen from an air bubble that they trap on their ventral sides. They must go to the surface periodically to replenish their air supply.

Life cycle and reproduction

Both males and females have stridulatory organs that they use to call to one another before mating. The females lay their eggs in plant tissue in spring. Nymphs hatch after three to four weeks and go through five nymphal stages. The development from the first instar nymph to adult takes approximately 60 days. All life stages are fully aquatic. Adult pleids live for the duration of one or two subsequent generations.

Habitat

Pygmy back swimmers can be found in the vegetation of still or slow-flowing waters. They are not very common in South Australia, but have been found in the Mount Lofty Ranges and in the South East region of South Australia.

Critter facts

A species of Pleidae in the northern hemisphere periodically leaves the water and applies an antimicrobial secretion to the hairs in the area where the animal holds its air bubble. The secretion keeps the hairs hydrophobic (water-repelling) and free of microbial contamination. This grooming activity is triggered by changes in light intensity and temperature, and occurs more often in summer, during higher temperatures.

Identification

Pleids are easily recognised by their small size and very curved body. The back is often pitted. Pygmy back swimmers may be mistaken for small beetles, but the presence of the long beak-the sucking mouthparts-is typical of Hemiptera and will identify them easily. They have long rowing arms like back swimmers (Notonectidae), but the pleid body is much smaller and squatter than that of a notonectid. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Hemiptera (2)

Family Pleidae (2)

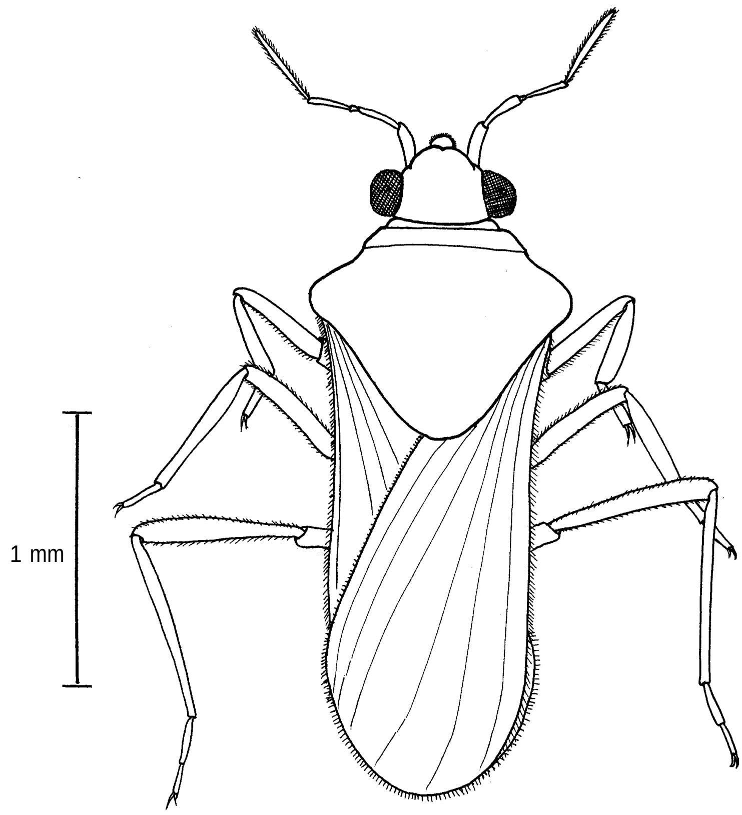
References

Hawking & Smith 1997, p 118; Williams 1980, p 227; Gooderham & Tsyrlin 2002, pp 158.

Family Veliidae-small water striders or riffle bugs

Background

Some 500 species are recorded for this family, which occurs worldwide except in Antarctica, and has both freshwater and estuarine species. A total of 12 genera occur in Australian waters, three inhabiting marine intertidal zones in northern Australia. The two most commonly occurring genera found in inland waters of Australia are *Microvelia* and *Rhagovelia*. Two species, *Microvelia* oceanica and *Microvelia peramoena*, occur commonly throughout South Australia. These bugs are only semi-aquatic, spending their time on the surface of the water. Veliids were first described in 1916. Fossils of this family have been discovered from the Lower Cretaceous period, about 65 million years ago.



The small water strider *Microvelia oceanica* (family Veliidae)

Size

Adult Veliidae vary in size, depending on whether or not they have wings, but they are usually less than 4 mm long. Adult females can be slightly larger than males. Immature veliids may be less than 1.5 mm long.

Features

Winged and wingless forms of these dark-coloured bugs can be found. Veliids have short legs, with claws that are inserted before the tips of the legs. The antennae are quite long and project beyond the end of the head.

Diet and feeding

These animals are carnivores-they pierce their prey with long mouthparts and feed on their juices. Veliids feed on small animals that are trapped on the surface layer of the water or that swim just under the surface. They detect their prey by the ripples that are produced on the water surface.

Locomotion

The legs of these lightweight animals are modified to allow them to run across the surface of the water. The claws on the legs appear before the tips, thus preventing them from breaking the surface tension and falling through the water. Members of the genus *Rhagovelia* have deeply split legs that contain a fan-like arrangement of hairs. When expanded, this fan of hairs enables the animal to run rapidly over any water surface, even over fast-flowing water. Veliids also have another neat trick-they exude a fluid from the end of their abdomen, which reduces the surface tension behind them and propels them forward so that they appear to glide across the surface of the water. They are able to move quietly when sneaking up on prey.

Gas exchange (breathing)

As they spend their time on the surface of the water, veliids obtain oxygen directly from the air, via their well-developed tracheal system.

Life cycle and reproduction

There are both male and female Veliidae. Females lay eggs at varying times of the year, depending on the species. The number of eggs that a female lays depends on the amount of food that is available: if there is plenty of food, she can lay the maximum number of eggs. The eggs are laid in or near plants or near the bank of the water body. There are five nymphal instars, and development of the juveniles to the adult stage can take up to 65 days. Variation in the development of the young occurs within a brood so that some reach sexual maturity far quicker than others. Adults can produce two or three generations in their lives.

Habitat

Veliids are commonly found on the surface of still or stagnant water bodies, sometimes clinging to floating leaves and emergent water plants. They are quite common in inland waters of South Australia and are found throughout the state, often in small groups.

Critter facts

In the tropics, veliids can be an important component of pest control as they feed on the nymphs of pests in rice paddies.

Identification

Veliids resemble Gerridae (water striders), but have much smaller legs. They also resemble Mesoveliidae from which they can be separated by the position of the claws. Mesoveliids have claws at the very tip of the legs whereas the claws of Veliidae are inserted before the tip of the legs. Veliids are smaller than both gerrids and mesoveliids. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

  Class Insecta

    Order Hemiptera (2)

      Family Veliidae (3)

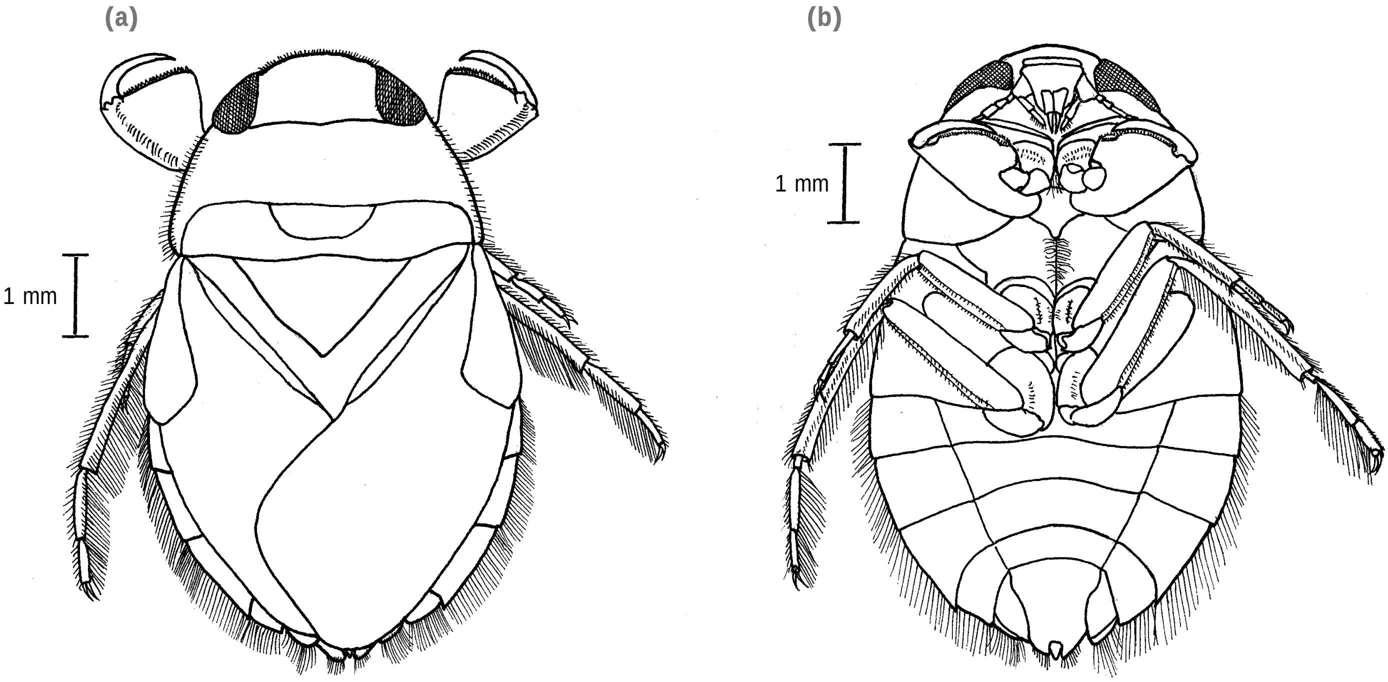
References

Hawking & Smith 1997, p 132; Williams 1980, p 218; Gooderham & Tsyrlin 2002, pp 159-160.

Family Naucoridae-creeping water bugs

Background

At least 400 species of Naucoridae occur worldwide. In Australia, this family of bugs consists of two genera and eight species. Only one species, Naucoris congrex, occurs in South Australia. Fossils of Naucoridae have been found in Mesozoic deposits, over 140 million years old.



The creeping water bug *Naucoris congrex* (family Naucoridae) (a) dorsal view and (b) ventral view

Size

Adult naucorids can grow up to 15 mm long. Juveniles can be as small as 3 mm.

Features

They are brownish in colour, often with the sides bordered by yellow and black. Their front femurs are broadly triangular and adapted for seizing and grasping prey. Naucorids have a broad body and antennae that are not easily visible. Juveniles lack wings.

Diet and feeding

Naucorids are predators and sit waiting for their prey in submerged water plants. They use their strong front legs to grasp the prey while piercing it with their sharp beak. They then suck out the prey's juices. Naucorids feed on insect larvae, such as mosquito 'wrigglers', as well as small crustaceans. They may also feed on fish and snails. In the absence of other food, they may be cannibalistic.

Locomotion

Naucorids are able to swim through the water easily, using the second and third pairs of legs. They have hairs on their legs that help them swim swiftly. They are also able to cling to, and climb, submerged water plants. The adults have a pair of wings but it is believed that since they are not strong fliers, they may migrate to other water bodies by crawling on the ground.

Gas exchange (breathing)

Naucorids hold an air bubble underneath the wings and often surface to renew their air supply.

Life cycle and reproduction

Mature adults are found in water bodies in southern Australia from March to October, but by October numbers of adults are low. Mating between male and female adults occurs once a year, in August/September. The mating process may continue for several hours, the male positioned on the back of the female. Eggs laid by the female are either attached to the leaves of water plants or inserted into the stem. The eggs hatch after a few weeks. A juvenile naucorid goes through five nymphal instars before becoming an adult, a process that takes up to 35 days. Moulting occurs between each instar. Naucorids take about 30 minutes to moult and do so while floating on their backs. Juveniles can be seen in southern Australian waters between September and February.

Habitat

Creeping water bugs can be found in still to slow-flowing water that is heavily vegetated. They are not commonly found in South Australia, but they have been recorded from the southern parts of the state.

Critter facts

Adult naucorids can give a sharp bite if they are handled carelessly.

Identification

These animals are easily recognised by their broadly triangular front femurs. They resemble members of the family Belostomatidae (giant water bugs), but are considerably smaller and do not have veins visible on the wings. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Hemiptera (2)

Family Naucoridae (2)

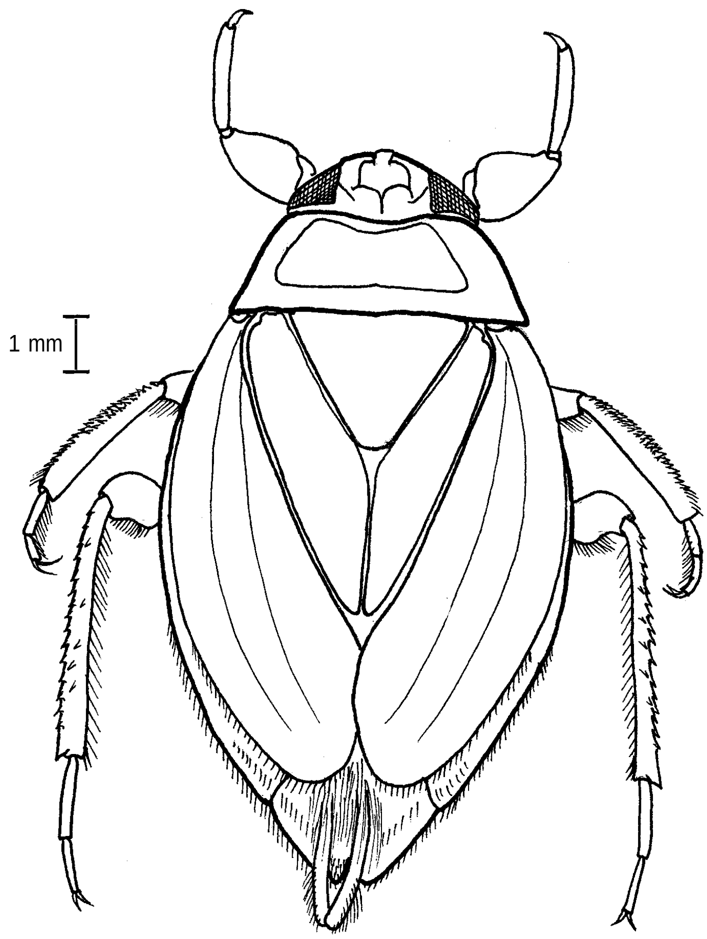
References

Hawking & Smith 1997, p 117; Williams 1980, p 221; Gooderham & Tsyrlin 2002, p 154.

Family Belostomatidae-giant water bugs

Background

This family can be found worldwide and there are about 150 species. Two genera, *Diplonychus* and *Lethocerus,* each with two species, have been described from inland waters of Australia. Only one genus, *Diplonychus*, can be found in South Australia. Belostomatids are now primarily tropical; however, fossils have been recorded from Europe.



The giant water bug *Diplonychus* sp. (family Belostomatidae)

Size

Animals of the genus *Diplonychus* can grow up to 23 mm in length, while *Lethocerus* species can grow up to 75 mm long. Juveniles are smaller than the adults.

Features

Members of this family have two retractable respiratory filaments on the abdomen and strong forelegs that are modified for seizing and grasping their prey. They can be quite large bugs with a wide body. They are usually brownish in colour and have inconspicuous antennae.

Diet and feeding

Frogs, fishes and aquatic invertebrates form the staple diet of giant water bugs. Belostomatids have very powerful forelegs that are used for grasping prey. Their strong mouthparts easily pierce the prey, injecting an anaesthetic saliva to prevent the animal from escaping from their clutches. The juices are then sucked out of the victim. Belostomatids are also known to feed on each other.

Locomotion

Giant water bugs have a fringe of hair on the middle and last pairs of legs, which helps them to swim swiftly through the water. Adults have two pairs of wings, but fly only to migrate to other water bodies when conditions become unfavourable.

Gas exchange (breathing)

These bugs have a tube-like siphon at the end of the abdomen through which they make contact with the air, enabling gaseous exchange. They do this while sitting beneath the surface of the water with the tip of the abdomen breaking through the water surface. When diving under water, the giant water bug takes a bubble of air with it under the wings.

Life cycle and reproduction

The sexes are separate and generally they only produce one generation per year. After mating, the female attaches her eggs to the back of the male and he carries them around until they hatch. This process ensures that the eggs are well oxygenated and prevents fungus from growing on them. The female lays only a few eggs after each mating, but a male and female will mate with each other several times, producing up to 150 fertilised eggs in one brood. Nymphs hatch after approximately three weeks. At this stage, the glue that has attached the eggs to the back of the male deteriorates and the empty egg sac falls off. The nymphs are pale yellow as soon as they hatch, but darken in colour after a few hours. Nymphs go through five instars over about ten weeks before becoming adult, and adults live for about one year, sometimes longer.

Habitat

Belostamatids can be found in still to slow-flowing waters among water plants. They are not found in polluted waters. In South Australia, they are not very common, but they can be found in the South East region of the state and in some water bodies on the Fleurieu Peninsula.

Critter facts

These bugs have been known to pierce human flesh and inflict a painful wound, so care is required in handling them.

They are considered a delicacy in China and are sometimes available in Chinese markets.

Identification

Belostomatid bugs are the largest of all aquatic hemipterans. They are brown in colour and have a wide body and small antennae that are very difficult to see. They can be confused with naucorids (creeping water bugs), but the wings of naucorids lack veins whereas veins are present on the wings of belostomatids. Male *Diplonychus* that are carrying yellow eggs are very easily recognised. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Hemiptera (2)

Family Belostomatidae (1)

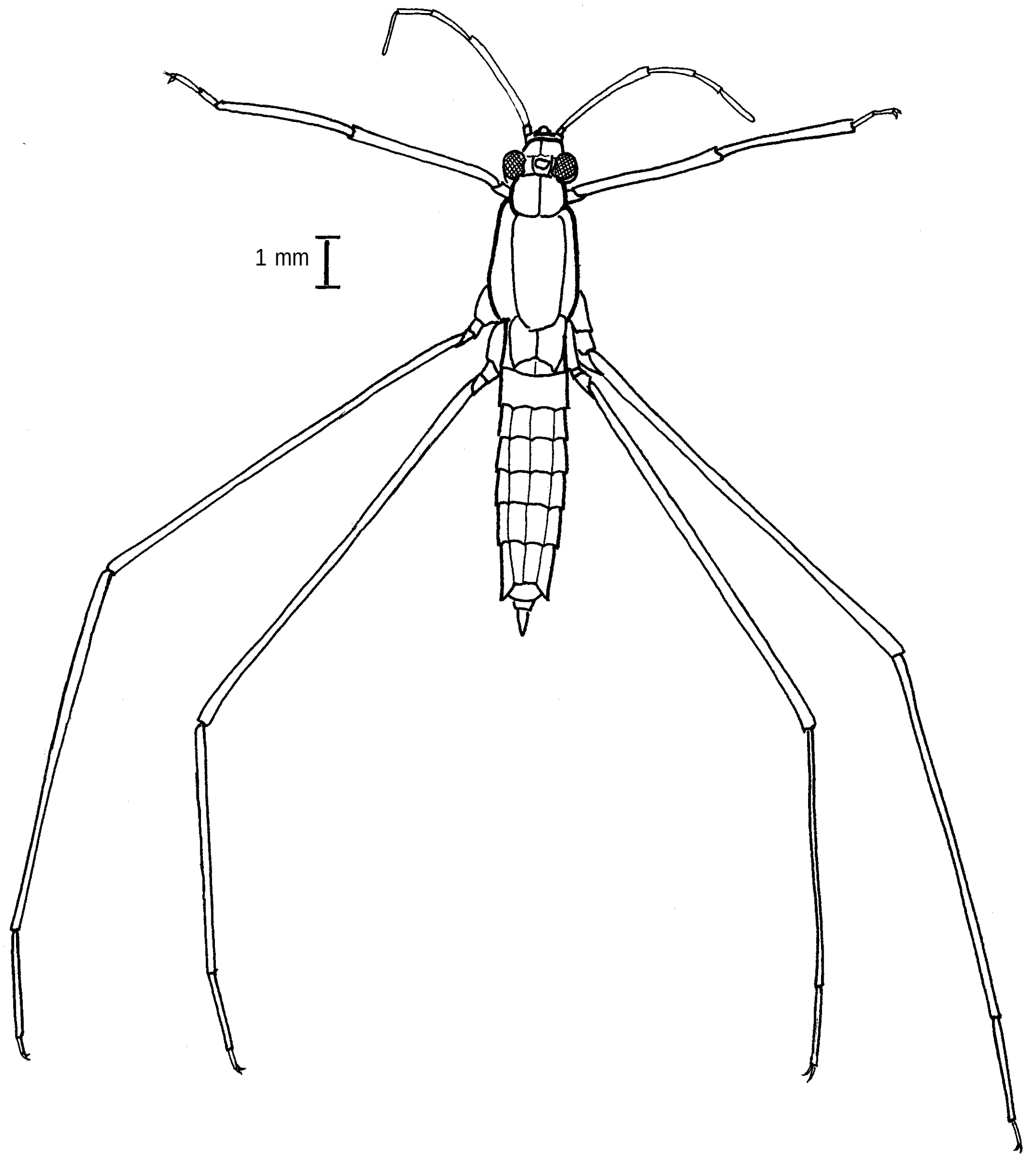
References

Hawking & Smith 1997, pp 128-129; Williams 1980, p 224; Gooderham & Tsyrlin 2002, pp 148-149.

Family Gerridae-water striders

Background

Gerrids occur worldwide, except in the Antarctic. About 500 species of Gerridae have been described. One genus, *Halobates*, is truly marine and can be found far off-shore. Five genera and twelve species are recorded from the inland waters of Australia, and at least two genera have been recorded from inland waters of South Australia. Fossil records of the group date back to the Upper Palaeocene epoch, about 60 million years ago.



The water strider *Aquarius antigone* (family Gerridae)

Size

Adult gerrids can grow up to 12 mm long, but juveniles are generally much smaller. In the Northern Hemisphere, one genus grows to a length of 36 mm.

Features

These long-legged, very active bugs have antennae that are much longer than their heads. Their first pair of legs are short compared with the second and third pairs, which are almost twice as long as their bodies. They have a scent gland on the thorax, secretions from which may discourage fish from eating them. Members of the same species can be either winged or wingless. The relative frequency of winged versus wingless forms in a population depends on the habitat.

Diet and feeding

Water striders feed on insects and other aquatic animals and are attracted to their prey by vibrations on the water surface. They use their short front legs to handle food. Some species sit on the surface of the water and wait for prey to fall from plants and trees above the water body. They pierce the prey with their long beaks and suck out the fluids of the victim.

Locomotion

Gerrids move swiftly and with agility. They skate on the water surface-having the claws attached to their legs behind the tip prevents them from breaking the surface tension. These bugs are covered with water-repelling hairs so, even if they are swamped by a wave, they rapidly float to the surface again. They are able to row themselves across the water surface using the second pair of legs. Some gerrids have wings and fly to other water bodies if conditions deteriorate.

Gas exchange (breathing)

As they are surface bugs, gerrids take oxygen directly from the air via spiracles and a tracheal system.

Life cycle and reproduction

Most Gerridae lay their eggs on floating vegetation or debris, which prevents the eggs from being stranded if the water level drops. However, some species lay their eggs under the water.

Males communicate with the females by creating ripple signals on the surface of the water. This communication alerts the female to possible egg-laying sites, excites the female when she meets the male and also deters other males in the area. Different ripple frequencies send different messages.

Males can mate in a variety of ways. Some only mate with the one female and subsequently defend her against other males. Other males mate with any females that come into their territory. For some species, the females can also be selective: several males may parade for one female and usually the best male wins. If the population is in decline, however, she will mate with any male.

There are five nymphal instars. Juveniles take up to 65 days to develop into adults.

Habitat

Water striders are found on the water surface of ponds, streams, rivers, wetlands and small dams. They often aggregate in small groups. Gerrids are not commonly found in South Australia. However, they are known to occur in the River Murray and in the Far North region of the state. They are unlikely to be found in waters that are polluted.

Critter facts: Studies have shown that some females mate with more than one male, and the last male with whom she mates sires 80% of the offspring.

Identification

These animals can be recognised by their extremely long legs and long antennae. They can be confused with Nepidae (water scorpions), but lack the long respiratory siphon attached to the end of the abdomen that is seen in nepids. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Hemiptera (2)

Family Gerridae (4)

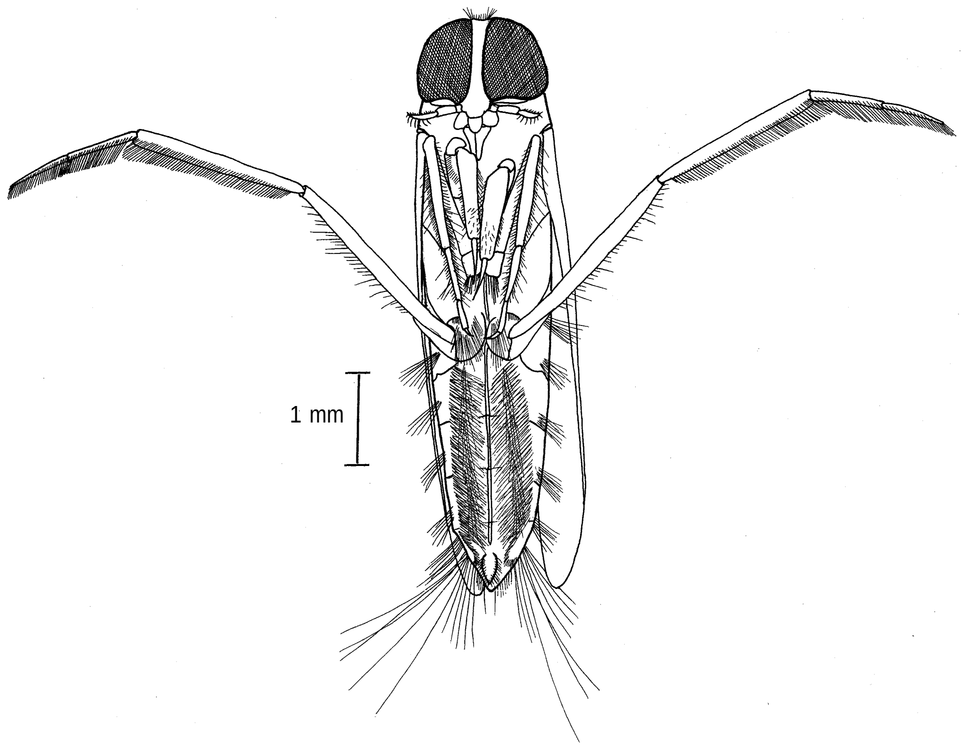
References

Hawking & Smith 1997, pp 120-121; Williams 1980, p 217; Gooderham & Tsyrlin 2002, pp 152-153.

Family Notonectidae-back swimmers

Background

Worldwide, there are about 170 species of Notonectidae. Six genera are known from Australia, of which two are found in South Australia. The taxonomy of this family is difficult, but at least 11 species have been recorded for South Australia.



Ventral view of the backswimmer *Anisops* sp. (family Notonectidae)

Size

Adults grow up to 15 mm long, but juveniles are much smaller.

Features

Back swimmers earn their name because they swim on their backs with their ventral surface uppermost. They have large, well-developed eyes, elongate bodies and long, oar-like hind legs fringed with hairs that help them swim quickly.

Diet and feeding

Notonectids are active predators. They wait until they see or feel vibrations from their prey, give chase, then catch the victim with their front legs. They extract body juices with their piercing and sucking mouthparts. They feed on other insects, small crustaceans, tadpoles and small fish.

Locomotion

Notonectids are active swimmers and use their long hind legs like oars to propel themselves whilst they lie on their backs. Adults are strong fliers and are often the first invertebrates to colonise a newly filled water body. Adults must leave the water before taking flight.

Gas exchange (breathing)

Back swimmers carry a bubble of air on their abdomen while under water. They regularly return to the surface to replenish their air supply. *Anisops* has haemoglobin present in the haemolymph (blood) of the abdominal tracheal gills, and the oxygen bound to the haemoglobin can be released into a gas bubble to modify the density, and hence buoyancy, of the body. By controlling their density and conserving energy, back swimmers can stay submerged, searching for prey for long periods. This mechanism enhances the ability of back swimmers to prey on other invertebrates.

Life cycle and reproduction

The sexes are separate and mating usually occurs in spring. Males attract the females by producing a mating call of a particular frequency, using stridulatory organs on their legs to make the sounds. The female inserts her eggs into plant tissue or attaches them to rocks and other stable substrates. Nymphs go through five instars before becoming adults. Adults can produce eggs only once or twice in their lifetime.

Habitat

Back swimmers occur in most aquatic habitats, but are less common in fast-flowing sections of streams. They are often found in water bodies such as ponds, slow-flowing streams, backwaters, dams and wetlands. They can be found throughout South Australia. Being tolerant animals, they can survive in saline and slightly polluted water.

Critter facts

A male notonectid makes chirping sounds by rubbing his front legs against his 'rostral prong', which is the part of the head from which the mouthparts extend.

Although it happens infrequently, back swimmers can pierce human skin with their mouthparts if they are handled carelessly, or trapped inside a swimming costume.

In Mexico, a food called 'ahuautle' is often eaten, a dish made of toasted back swimmers. Back swimmers are also known as a delicacy in Asia.

Identification

Back swimmers can be easily recognised by their large eyes, which occupy most of the head, their elongate keeled bodies and long oar-like second legs. They are similar to Corixidae (water boatmen), but corixids swim belly down. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

- Class Insecta
  - Order Hemiptera (2)
    - Family Notonectidae (1)

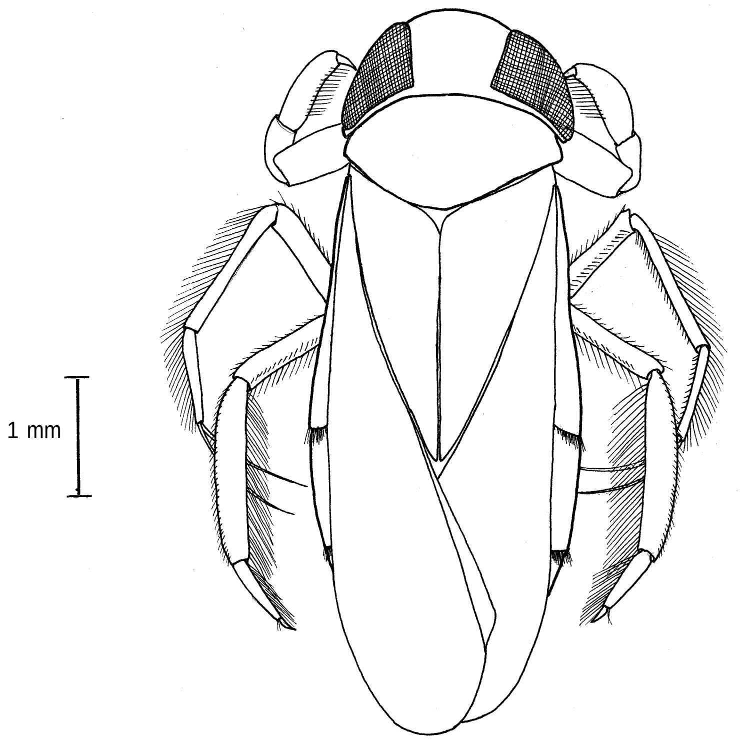
References

Hawking & Smith 1997, pp 121-122; Williams 1980, p 225; Gooderham & Tsyrlin 2002, pp 157-158.

Family Corixidae-water boatmen

Background

There are over 300 species of Corixidae worldwide. They are commonly known as water boatmen and live in most inland water bodies. Five genera and 31 species are recorded for Australia. Four genera, *Diaprepocoris, Agraptocorixa, Sigara* and *Micronecta,* are known from South Australia.



The water boatmen *Agraptocorixa* sp. (family Corixidae)

Size

Adult corixids grow 4-10 mm long, depending on the species. Adults of Micronecta species are smaller than those of the other three genera, although first instar juveniles of all four genera are about the same size, approximately 1.5 mm long.

Features

Water boatmen have a long, flattened, oval body and their hind legs are long and oar-like, and used for swimming. Their middle legs are used for clinging to the substrate. The first pair of legs have scoop-shaped 'tarsi', the fifth segments at the end of their front legs, which are used to scoop up detritus or in finding prey. As with all insects that develop wings, the wings are present only in the adult stage, which is usually the dispersal stage. The bodies of the water boatmen are so buoyant that, when underwater, they must swim or they float to the surface.

Diet and feeding

Some corixids feed mainly on small particulate plant material-they suck up debris with their beaks. Others are predatory and feed on insects and other invertebrates, which they catch using the modified front legs.

Locomotion

The last pair of legs are fringed with long hairs that help water boatmen to swim easily. As well as being strong swimmers, the adults are good fliers. They tend to fly at night, rather than by day. Flight is important, aiding dispersal from one water body to another, especially when conditions become unfavourable.

Gas exchange (breathing)

Corixids carry air bubbles under their wings that enable them to continue to obtain oxygen through the tracheal system when under the water. They must come to the surface periodically to replenish their air supplies.

Life cycle and reproduction

Corixids mate in spring or autumn, depending on the species. The males attract females by making mating calls using their stridulatory organs. They rub their front legs against their beaks or rub opposite legs together to produce sounds of a particular species-specific frequency. Mating occurs away from the water. Corixids aggregate in groups to breed, and return to the water to attach their eggs to submerged rocks or filamentous algae. The eggs are round and each has a stalk used to attach the egg to a surface. The eggs hatch in 7-15 days. Nymphs go through five instars before becoming adults. The life cycle is completed in one year.

Habitat

Corixids are often the first colonisers of newly flowing water. They are very common in almost all aquatic habitats in South Australia, including saline and polluted waters. Throughout the state, they can be found in most slow-flowing or still water bodies that have open pool areas as well as vegetation.

Critter facts

In Mexico, corixid adults and eggs are gathered as food for humans. Some corixids lay their eggs on crayfish, which can reduce the market value of the crayfish.

One species of corixid lives 12 metres below the surface of the Great Lakes in North America and can stay submerged for long intervals.

Fly-fishers sometimes tie flies that resemble water boatmen as they are a favoured food source for freshwater fish.

Identification

Water boatmen are easily seen swimming in still waters. They are oval-shaped animals with very small antennae, and are usually brownish on the backs and yellow underneath. They may be mistaken for back swimmers as they can be found in the same habitats, but back swimmers swim upside down and are able to hover in the water column. Corixids cannot stay still, since unless they are clinging to a plant or to debris, they will float to the surface.

When looking at corixids swimming in a water body or a tray it may be difficult to distinguish them from small beetles, particularly dytiscids (predacious diving beetles). See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Hemiptera (2)

Family Corixidae (2)

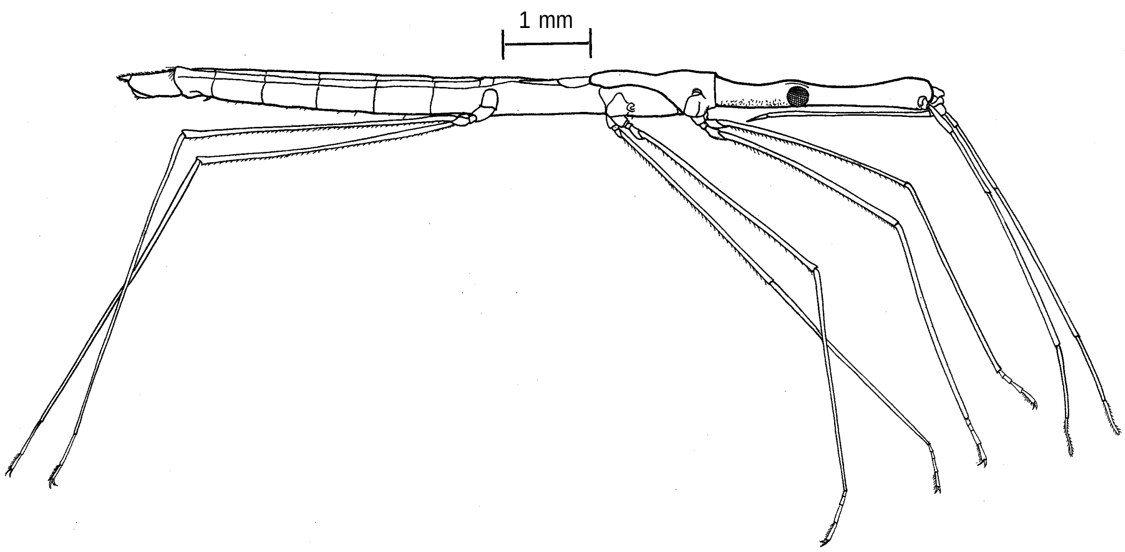
References

Hawking & Smith 1997, pp 123-125; Williams 1980, p 219; Gooderham & Tsyrlin 2002, pp 149-150.

Family Hydrometridae-water measurers

Background

Hydrometridae have a worldwide distribution, being found on every continent except Antarctica. In total, there are 112 species. Only the genus *Hydrometra*, with eight species, is found in Australia. *Hydrometra* species are difficult to distinguish, so it is unknown how many species occur in South Australia. Fossil records date back to the Upper Palaeocene epoch, about 60 million years ago.



Side view of the water measurer *Hydrometra* sp. (family Hydrometridae)

Size

Adult Hydrometridae can grow up to 16 mm long. Males are slightly smaller than females.

Features

The body of a water measurer is very long and slender. The eyes are situated halfway along the head, which is as long as the thorax. The legs are long, and have very long tarsi (feet), which enhance the animal's ability to walk on water without breaking the surface tension. Winged and wingless adults occur.

Diet and feeding

Water measurers feed on small animals that are associated with the surface film of water, including ostracods, mosquito larvae, other water measurers and terrestrial animals that fall onto the water. They are attracted to their prey by vibrations on and just below the water surface.

Locomotion

Hydrometrids are slow-moving skaters on the surface film of water and they also climb on vegetation. When swimming, they move their legs alternately.

Gas exchange (breathing): As they sit on the surface of the water, hydrometrids take oxygen directly from the air, via the spiracles and tracheal system.

Life cycle and reproduction

Females attach their eggs to stone or vegetation above the water surface. The eggs are laid one at a time during spring. Hatching takes place up to 19 days after the eggs are laid. The juveniles go through five instars and take up to 65 days to reach the adult stage. There is only one generation each year and adults are able to mate as soon as two days after the final moult.

Habitat

Water measurers are usually found among emergent vegetation at the edge of still waters. They can be found in ponds, wetlands, slow-flowing streams and dams. They are not common in South Australia, but have been collected in the Flinders Ranges, the Riverland, the South East region and in the Torrens River. They are not found in water bodies that are polluted or saline.

Critter facts

Unlike other surface-dwelling Hemiptera, hydrometrids do not have scent glands on the thorax, and their claws are at the ends of their legs. Hydrometrids have been considered as biological control agents for mosquito larvae, which are the favoured food source of the bugs.

Identification

Water measurers can be recognised easily by their long slender bodies. In general appearance, they resemble terrestrial stick insects. They might be mistaken for Nepidae (water scorpions or needle bugs), from which they can be separated by the placement of the eyes. The eyes of needle bugs or water scorpions are at the front of the head, whereas water measurers have eyes in the middle of the head. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

Phylum Arthropoda

- Class Insecta
  - Order Hemiptera (2)
    - Family Hydrometridae (3)

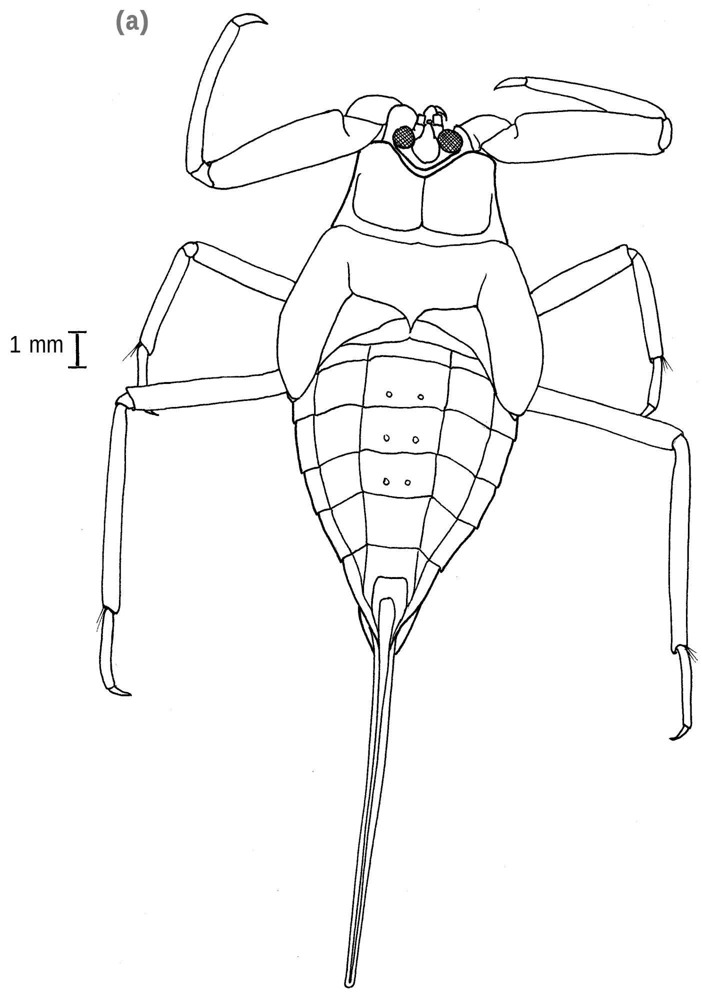
References

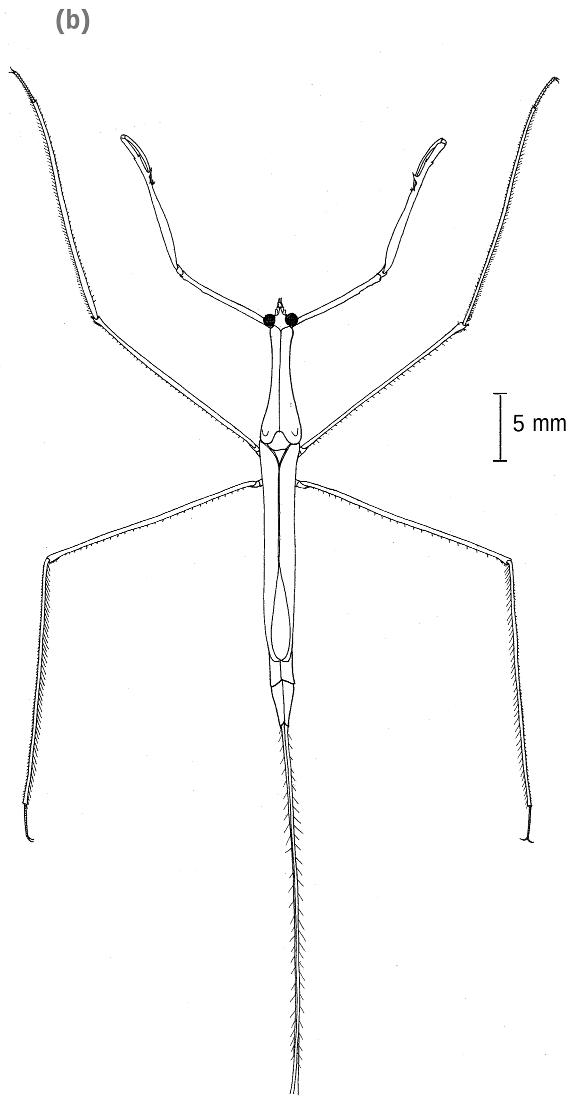
Hawking & Smith 1997, p 126; Williams 1980, p 217; Gooderham & Tsyrlin 2002, p 153.

Family Nepidae—water scorpions or needle bugs

Background

Worldwide, there are about 150 species of Nepidae. Most are found in tropical regions and all occur in fresh water. Five genera are recorded for Australia, of which two are known to occur in inland waters of South Australia. Members of the genus *Laccotrephes* are known as water scorpions, while needle bug is the name given to species in the genus *Ranatra*. Fossil records date back to Late Silurian period, nearly 430 million years ago.





The water scorpion:
(a) *Laccotrephes* sp.
(b) *Ranatra* sp. (family Nepidae)

Size

Nepids vary in length from 7 mm to 50 mm (not including the respiratory siphon).

Features

All nepids have a modified first pair of legs that look like claws. They are used for grasping prey. Water scorpions have long, broad, flat bodies that resemble leaves in shape and have a breathing tube at the tip of the abdomen. Needle bugs are slim with long slender legs. Nepids do have antennae, but these are so small that they are difficult to see.

Diet and feeding

Nepids are predators that hide, lying in wait until their prey move within range, then grasping them with their front legs. Adult nepids eat aquatic insects and crustaceans and have been known to feed on tadpoles and small fish.

Locomotion

Nepids are poor swimmers and prefer to climb and crawl. However, they do sometimes swim, using alternating leg movements to propel themselves through the water. The adults are able to fly and can migrate to other water bodies.

Gas exchange (breathing)

Nepids obtain oxygen via a respiratory siphon situated at the tip of the abdomen. They push the siphon through the surface of the water to contact the air. They can also hold an air bubble under their wings.

Life cycle and reproduction

Nepids produce one or two broods per year, depending on the species. Males attract females with sounds that they produce by rubbing the base of the front of their legs against the upper part of their bodies. After mating, females attach the fertilised eggs to submerged water plants. The eggs hatch in autumn and the nymphs go through five instars before reaching adulthood. The nymphs have hairy bodies when they are young, but each instar more closely resembles an adult.

Habitat

Nepids are found among submerged vegetation in still or slow-flowing fresh water, including creeks, ponds, dams and wetlands. Nepids are not very common in South Australia, although they occur in streams and well-vegetated ponds and farm dams in the Mount Lofty Ranges and the Flinders Ranges. They do not like saline water and are not very tolerant of polluted water.

Critter facts

When disturbed, water scorpions tend to 'play dead' and can be mistaken for leaves. Care is needed in handling them as the mouthparts can pierce human skin and deliver a painful bite. Some aquatic biologists have discovered that sampling while wearing sandshoes without socks is risky, especially if a nepid gets caught inside your shoe!

Identification

Needle bugs might be mistaken for hydrometrids (water measurers), but can be separated by the placement of the eyes. In needle bugs the eyes are at the front end of the head, whereas water measurers have eyes in the middle of the head. Hydrometrids lack a respiratory siphon at the tip of the abdomen, whereas this siphon is very obvious in needle bugs.

Water scorpions may also be mistaken for Belostomatidae (giant water bugs), although again the long siphon at the end of the abdomen is absent in giant water bugs. See page 147 of *The Waterbug Book* for a key to the families of Hemiptera.

Classification and sensitivity

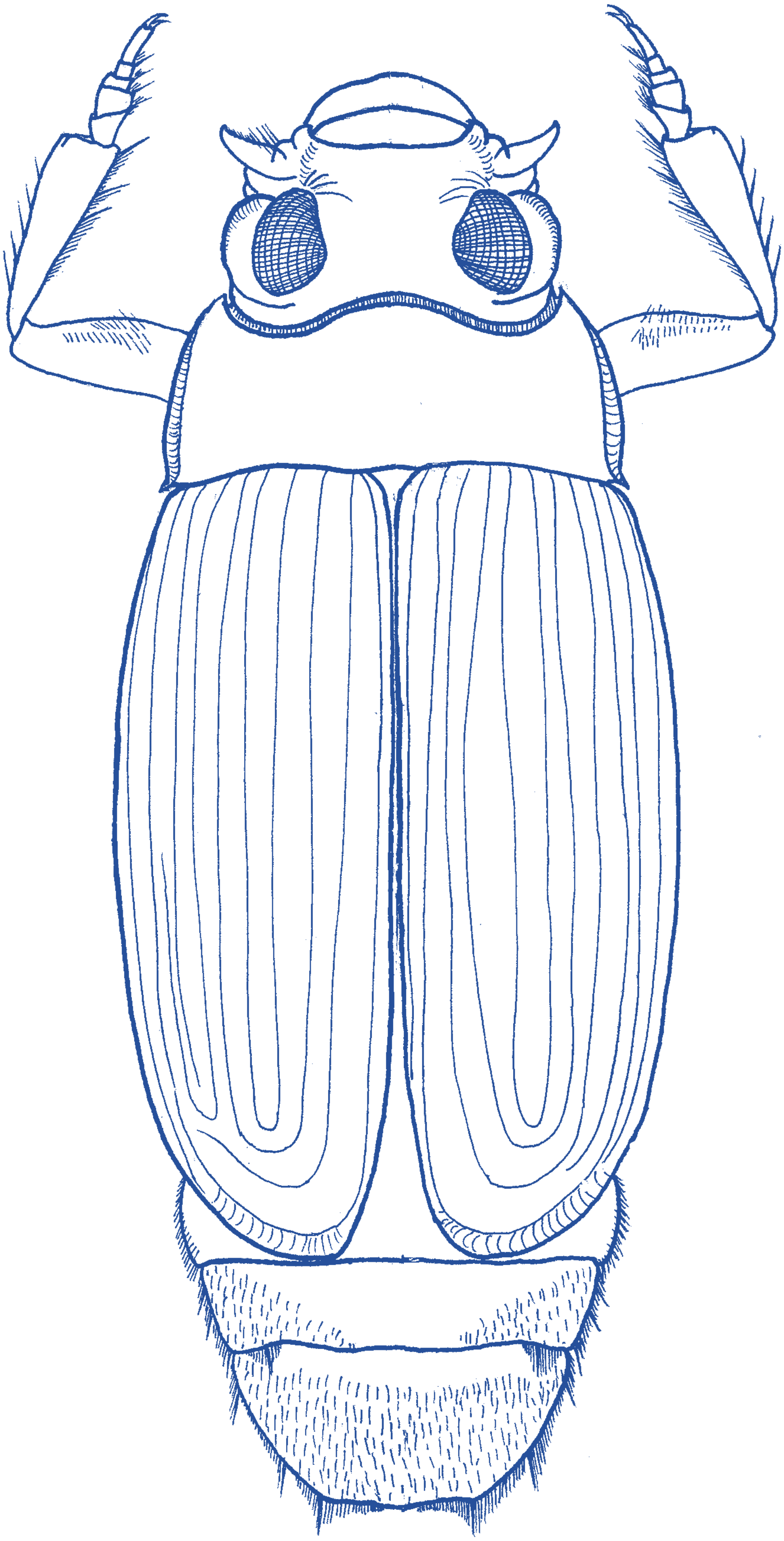
Phylum Arthropoda

- Class Insecta
  - Order Hemiptera (2)
    - Family Nepidae (3)

References

Hawking & Smith 1997, pp 130-131; Williams 1980, p 221; Gooderham & Tsyrlin 2002, pp 155-156.

Beetles



12.6 Order Coleoptera—beetles

Background

Worldwide, there are 151 families and over 350,000 described species of Coleoptera. In Australia, some 113 families and around 28,200 species are known. Beetles occupy almost every available terrestrial and aquatic habitat, and some marine habitats, too. Nineteen families have representatives in which both the adult and larvae are aquatic, or just the larvae.

South Australia has 15 families with aquatic representatives: Dytiscidae (predacious diving beetles), Gyrinidae (whirligig beetles), Hydrophilidae (water scavenger beetles), Scirtidae (marsh beetles), Elmidae (riffle or long-toed beetles) and Psephenidae (water pennies) are discussed in more detail below. The families Heteroceridae, Staphylinidae, Chrysomelidae, Brentidae, Carabidae (ground beetles), Haliplidae (crawling water beetles), Hygrobiidae (screech beetles), Hydraenidae (minute rove beetles) and Curculionidae (weevils) are also found in South Australia but are not discussed further.

Coleoptera fossils have been discovered in Australia from the Upper Permian period, 280 million years ago. These fossil beetles are believed to be related to the family Hydrophilidae. Beetles that seem to be related to the family Dytiscidae have been found in the Upper Jurassic, about 200 million years ago.

Size

Aquatic adult beetles range in length from less than 1 mm up to 40 mm. Larvae can range from very small to 20 mm long.

Features

Coleoptera adults have rigid ‘elytra’, the first pair of wings. The hard, armoured ‘shell’ created by the elytra and dorsal plates is suggested as one reason for the beetles’ astonishing evolutionary success. Reduction in the area of exposed membranes and soft tissues provides protection against predators and parasites, and microbial, chemical and physical dangers. The elytra can be many colours including brown, black, red or dark green. In some species, the elytra have a metallic sheen.

Adult beetles usually have mouthparts that are adapted to biting.

Aquatic larvae in this order range from grub-like forms to highly specialised animals such as water pennies.

Diet and feeding

Water beetles can be detritivores, herbivores or carnivores. Some are even cannibals. It is not unusual for the larvae and adults of the same species to eat different foods. Some larvae are predators and grasp their prey with stout mandibles. They release digestive fluids into the prey to paralyse the animal and break down the body tissues. Then the juices from the prey are sucked out. Some adults are detritivores and grazers, feeding on detritus and plant matter. Those that are carnivorous are often scavengers rather than being predatory. They therefore tend to feed on sick and dying animals.

Locomotion

Adults and larvae range from strong to weak swimmers. Adult beetles fly, using the second pair of wings. In flight, the elytra are held horizontally, possibly providing extra lift, similar to the wings of an aeroplane.

Gas exchange (breathing)

Some members of two suborders of Coleoptera are aquatic. Aquatic adults from the beetle suborder Adephaga (including Carabidae, Haliplidae, Dytiscidae and Gyrinidae) trap air under their elytra and, when they return to the surface of the water to renew their air supply, break through the surface of the water with the end of their abdomen. Aquatic Polyphaga (including Staphylinidae, Chrysomelidae, Curculionidae, Hydrophilidae, Scirtidae, Psephenidae and Elmidae) also carry air bubbles underneath their elytra but, in addition, they have hairy abdomens that hold a thin film of air.

As with the adults, larvae of some families must periodically come to the surface to renew their air supplies. In most larvae renewal of air is achieved by breaking through the surface of the water with the tip of the abdomen. On the end of the abdomen are two respiratory spiracles. These spiracles are connected to a complex network of tracheae (air tubes) that take the air, containing oxygen, to other parts of the body. However, some larvae have gills-membranous outgrowths on the sides of the body-that they use for obtaining oxygen from the water. Dissolved oxygen diffuses across the gill surface.

Life cycle and reproduction

Adult female beetles produce sex pheromones to attract males and the males use their antennae to detect these chemicals. Beetles reproduce sexually and have internal fertilisation. Aquatic Coleoptera usually lay eggs in air-filled cocoons, air-filled stems of aquatic plants, or out of the water. A larva must go through between three and eight instars or stages before moulting to the adult stage. The exact number varies between species. Larvae pupate in a hollow chamber of mud or organic matter that they build on the edge of the water. Adults live for one or more years, depending on species, and many breed at least twice in that time.

Habitat

Coleopterans can be found in a broad range of environments: fast-flowing to still waters, fresh to hypersaline waters, temporary to permanent water bodies, healthy to polluted waters, and arid to alpine environments. Adult beetles are successful at colonising temporary waters once flow begins. They can be found in many water bodies throughout South Australia.

Critter facts

In terms of numbers of species and diversity of habitats and life styles, the order Coleoptera is probably the most successful group of animals in the world. Of all the different animal species on earth about 30% are beetles. About 40% of all described insect species are beetles. There are six times more beetle species than there are species of vertebrates (animals with backbones). There are more beetle species than there are species of vascular plants or fungi. A distinguished theologian once asked J.B.S. Haldane, an important geneticist and evolutionary biologist, ‘What inference one could draw about the Creator from the nature of His creation?’ Haldane replied, ‘An inordinate fondness for beetles.’

Some water beetles have demonstrated an ability to learn and memorise. Dytiscids have been taught to associate certain artificial scents with suitable or unsuitable food. However, the memory will last only for a few days. Gyrinids have been found to be able to associate wave motions produced on water by a tuning fork with a particular kind of food. They pick up or sense the wave motions using detectors in their antennae called 'Johnston's organs'.

Some water beetles cause problems in domestic water supplies; gyrinids have been known to be a nuisance in fish ponds as they can kill small fish. Adult and larval elmids feed on the roots of aquatic plants, but the extent of damage they are capable of is unknown.

Water beetles are important food sources for waterbirds, turtles, frogs and fish.

Identification

Adult water beetles are easily recognised by their hard, shell-like backs. They can be quite large. Sometimes they may be confused with hemipterans such as giant water bugs. In almost all bugs, however, the outline of overlapping wings on the back is visible, whereas in beetles only a single line down the middle of the elytra can be seen. Coleopteran larvae are not so distinctive as they vary greatly.

The key starting on page 20 of *The Waterbug Book* should help you tell if you have a beetle adult or larva. Once you are sure of that, larval and adult keys to family are on page 94 and 95.

Classification and sensitivity

Phylum Arthropoda

- Class Insecta
  - Order Coleoptera (5)
    - Family Carabidae (NR)
    - Family Haliplidae (2)
    - Family Hygrobiidae (1)
    - Family Dytiscidae (2)
    - Family Gyrinidae (4)
    - Family Hydrophilidae (2)
    - Family Hydraenidae (3)
    - Family Staphylinidae (NR)
    - Family Scirtidae (6)
    - Family Elmidae (7)
    - Family Heteroceridae (NR)
    - Family Psephenidae (6)
    - Family Chrysomelidae (NR)
    - Family Brentidae (NR)
    - Family Curculionidae (2)

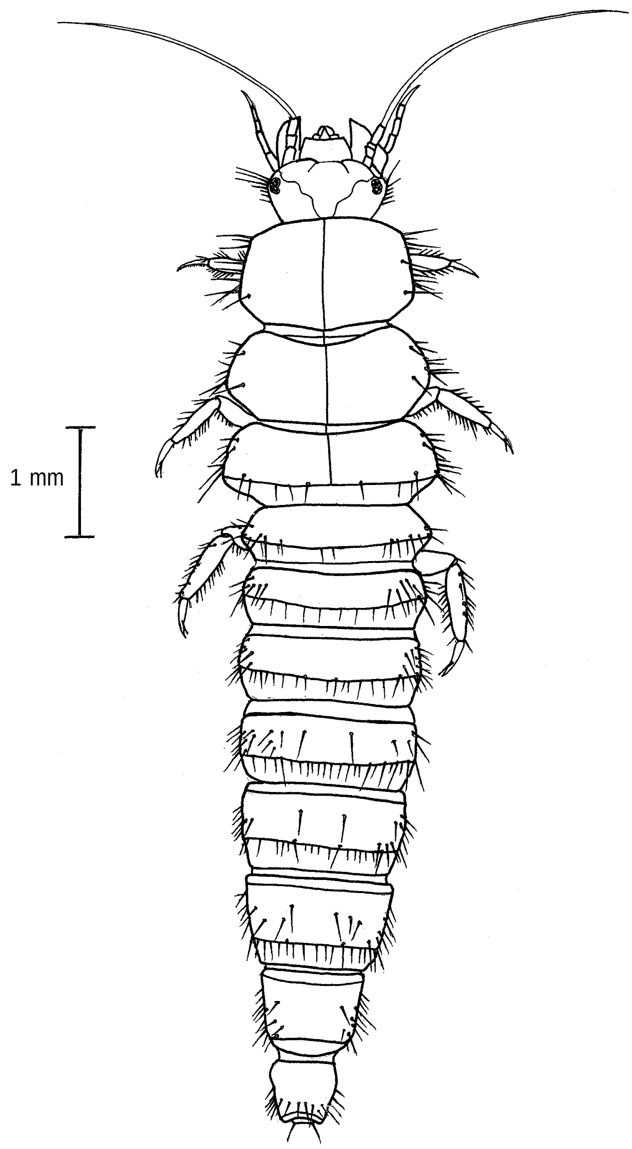
References

Hawking & Smith 1997, pp 136-157; Williams 1980, p 266; Gooderham & Tsyrlin 2002, pp 92-111.

Family Scirtidae—marsh beetles

Background

Scirtids occur worldwide, although they are most common in the cooler climates of both hemispheres. Worldwide, there are some 360 species of Scirtidae. In some older publications this family is called Helodidae. The larvae are aquatic and the adults terrestrial, although the adults can be found near water bodies. Eight genera of marsh beetles are recorded for Australia, with 70 species in total, occurring mainly in the north and east. It is possible that four genera occur in South Australia. Fossil records for Scirtidae have been found in a glacier in Antarctica dating back to the Cretaceous period, more than 65 million years ago.



A larva of a marsh beetle (family Scirtidae)

Size

Both larvae and adults can grow up to 10 mm long.

Features

The larvae have broad, flattened bodies that are usually brown in colour. They have long, segmented antennae and a strongly ‘deflexed’ head—that is, the head is bent sharply downwards. The larvae have anal gills that are hidden inside the final abdominal segments. Adult scirtids have a sharp ridge that runs under the eyes. They have a plate that covers the hind pair of legs; in the genus Scirtes, however, the femur of the hind legs is enlarged and modified for jumping.

Diet and feeding

The larvae are filter-feeding detritivores, taking fine particles from the water. They filter the food, compress it, and ingest it in small clumps.

Locomotion

The larvae live among aquatic plants and cling and climb through plant matter rather than swim through the water.

Gas exchange (breathing)

The last abdominal segment of the larva contains two membranous structures. One enables the larva to obtain oxygen and the other regulates water and salt concentrations in the body, possibly also absorbing chloride from the water.

Life cycle and reproduction

Little is known about the life cycle of these beetles. After mating, the female lays eggs in the water. The larvae hatch and go through between three and eight instars. It is believed that pupation occurs on the bank of the water body, in a pupal cell. There appears to be one generation a year and adults are terrestrial and short-lived.

Habitat

The larvae can be found on the edges of still and flowing waters, sometimes in organic matter. They are not usually found in saline waters. Larvae are found in many water bodies throughout South Australia, including wetlands, streams and rivers.

Critter facts

Members of one genus of Scirtidae, *Scirtes*, are able to jump with the help of their enlarged hind femurs. Adult scirtids are sometimes attracted to light.

Identification

Adult scirtids have a sharp ridge that runs under their eyes. Adults of the genus *Scirtes* are easily recognisable by the enlarged hind femurs. All other scirtid adults have a plate covering the last pair of legs.

The larvae look similar to other beetle larvae, but can be recognised by the long, segmented antennae and broad, flattened bodies. Occasionally, they have been identified mistakenly as elmids, which are much smaller and do not have long antennae. The key on page 94 of *The Waterbug Book* should help identify larval scirtids.

Classification and sensitivity

Phylum Arthropoda

    Class Insecta

        Order Coleoptera (5)

            Family Scirtidae (6)

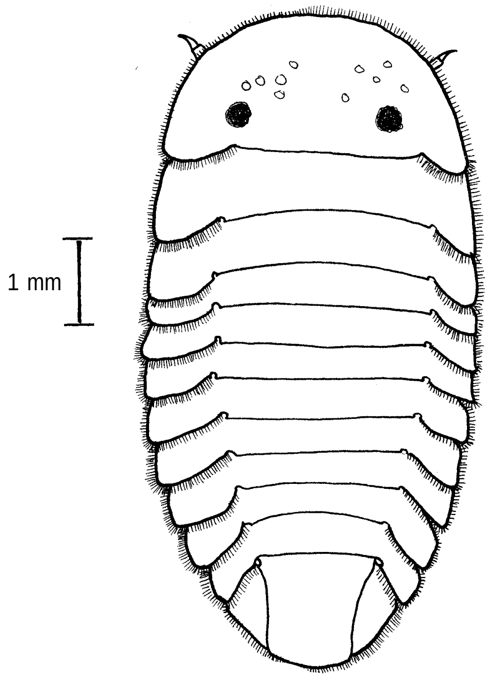
References

Hawking & Smith 1997, p 149; Williams 1980, p 288 [called Helodidae]; Gooderham & Tsyrlin 2002, pp 110-111.

Family Psephenidae—water pennies

Background

Water pennies are widespread, occurring in Europe, North and South America, Africa, India, South-East Asia, Japan and Australia. The family is represented in Australia by just one genus. The restricted southern distribution of this genus suggests a Gondwanan (southern hemisphere) origin. Recent work has shown that there may be up to 18 different species of this genus in Australia, where only 15 were previously recognised. Only one species, *Sclerocyphon fuscus*, is present in South Australia. Larvae are aquatic and adults are terrestrial.



The water penny larva *Sclerocyphon* sp. (family Psephenidae)

Size

Adult water pennies are quite small—approximately 3 mm long. The larvae can grow to lengths of up to 6 mm.

Features

The adults are small, round, dark-coloured beetles with a dense pile of hair on the elytra. The larvae are also round, but are flattened and have a fringe of hair around the entire body. They have segmented abdomens and organs called 'gin traps' that occur between some of the segments. The head is deflexed and covered by the plate-like body so that it is not visible from the dorsal side of the beetle.

Diet and feeding

Water pennies are herbivorous. They feed on biofilm attached to detritus and rocks.

Locomotion

The adults can fly: they have been seen in rapid flight above streams on hot sunny days. The larvae are not good swimmers, but crawl and cling to boulders and cobbles on the waterbed.

Gas exchange (breathing)

Larvae of all instars have anal tracheal gills that can be retracted into the body. Before pupation, the last instar larva obtains oxygen from the air via brush-like spiracles on the end of the abdomen, and the internal tracheal system of fine tubes. Similarly, spiracles and the tracheal system are involved in gas exchange in the pupa and adult.

Life cycle and reproduction

The adults mate in the detritus on the bank of the water body and the females lay their eggs in the water. The eggs are deposited in a single layer on a submerged stone and are virtually invisible to the naked eye. The larval life stage of the water penny is the most dominant: the pupal, adult and egg stages are very short. One species in Tasmania has a larval life of 22 months and takes 24 months to complete its life cycle. In warmer climates, water pennies have a shorter life cycle, usually of 12 months. The last instar larva pupates within its larval skin in the moist litter on the edge of the water. During the pupal stage, the pupa crawls free of the larval skin but rarely moves far. The pupal stage lasts for two to three weeks.

Habitat

The larvae are completely aquatic, favouring rocky substrates in moderate and fast flowing streams. A few species, however, have been found in still lakes in Tasmania and central Australia. Water pennies are usually absent from water bodies that have mainly sandy or silty substrates and those that have high nutrient levels, as they are very intolerant of pollution. Water pennies are not very common in South Australia, but have been found in flowing streams of the Mt Lofty Ranges.

Adult water pennies are terrestrial. They can be found in moist earth, moss and detritus on the stream edge, but are rarely collected.

Critter facts

A species of adult water penny was collected by Sir Joseph Banks during his voyage on Endeavour under the command of Captain James Cook. It was taken back to England and placed in the Banks Collection of the British Museum. It is believed to have been collected from northern Queensland.

The larvae of the water penny tend to remain hidden during daylight hours and to move to the surface of the substrate to feed at night. This habit probably reduces the likelihood of detection and consumption by visual predators.

Identification

Water penny larvae may resemble isopods: they can look a little like terrestrial slaters. They also resemble extinct trilobites. They are quite often brown and gold in colour, and the dense fringe of hair around the larval body is very obvious. The head of the larva is completely covered by the body. The key on page 94 of *The Waterbug Book* should help identify larval water pennies.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Coleoptera (5)

Family Psephenidae (6)

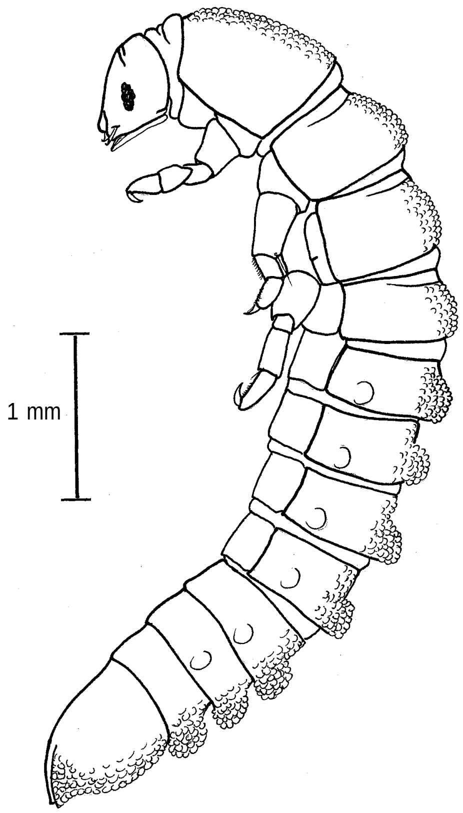
References

Hawking & Smith 1997, p 137; Williams 1980, p 289; Gooderham & Tsyrlin 2002, p 109.

Family Elmidae—riffle beetles or long-toed beetles

Background

Elmids are found throughout the world and they used to be called Helminthidae. Both the adults and larvae can be aquatic. Members of two subfamilies of Elmidae occur in Australia, one aquatic and one terrestrial, and among these, 11 genera and over 150 species are recorded. Four genera are known from South Australia, for all of which both adults and larvae are aquatic. Fossil records date back to the Miocene epoch of the Caenozoic era, nearly 25 million years ago.



The riffle beetle larva *Simsonia* sp (family Elmidae)

Size

Adults can grow up to 5 mm long and larvae to 6 mm.

Features

Adults are dark in colour and have long tarsal claws and long, slender antennae. Larvae are cylindrical, generally brown or dark in colour, and often well sclerotised—that is, they have well-hardened cuticles. Some species have prominent dorsal humps on their abdominal segments. The larvae have gills that extend from cavities on the last abdominal segment.

Diet and feeding

Both the adults and the larvae are herbivores. They feed on algae, moss and plant roots.

Locomotion

Neither adults nor larvae can swim. Instead, they move by crawling along the bottom of the water body.

Gas exchange (breathing)

Adults obtain oxygen from air trapped in a bubble, or 'plastron', and do not have to come to the surface very often. The air in the plastron is in contact with the body via the spiracles and tracheal system, from which oxygen from the air diffuses into the tissues of the beetle. Larvae have retractable gills on the last segment of the abdomen. In the last instar, larvae develop a line of spiracles along the sides of the abdomen.

Life cycle and reproduction

Females lay their eggs either singly or in groups. The eggs are attached to submerged water plants, rock or wood, depending on the species. Hatching takes place after 5-15 days. The number of larval instars varies between five and eight, depending on species, temperature and availability of food. The time taken for larval development depends on body size and temperature. Smaller species develop faster than larger species, and development is faster in warmer waters. Mature larvae move from the water to pupate in damp soil at the water's edge.

In Australia, the adult elmids return to the water without ever flying, whereas in the northern hemisphere, the adults take a short flight before entering the water. After this, the wing muscles deteriorate and the adults are no longer able to fly.

Habitat

Both larvae and adults are aquatic. They are generally found in the faster-flowing, well-oxygenated sections of streams. They are intolerant of saline and polluted waters. Elmids can be found on wood, rocks or sandy substrate. They are not commonly found in South Australia and their distribution is restricted to certain areas of the state. The genus *Coxelmis* has been found in the River Murray, *Kingolus* larvae have been collected from Kangaroo Island, *Simsonia* has been found in the Mt Lofty Ranges and Fleurieu Peninsula, and *Austrolimnius* has been found in the South East region of the state.

Critter facts

Adult elmids have been kept alive for nine years in captivity.

Due to their scent gland secretions, adult elmids are particularly distasteful and are rejected by fish. However, one South American species is used as a spice.

Identification

Adult elmids are usually small, shiny and reddish-black in colour, and the head is deflexed. It is not easy to identify adults to genus or species level. Larvae are elongate, sometimes with a hardened exterior (cuticle). The abdomen tapers at the end and sometimes gills can be seen protruding. These gills look like tiny hair-like filaments. The body is segmented and sometimes the larva has a bump on the back of each segment. Some larvae have long hairs attached to the body. The larvae may be confused with those of other beetles and are not easy to identify below family level. As they are very small, they are often overlooked without the aid of a microscope.

The keys on page 94 and 95 of *The Waterbug Book* should help you identify adult and larval Elmidae.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Coleoptera (5)

Family Elmidae (7)

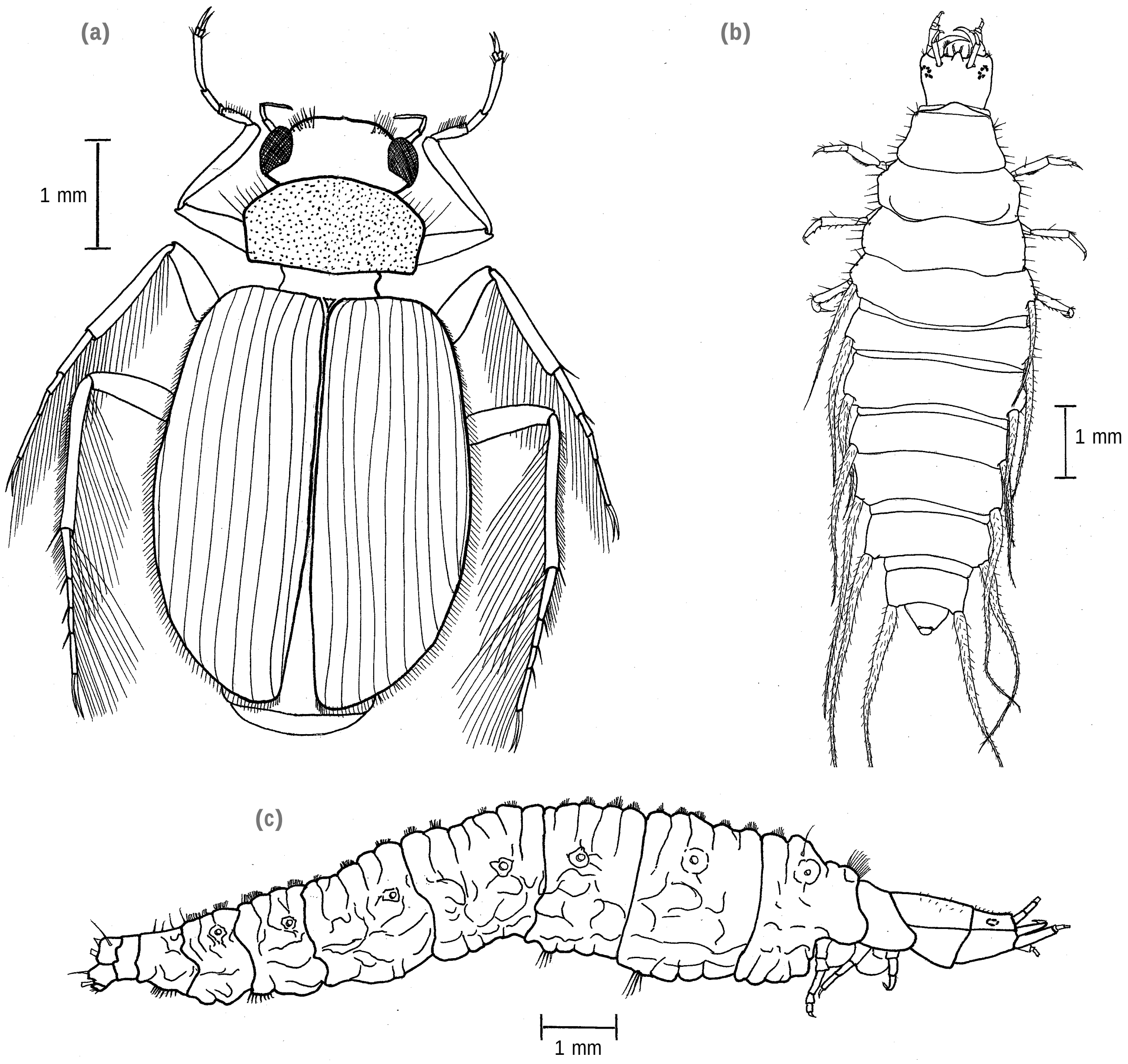
References

Hawking & Smith 1997, pp 138-139; Williams 1980, p 288 [called Helminthidae]; Gooderham & Tsyrlin 2002, pp 100-101.

Family Hydrophilidae—water scavenger beetles

Background

Hydrophilids are among the most common and largest of all beetles and are present throughout the world. In Australia, there are 18 genera and 175 species of aquatic Hydrophilidae; there are also terrestrial species. At least ten genera of aquatic Hydrophilidae occur in South Australia.



Water scavenger beetles:

(a) a *Berosus discolor* adult

(b) a *Berosus* sp. larva and

(c) a *Helochares* larva (family Hydrophilidae)

Size

Adults range in size from 2 mm to over 40 mm, depending on the species. The larvae grow to at least 8 mm long.

Features

The adult beetles are smooth and oval in shape. They vary in colour from light brown to black and some are even green. Some are dull in colour, some have a metallic sheen, and others are patterned. They have antennae with 7-9 segments and the last 3-5 segments are often club-shaped. The antennae are frequently held under the head. Many species have long maxillary palps—'feelers'—that are part of their mouthparts. These extend forward from the head and are longer than the antennae.

The larvae are generally elongate and have fleshy bodies. They have well-sclerotised heads and large fierce-looking jaws. One genus, *Berosus,* has seven pairs of lateral gills that extend from the sides of the abdomen. The other genera found in South Australia do not have these gills.

Diet and feeding

Adults are detritivores and scavengers, feeding mainly on plant material and a variety of decaying organic matter, although some have been known to eat snails, fish or tadpoles as well. Some species seem to need a regular intake of animal protein to survive and reproduce; this protein usually comes from decaying animal tissue.

The larvae are predators. They ambush their prey, which include small aquatic insects, crustaceans, snails, small fish and tadpoles. The larva secretes a digestive fluid into the victim that aids in the breakdown of the animal tissues. It then sucks out the fluids of the prey through its mandibles.

Locomotion

Adults are active fliers and most are average swimmers. They swim using alternate strokes of their hind legs, which are often fringed with long hairs that help to propel them through the water. Other hydrophilid adults do not swim much at all; instead, they prefer to crawl over the substrate. The larvae of some hydrophilids can be very active swimmers. They use the long hairs on their legs and undulate their abdomens to propel themselves through the water. Other species crawl along the bottom of the water body.

Gas exchange (breathing)

Adults carry an air bubble under their elytra on their abdomens. When they rise for air they break the water surface with their clubbed antennae to replenish their air supplies. The larva of one genus, *Berosus*, has gills and obtains oxygen by direct diffusion from the water. Other Hydrophilidae larvae have spiracles in a chamber at the end of their abdomens, connected to the tracheal system, and they have to come to the surface to obtain air.

Life cycle and reproduction

After mating, the female lays her eggs in a small cocoon that she attaches to plant material, lets float freely, or carries around with her. Females lay up to 50 eggs at a time that hatch in five to ten days, although the number of eggs varies with the species. There are three larval instars or stages. The first larval stage is very active and in most species exhibits cannibalism, which is probably why the larvae move away from egg sacs as soon as they have hatched.

Third instar larvae crawl out of the water to pupate, usually in moist soil during spring and summer. The larvae dig tunnels using their mouthparts and heads. Once the pupal chamber is complete, the larva closes the entrance to the chamber. If the water level rises to cover a pupa it will drown, so the larvae must choose a suitable site well above water level.

Habitat

Adult and larval Hydrophilidae are found in flowing and non-flowing waters and can live in fresh or saline water bodies. They have been found in streams, ponds, wetlands and dams throughout South Australia, including sites that are slightly polluted.

Critter facts

In China, people eat large hydrophilid adults for medicinal reasons and as a confection.

Hydrophilids have been used in the Phillippines and Hawaiian Islands in control programs against the beetle borer, which feeds on sugar cane. They have also been used in Jamaica against the banana borer.

Hydrophilids are attracted to lights. Adults have been seen in flight far from any water body.

Identification

Adult Hydrophilidae can be mistaken for Dytiscidae (predacious diving beetles), but hydrophilids have clubbed antennae and use alternate strokes of their hind legs when swimming. Dytiscids have long thin antennae with many segments and move their hind legs in unison when swimming. Hydrophilid larvae are quite distinctive, but Berosus larvae may be mistaken for Gyrinidae larvae. Berosus larvae have simple, long, linear gills whereas gyrinids have feathery gills and two pairs of hooks on the last abdominal segment. The keys on page 94 and 95 of The Waterbug Book should help you identify adult and larval Hydrophilidae.

Classification and sensitivity

Phylum Arthropoda

- Class Insecta
  - Order Coleoptera (5)
    - Family Hydrophilidae (2)

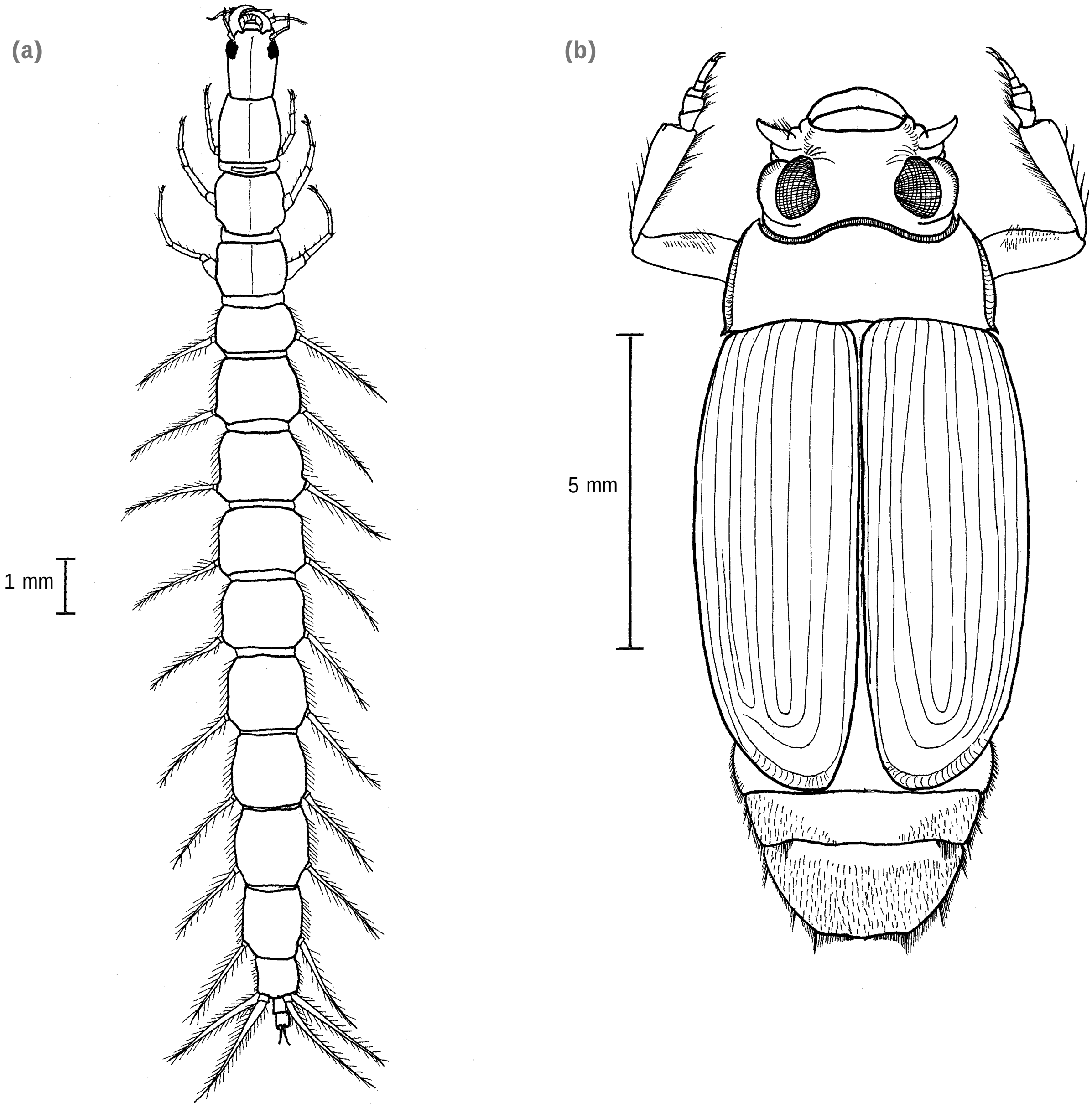
References

Hawking & Smith 1997, pp 140-143; Williams 1980, p 286; Gooderham & Tsyrlin 2002, pp 106-107.

Family Gyrinidae—whirligig beetles

Background

Gyrinids occur almost worldwide, being found in Africa, Europe, South America, South-East Asia, New Caledonia, New Guinea and Australia. Their strongly southern hemisphere distribution is thought to reflect Gondwanan origins. Four genera of Gyrinidae are recorded for Australia and all four have been found in South Australia. Both adults and larvae are aquatic. The adults are called 'whirligig beetles' because they swim around madly in groups on the surface of the water. At the first sign of danger, they dive under the water and cling to submerged vegetation.



The whirligig beetle *Macrogyrus* sp.:

(a) larva and

(b) adult (family Gyrinidae)

Size

Adult gyrinids can be up to 14 mm in length and larvae grow to 20 mm.

Features

Adult gyrinids are a streamlined oval shape, dark green to black in colour with a metallic silvery sheen. The eyes of whirligig beetles are completely divided into upper and lower sections by a strip of cuticle, enabling them to see above and beneath the water at the same time. Their antennae are very short and compact. Their middle and hind legs are highly modified, being short, flattened, paddle-like appendages that make them excellent swimmers. Their long front legs are modified for grasping prey.

The larvae have well-developed mandibles that are used for feeding. They have one pair of feathery gills on each of the first eight abdominal segments, two pairs of gills on the ninth abdominal segment, and two pairs of hooks at the end of the tenth abdominal segment.

Diet and feeding

Adult gyrinids feed mainly on animals that fall onto the water surface. They use the Johnston's organs on their antennae to detect waves produced by struggling prey. They are usually scavengers rather than predators.

The larvae are strictly predacious and hunt on the bottom. They eat mainly small invertebrates, such as mites, snails, and small aquatic insects. They have been known to take small fish as well. They inject digestive secretions into their prey through a canal in their mandibles and then feed on the victim's body juices.

Locomotion

Adults are strong fliers and swimmers and can dive to avoid predators. Adult gyrinids are often seen swimming in groups on the surface of the water. They rely on the surface tension to stay afloat. They can fly long distances in search of new and more suitable water bodies. Larvae mainly crawl on the sediments.

Gas exchange (breathing)

Adults hold an air bubble under their elytra when diving under the water to catch prey or escape danger. The rest of the time, they swim on the surface of the water and obtain oxygen from the air via the spiracles and tracheal system. Larvae obtain oxygen by diffusion across the gill surfaces.

Life cycle and reproduction

Adult gyrinids copulate on the surface of the water, the male and female remaining locked together for a few minutes to a few hours. Females often attach their eggs to submerged plants, sometimes in regular rows. Gyrinids mate only once and both male and female die within a few weeks of the eggs being laid. The eggs hatch in one to two weeks and the larvae immediately start hunting for food. The larval stage can last up to three months.

Pupation occurs at the water's edge. The mature larva crawls out of the water onto the bank where it constructs a cell in which to pupate. Upon emerging from the pupa, the adult crawls back into the water. Gyrinids live for less than a year.

Habitat

Adult gyrinids are found on the surface of still and slow-flowing waters. They frequently whirl around in large groups on the surface of the water. When disturbed, they dive down into the water to avoid harm, which makes them difficult to catch. They can live in permanent or semipermanent, fresh or slightly saline waters. Larvae live on the bottom of water bodies. Gyrinids are not frequently collected, although they have been found in water bodies throughout South Australia.

Critter facts

In Bunyeroo Creek in the Flinders Ranges, schools of one and two species have been observed; in North America, schools containing up to 13 species have been recorded.

Adult gyrinids have glands that produce chemicals to deter predators such as fish.

Identification

Adult gyrinids may be mistaken for dytiscids (predacious diving beetles), but gyrinids have two sets of eyes whereas dytiscids have only one set. Larvae may be mistaken for those of the hydrophilid genus Berosus, but Gyrinidae larvae have feathery gills and two pairs of hooks on the last abdominal segment, whereas Berosus larvae have simple, linear gills. The keys on page 94 and 95 of *The Waterbug Book* should help you identify adult and larval Gyrinidae.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Coleoptera (5)

Family Gyrinidae (4)

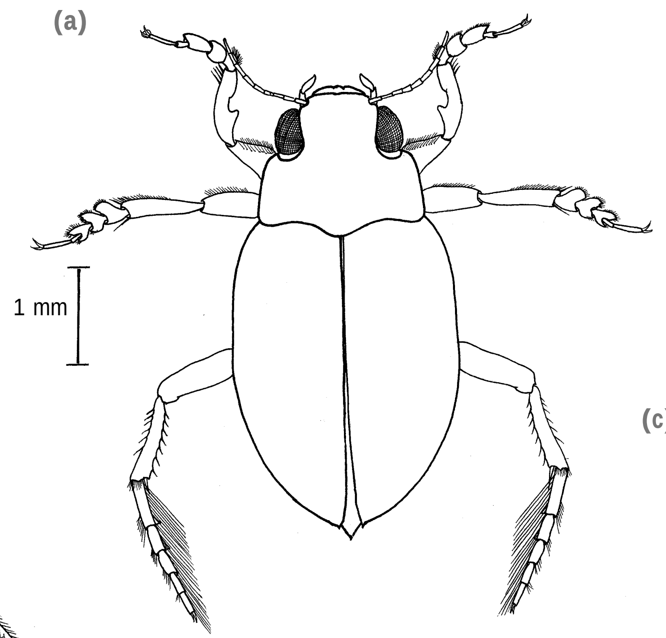
References

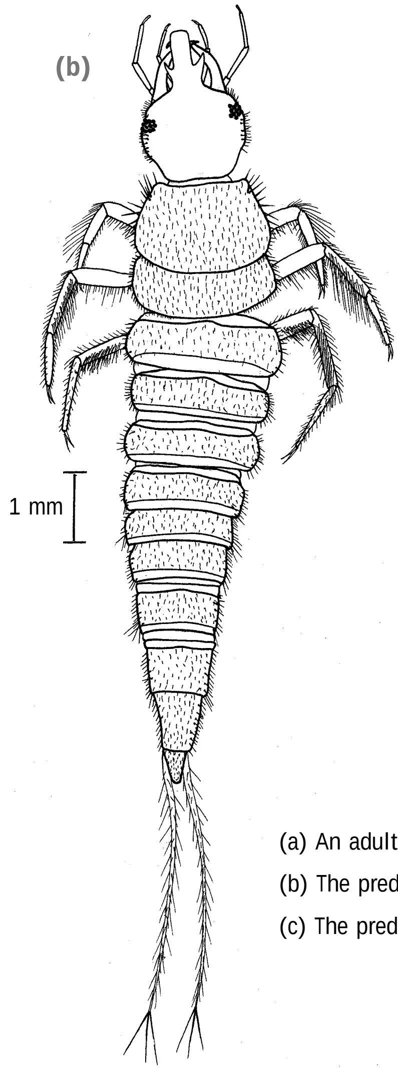
Hawking & Smith 1997, pp 145-146; Williams 1980, p 280; Gooderham & Tsyrlin 2002, pp 102-103.

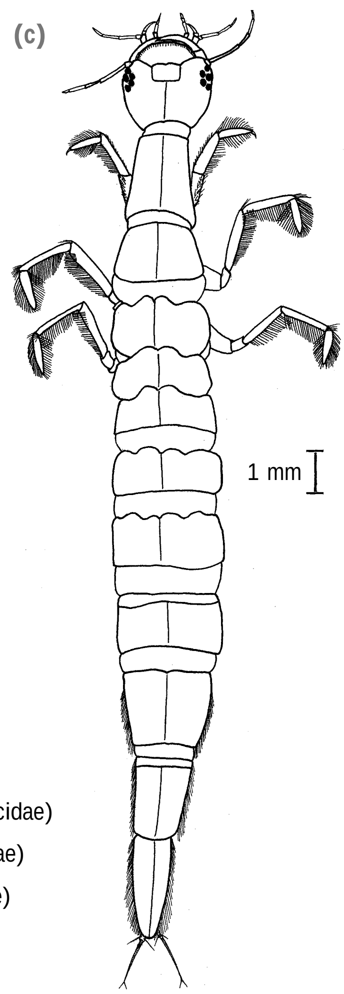
Family Dytiscidae—predacious diving beetles

Background

Dytiscids are probably the most common and widespread aquatic beetles. Worldwide, there are about 5000 species. Both the adults and larvae are aquatic. Thirty-seven genera and 185 species of Dytiscidae are recorded for Australia, and at least 22 genera and 44 species occur in South Australia.







(a) An adult predacious diving beetle, *Necterosoma dispar* (family Dytiscidae)

(b) The predacious diving beetle larva *Necterosoma* sp. (family Dytiscidae)

(c) The predacious diving beetle larva *Eretes australis* (family Dytiscidae)

Size

In South Australia, adult dytiscids range in length from 3 mm to 34 mm. Some larvae grow up to 21 mm, but the maximum length for most species is not much more than 6 mm.

Features

Adult dytiscids have streamlined bodies and long, slender antennae. Their hind legs act like oars and are often flattened and fringed with hair. These beetles vary in colour, but most are yellow or black, and many have patterns of stripes or spots on their back.

Dytiscid larvae are elongate and slender. They have a large head with prominent mandibles. In some genera the head is rounded and others have prominent projections at the front. Some larvae have a pair of cerci, which vary in length, at the tip of the abdomen. The last two segments of the abdomen of some larvae are elongate and fringed with swimming hairs. Those larvae that have large sharp mandibles at the front of their heads look quite ferocious.

Diet and feeding

Adult dytiscids eat other aquatic insects, small fish and tadpoles. They chew and tear their prey using specialised mouthparts. Prey include other aquatic insects, small fish and tadpoles. Larvae feed through their hollow mandibles. The digestive fluids they inject into the prey acts as venom and also liquefy the animal tissue. The dytiscid then sucks the resulting 'soup' out of the prey through its jaws. A few larvae lack hollow mandibles and swallow prey whole.

Locomotion

Adults are strong swimmers: they swim by stroking both back legs at the same time, like a pair of oars. Adults are also able fliers, but must crawl out of the water to take off. When landing, they fly directly into the water. The ability to fly enables these beetles to move to other water bodies when conditions become unfavourable. Larvae can crawl and swim. Some genera are heavier than water and have to swim to reach the surface while others are buoyant and have to swim or cling to objects to remain submerged.

Gas exchange (breathing)

Dytiscid adults carry an air bubble under their elytra. They must surface regularly to refresh their air supply through the tip of the abdomen. Adults can remain swimming under water without surfacing for longer periods of time than the larvae. Larvae must come to the surface periodically to replenish their tracheal air supply, which they do using spiracles situated at the end of the abdomen.

Life cycle and reproduction

After mating, the female lays eggs on the ground at the edge of a stream or on submerged plants. Some species cut slits in water plants and insert their eggs. The larvae pass through three instars; the whole larval stage can last between 3-8 weeks.

Larvae crawl from the water to pupate. They create a pupal cell by burrowing into soft sediment using their mouthparts and head. When the cell is complete, they close the entrance to the cell and pupate. The newly emerged adult crawls back to the water. The entire life cycle is completed in as little as four months.

Habitat

Dytiscids colonise almost all types of aquatic habitats, from alpine to desert, fast-flowing to still, and fresh to saline waters. They are not common in waters that contain fish, although they will consume small fish. Although larvae and adults are aquatic, both stages are able to survive out of water for extended periods of time. Dytiscids are quite common and can be found in most water bodies throughout South Australia, including slightly polluted ones. Adults of the dytiscid genus, *Necterosoma*, were the only animals found in an acid pond with a pH of 2.5, located near Leigh Creek in South Australia. One member of this genus is also very tolerant of waters with elevated salinity levels. Many different species of Dytiscidae may be found in one water body.

Critter facts

Adult dytiscids are strong fliers and are therefore good at colonising new habitats. Beetles seen in domestic swimming pools may well be dytiscids.

In China, large dytiscid adults are eaten and some are believed to have a medicinal value. Dytiscids can emit a bad-tasting chemical, however, when they are attacked. This chemical makes the dytiscids less palatable and acts as a deterrent to predators.

Identification

Adult dytiscids may be confused with hydrophilids (water scavenger beetles), but can be separated by their long slender antennae and mode of swimming, with both back legs beating in unison. Hydrophilid adults have clubbed antennae and, when swimming, their legs move alternately. Some dytiscid larvae have two cerci and may be mistaken for stonefly larvae. Dytiscids can be distinguished by their large jaws and short antennae. The keys on page 94 and 95 of *The Waterbug Book* should help you identify adult and larval Dytiscidae.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

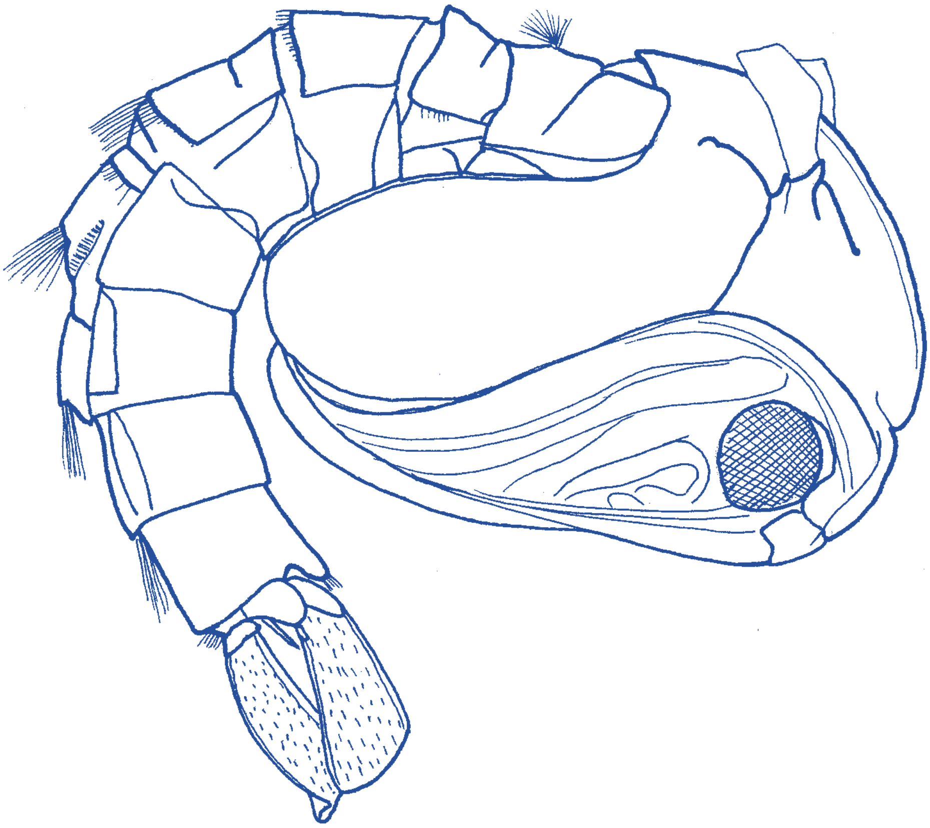
Order Coleoptera (5)

Family Dytiscidae (0)2

References

Hawking & Smith 1997, pp 150-155; Williams 1980, p 282; Gooderham & Tsyrlin 2002, pp 98-99.

True flies



12.7 Order Diptera—true flies

Background

About 120,000 species of Diptera have been described worldwide. Ninety-eight families and 7786 known species of Diptera are reported for Australia. Twenty of these families include species that have freshwater larvae. There are also species that live in terrestrial or marine environments; some are parasitic in plants or other animals.

Only larvae and pupae of Diptera are aquatic. Adults are always terrestrial, although many are often seen near water bodies. All larvae from the families Simuliidae and Culicidae are aquatic, which is unusual—in most other families, there is a mix of terrestrial and aquatic species.

Families of aquatic Diptera that can be found in South Australia and are covered in this guide include: Chironomidae (non-biting midges and bloodworms), Simuliidae (black fly larvae), Culicidae (mosquito larvae or wrigglers), Syrphidae (hoverfly larvae), Tipulidae (crane fly larvae), Tabanidae (march or horse flies), Stratiomyidae (soldier fly larvae) and Ceratopogonidae (biting midge larvae). Those that occur in South Australia but are not covered further in this guide are Dixidae (dixid midge larvae), Psychodidae (moth fly larvae), Sciomyzidae (marsh fly larvae), Empididae (dance fly larvae), Ephydridae (brine fly larvae), Sciaridae, Muscidae, Scatopsidae, Cecidomyidae and Dolichopodidae.

The earliest fossil records of dipterans date from the Upper Triassic period, nearly 225 million years ago.

Size

Dipterans range in length from about 1 mm to 50 mm, depending on species and age.

Features

Adult dipterans are characterised by the presence of only one pair of wings: the second pair are reduced to club-like structures called 'halteres', which are used for balance during flight. Adult mouthparts are often modified for sucking or piercing. Adults usually have a pair of large compound eyes.

Larvae do not have true legs, but often have fleshy protrusions, or 'prolegs', on the end of the abdomen or the front of the thorax, which they use to move. The body is generally grub-like in form, and has up to 12 body segments. The head varies from being a completely sclerotised capsule, fully extended from the thorax and having well-formed jaws and antennae, to being reduced to a few sclerotised rods with hooks for mouthparts and merged with the thorax.

Diet and feeding

Most adult dipterans have piercing and sucking mouthparts and must feed on liquids. Some have been known to feed on vertebrates such as birds, fish, frogs, horses, cattle and humans. Some adults even require a blood meal to complete their life cycle. Others feed on nectar from plants. The larvae consume mainly decaying plant and animal matter, but some are predators.

Locomotion

All adult dipterans have wings and are generally able fliers. Most aquatic larvae crawl or burrow into the sediment at the bottom of the water body. Sometimes they can be seen wriggling through the water. The larvae are not very good swimmers and undulate their bodies to propel themselves forwards.

Gas exchange (breathing)

Many dipteran larvae gain all the oxygen they need by diffusion from the water; others have spiracles and tracheal systems and must come to the surface to replenish their air supply. As the adults are terrestrial, they obtain oxygen directly from air through their spiracles and tracheal systems.

Life cycle and reproduction

Depending on the species, mating can occur once, twice or many times during a year. Adult dipterans usually lay eggs in groups in the water. The eggs hatch after a period ranging from a few days to a few weeks. The number of larval instars varies, depending on the species.

Larvae pupate either in their last larval skin in the water, or within little cocoon-type structures that they construct. The pupae are usually inactive, but those of some dipterans, such as mosquitoes, are active swimmers. Adults emerge from the pupal skin and fly away. The adult stage is usually quite short: for some species it lasts for only two days.

Habitat

Aquatic dipterans are very widely distributed—from the Arctic to the Antarctic. The larvae live in aquatic environments in deserts, forests and snowfields. They are known to inhabit some of the most inhospitable aquatic environments, including rocky intertidal pools, thermal springs with temperatures of around 50˚C, seeps of crude petroleum, and hypersaline pools. In South Australia, expect every water body you sample to contain members of at least one family of Diptera, if not more.

Critter facts

Many adult Diptera with aquatic larvae are pests that can bite and transfer disease among vertebrates, including humans. Culicids (mosquitoes) spread malaria, encephalitis, yellow fever and filariasis. Tabanids (march/horse flies) spread disease in kangaroos and wallabies. Simuliids (black flies) spread human onchocerciasis, and leucocytozoon infections of poultry. Psychodids (moth flies and sandflies) spread leishmaniasis and sandfly fever. Ceratopogonids (biting midges, sometimes also called sandflies) spread diseases caused by nematodes (round worms), protozoans and viruses to humans and other vertebrates. Muscids (house flies/stable flies) help to spread dysentery and cholera.

Identification

Larvae of dipterans generally have fleshy, elongate bodies; however, Stratiomyidae sometimes have tough skins. Larvae do not have legs, but some have stumpy projections called prolegs. Larvae look very worm-like and may resemble some terrestrial invertebrates. While adult dipterans are reasonably well studied, little is known about many of the larvae. It is extremely difficult to identify most dipteran larvae past the family level, and even identification to family level can be quite difficult. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification, while the key on page 114 will help you get to the Family.

See Page 113 of *The Waterbug Book* for some general guidance on adult flies but note that they are difficult for non-specialists to identify.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Diptera (3)

Family Chironomidae (NR)

Family Simuliidae (5)

Family Culicidae (1)

Family Syrphidae (2)

Family Cecidomyidae (NR)

Family Tipulidae (5)

Family Tabanidae (3)

Family Dolichopodidae (3)

Family Dixidae (7)

Family Psychodidae (3)

Family Stratiomyidae (2)

Family Sciaridae (NR)

Family Scatopsidae (NR)

Family Ceratopogonidae (4)

Family Muscidae (1)

Family Empididae (5)

Family Ephydridae (2)

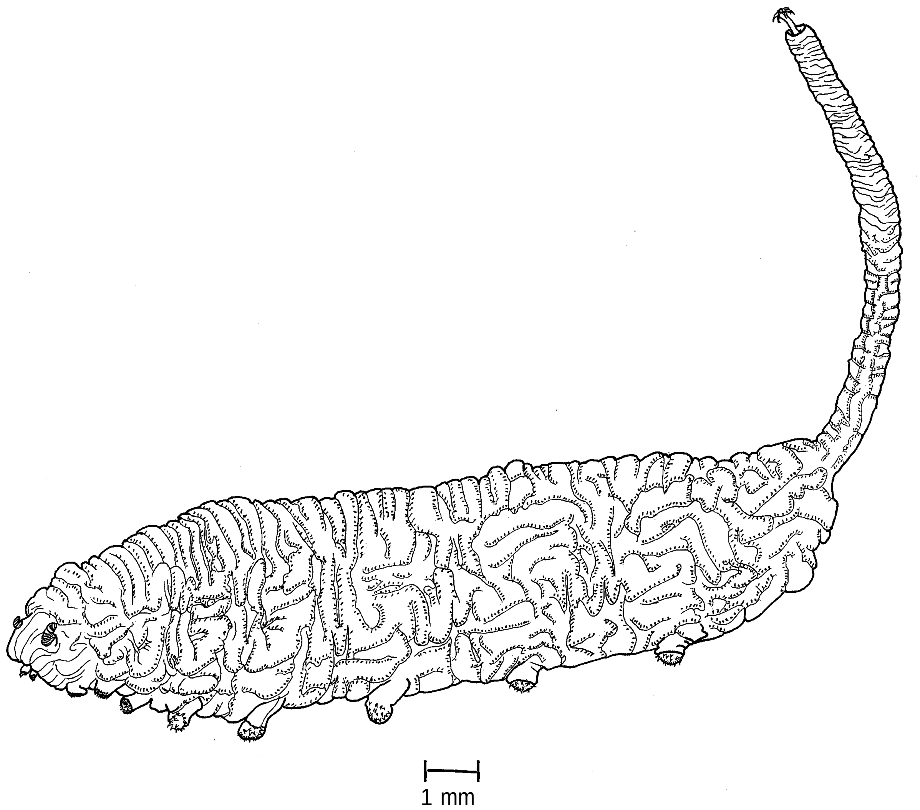
References

Hawking & Smith 1997, pp 158-175; Williams 1980, p 231; Gooderham & Tsyrlin 2002, pp 112-130.

Family Syrphidae—hoverflies

Background

Syrphids can be found throughout the world, except Antarctica, and number over 5500 described species. Only one genus, *Eristalis*, is aquatic. It is an Australia-wide genus with an aquatic larval stage and terrestrial adult stage.



The rat-tailed maggot *Eristalis* sp. (family Syrphidae)

Size

Syrphid larvae can grow up to 30 mm long, including the respiratory siphon.

Features

Eristalis species have tough bodies with a long respiratory siphon, resembling a tail, attached to the end of the abdomen. This tail can be retracted into the body of the larva. *Eristalis* larvae are called rat-tailed maggots and, with the siphon withdrawn, resemble the maggot of the common house fly. The adults resemble honey bees with yellow and black stripes.

Diet and feeding

Syrphidae larvae are detritivores that feed on animal and plant tissue that they happen to find in the sediment. Adult *Eristalis* are important pollinators of plants—when they feed on nectar from a flower, they inadvertently transport pollen from flower to flower.

Locomotion

The larvae are burrowers. They have thick skins that assist in burrowing into sediment and also assist in crawling along the sediment. When it is time to pupate, the larva crawls out of the water by twisting its body and moves across the soil. Adults are very good fliers, capable of hovering in the air. They can even fly backwards.

Gas exchange (breathing)

Eristalis larvae use the long respiratory tube at the end of the abdomen to contact the air. The respiratory spiracles at the end of the tube open to allow replenishment of the air in the tracheal system. Larvae break the surface of the water with the tips of their siphons and let the openings rest on the surface of the water. Special water-repelling hairs surround the opening of the tube, helping to keep it above the water and also preventing entry of water.

Life cycle and reproduction

In spring the adult hoverflies mate near water and the female then lays her eggs in a shallow water body, one at a time. The eggs hatch after a few days, the maggot-like larvae emerging. The larvae go through a series of instars before pupation. When a larva is ready to pupate, it crawls out of the water and pupates on the bank. Pupation occurs during summer; the pupal cell is the last larval skin. The adult breaks out of the pupal skin after approximately three weeks and flies away.

Habitat

Eristalis species can be found in organically or nutrient-enriched ponds or dams, wet manure pits, toilets, and sewage ponds. They are not found in clean waterways. They are not common in South Australian water bodies.

Critter facts

An *Eristalis* specimen was once found in a public toilet in the Riverland of South Australia.

Another species of *Eristalis* has been introduced into Australia. The maggot is known to cause problems on cattle farms when larvae wander onto dry land to pupate. If ingested by the cattle, intestinal myiasis can result, in which the larvae feed on the intestines of the animal. This genus has a specialised habitat and is not found very often in South Australia.

Identification

The larvae of *Eristalis* are easily recognised by the very long tail-like tube at the end of the abdomen. They can be confused with other dipteran larvae if the tail is retracted inside the body. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification, while the key on page 114 will help you get to family.

Classification and sensitivity

Phylum Arthropoda

- Class Insecta
  - Order Diptera (3)
    - Family Syrphidae (2)

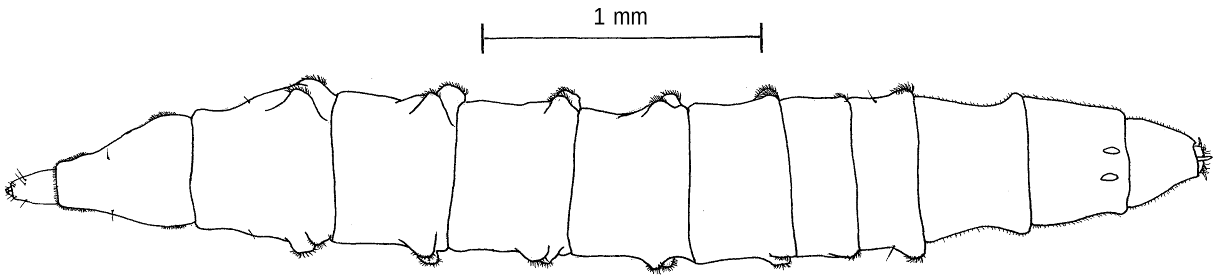
References

Hawking & Smith 1997, p 172; Williams 1980, p 252; Gooderham & Tsyrlin 2002, pp 126-127.

Family Tabanidae—march or horse flies

Background

This family occurs worldwide, with over 3000 described species. There are 243 species in Australia. Some of the larvae are aquatic and others are semi-aquatic. Adults of all species are terrestrial and a nuisance as they can bite horses, cattle and humans.



The larva of a march fly (family Tabanidae)

Size

Larvae of this family can grow up to 50 mm long.

Features

The head capsule of the larva is incomplete. The body is slightly elongate and grub-like, with obvious welts along the underside. The final segment of the abdomen is tapered. Larvae vary in colour—white, yellow, green or brown. Adults can be brown, black or green and have large eyes.

Diet and feeding

Tabanid larvae are carnivorous, feeding mainly on small molluscs and each other. They exhibit cannibalism even when there is an abundance of other food available. The adults usually feed on other insects or nectar. Some adults take a blood meal from a vertebrate, usually cattle, horses and humans. They have sharp mouthparts that enable them to puncture the skin.

Locomotion

The larvae do not swim well and prefer to burrow into muddy sediment. They can crawl along the bottom of water bodies, using the welts on the underside of their bodies for gripping onto the sediment. The adults are very good fliers: they hover in the air easily and then can quickly fly away.

Gas exchange (breathing)

Tabanid larvae obtain oxygen through the tracheal system, with the help of spiracles on the end of their abdomens.

Life cycle and reproduction

Mating between the adult males and females occurs near water. The female lays the eggs alongside one another, sometimes attached to a twig or leaf hanging above the water. A completed egg sac can contain 250-700 eggs. Eggs hatch within six or seven days. The larvae break free of the egg sac using just two or three strokes of their mouthparts and then drop into the water below. The larval stage lasts for at least three months, during which time they go through between six and nine instars.

When fully grown, the larvae move into relatively dry soil for pupation, burying themselves 5-15 cm below the soil surface. The time from pupation to adult emergence can take anywhere from two to six months, with the actual pupal stage lasting an average of 12 days. Adults usually emerge after rain, which suggests that the long delay is due to the larvae waiting for favourable conditions. The adults emerge and fly away. Adults of most species are only seen for about one month.

Habitat

Tabanid larvae can be found in muddy regions of ponds, lakes and wetlands. Adults can be seen flying near water bodies or near cattle. The activity of the adults over a year is shorter in the south than in the northern tropical regions, but the peak period of activity for both regions is during the summer months. Tabanids are not overly abundant, but can be found in water bodies throughout South Australia.

Critter facts

Adult tabanids have been known to bite humans and stock quite severely. One northern species is known to cause sensitisation after bites, with severe reactions to subsequent bites. Most adults suck blood, but one species is known to feed only on flowers. In Australia, disease transmission by the adult tabanids is limited to the transmission of a parasitic nematode in kangaroos and wallabies. In the northern hemisphere and in Africa, the family is responsible for the transmission of diseases that affect humans.

Identification

Larvae are grub-like with hard, tough outer skins and welts on the abdominal segments. The end of their abdomen is tapered. They may be mistaken for other dipteran larvae with welts, but tabanids are usually very large and the skin is tougher than the other 'welted' dipterans. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification, while the key on page 114 will help you get to the family.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Diptera (3)

Family Tabanidae (3)

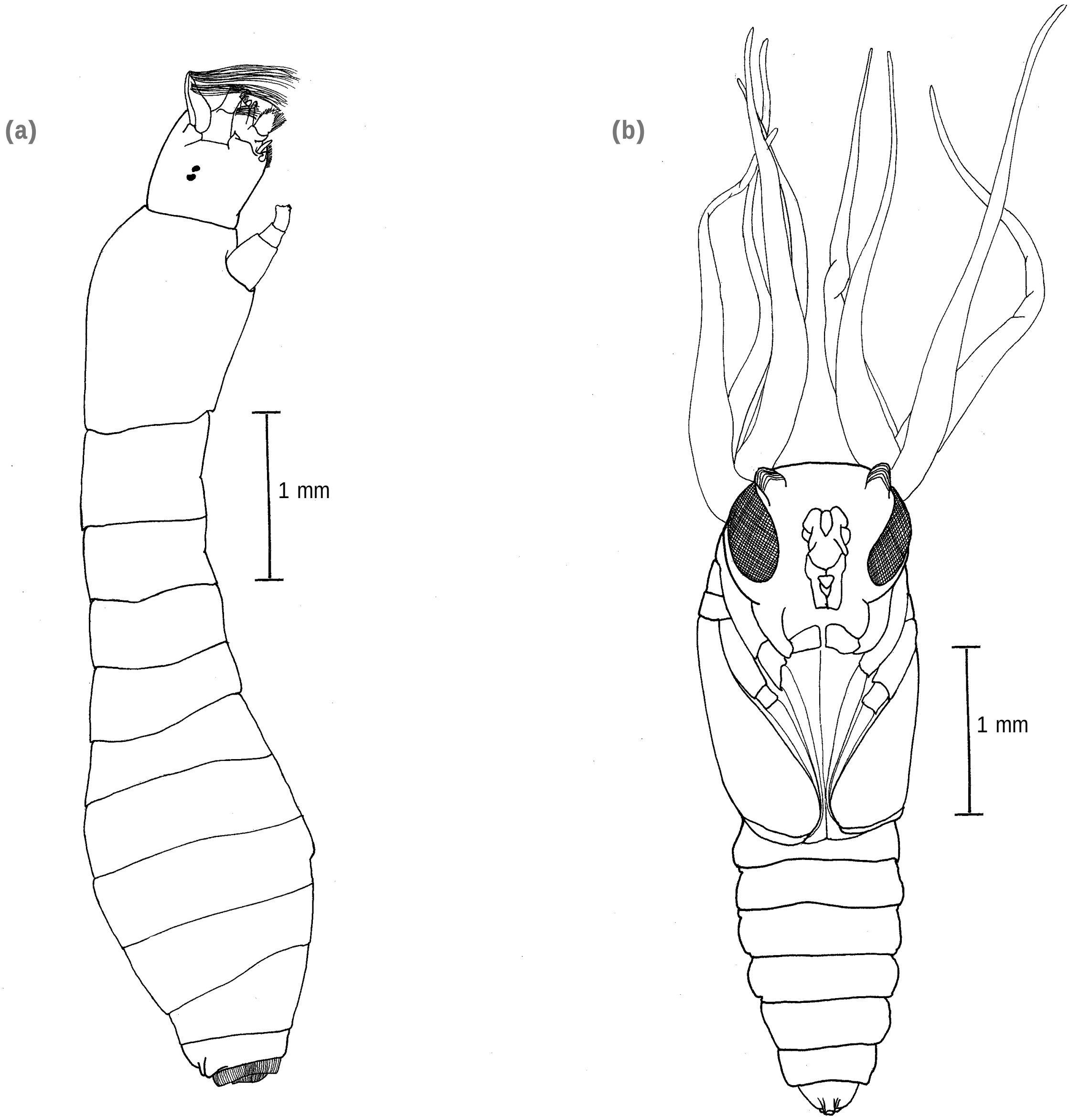
References

Hawking & Smith 1997, p 162; Williams 1980, p 250; Gooderham & Tsyrlin 2002, pp 124-125.

Family Simuliidae—black flies

Background

Worldwide, there are about 1500 species of Simuliidae. Their distribution is uneven in that some genera are restricted to the northern hemisphere. Three genera occur in Australia. One of these, *Paracnephia*, is present throughout the world, although noticeably absent from tropical regions. The second, *Austrosimulium*, is restricted to the southern hemisphere. Simulium is the third genus. All three occur in South Australia. These flies have aquatic larval and pupal stages and are terrestrial as adults. The oldest fossil record of a simuliid is from the Middle Jurassic period, about 165 million years ago.

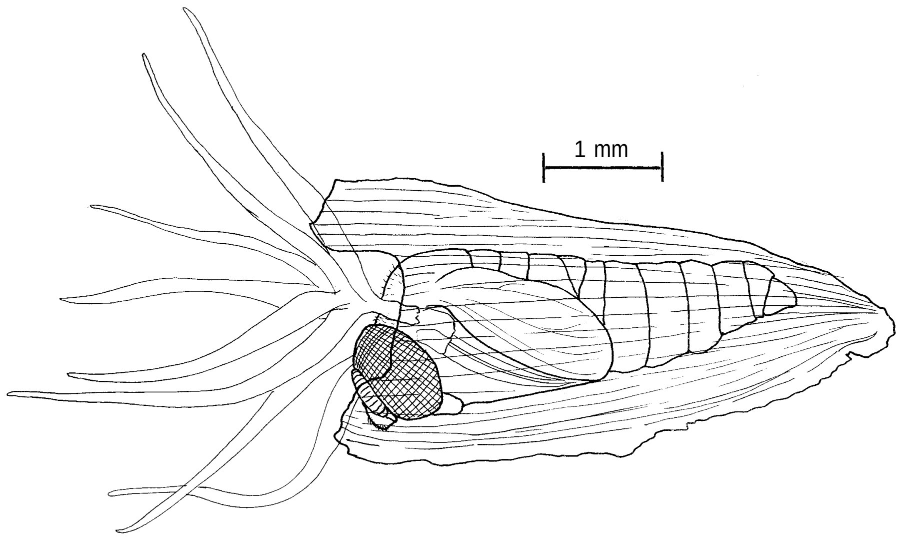


(a) The black fly larva *Simulium* sp.

(b) Ventral view of a *Simulium* pupa; and

(c) a *Simulium* pupa inside a pupal case (family Simuliidae)

(c)



Size

Simuliid larvae grow up to 7 mm long. Adults are 2-5 mm long.

Features

Simuliid larvae have a soft, cylindrical body with a well-sclerotised head capsule, and fairly obvious fleshy prolegs on the thorax. They have a pair of large fans on the head, used to filter food from the water. A circle of hooks on a posterior disc is used by the larva to anchor it to the streambed. The hooks grasp onto silk pads that the larva spin; if a larva is washed from its perch, it releases a silk safety line so that it can return to the substrate easily. Simuliids position themselves in flowing water for feeding and obtaining oxygen. Simuliid pupae are generally found attached to rocks in the fast-flowing waters of the stream. Their cocoons are distinctive: see page 159 of the *Colour Guide to Invertebrates of Australian Inland Waters* for a photograph. Adults can be black, grey or yellow in colour. They have large round eyes and broad clear wings.

Diet and feeding

Black fly larvae are filter feeders and use the fan-like structures on the top of the head to collect organic debris and algae from the water. The fans are periodically closed and cleaned by the mandibles and the whole catch is eaten. Adult females of nectar-feeding species, and males of all species, have mouthparts adapted to collection of free fluids. Blood-feeding females have serrated mandibles that cut the skin of their prey to release internal fluids.

Locomotion

Simuliid larvae can walk like caterpillars, with a looping motion. Most of the time, however, they stay attached by the end of the abdomen to rocky substrates, leaves or twigs.

Gas exchange (breathing)

Simuliid larvae obtain oxygen by diffusion from the water, using anal respiratory gills that consist of three lobes. The pupae obtain their oxygen by diffusion across branched filaments near their heads. The number and form of these branched filaments vary between species—some have only three or four branches; others look like small brushes and comprise many filaments. These filaments are present in the last larval instar as gill spots on the side of the body.

Life cycle and reproduction

Adults mate on the wing or on the ground. After mating, a blood meal is required for the females of some species to mature the eggs. Females lay 200-500 eggs: they either crawl under the water to lay the eggs onto a specific substrate or just drop them onto the water surface. Eggs hatch in 4-30 days. Larvae go through four to nine instars before pupation.

The larvae spin a distinctive cocoon in which to pupate. Adults emerge within four to seven days. When ready to emerge, the fly pulls itself out of the head end of the pupal skin through a 'T'-shaped slit. Adults live for a few weeks and can lay several broods of eggs. Two to sixteen generations can be completed in a year, depending on the species and climatic conditions. The eggs of some simuliids can lie dormant in dry waterbeds for long periods of time and hatch after floods.

Habitat

Simuliid larvae and pupae are aquatic, the adults are terrestrial. Simuliid larvae are confined to flowing water; species of the genus *Simulium* prefer faster-flowing water than members of the genus *Austrosimulium*. Throughout Australia, black flies are found from sea level to snow-melt streams. The larvae can be found in flowing waters attached to any stable substrate, including rocks, boulders, sticks and leaves of water plants, positioned with their heads into the flow. Most flowing streams in South Australia have simuliid larvae. The genus *Cnephia* is restricted to the cooler streams of the southern parts of South Australia, while *Simulium* and *Austrosimulium* can be found throughout the state. They are not often found in waters that are heavily polluted or saline.

Critter facts

Adult Simuliidae often emerge in large groups and their biting can be very aggressive, although not all species bite. Species of *Austrosimulium* and *Simulium*, however, have been known to bite humans, horses and cattle in Australia. Unlike mosquitoes, black flies usually bite during the day. In Ontario, Canada, where black flies are a real nuisance, the biting rates of one species were measured. The landing rate was 78 females per 6.5 cm^2 of bare skin per minute and the biting rate was 17 bites per 6.5 cm^2 of bare skin per minute

Some simuliids act as vectors or hosts for parasitic viruses. They are able to transmit the parasitic nematode that causes mansonellosis, a disease with flu-like symptoms. No simuliids are known to be vectors of human diseases in Australia, but they may aid in the transmission of cattle onchocerciasis, myxomatosis in rabbits, and diseases in poultry.

Adult simuliids have been captured at heights of more than 1500 metres, and records are available of swarms flying distances of 80 and 160 kilometres.

Identification

Simuliids are easily recognised by their short fattish bodies. They can be seen in most flowing water with their ends attached to a stable substrate and heads facing into the current. Under a microscope it is very easy to see the fans at the top of the head. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification while the key on page 114 will help you get to the family.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Diptera (3)

Family Simuliidae (5)

References

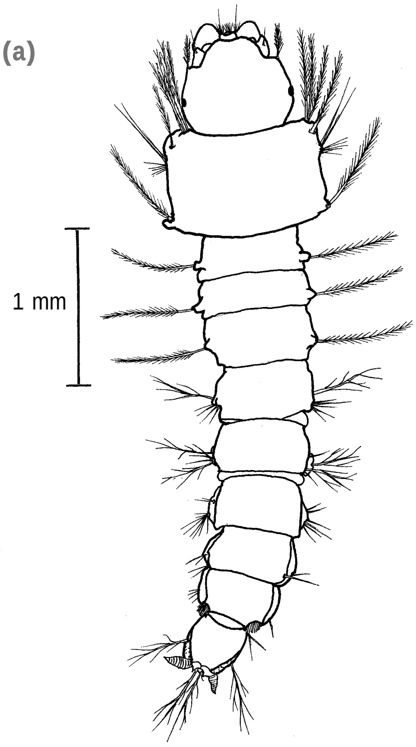
Hawking & Smith 1997, p 159; Williams 1980, p 237; Gooderham & Tsyrlin 2002, p 129.

Family Culicidae—mosquitoes

Background

here are over 3000 species of Culicidae worldwide. Three subfamilies and 275 species are known from Australia. Both larvae and pupae are aquatic, while adults are terrestrial. In South Australia, members of four culicid genera can be found. The earliest record of mosquitoes is of a fossil larva from the Lower Jurassic period, about 145 million years ago, and fossils of adults are known from the Cretaceous period, over 65 million years ago.

(a)



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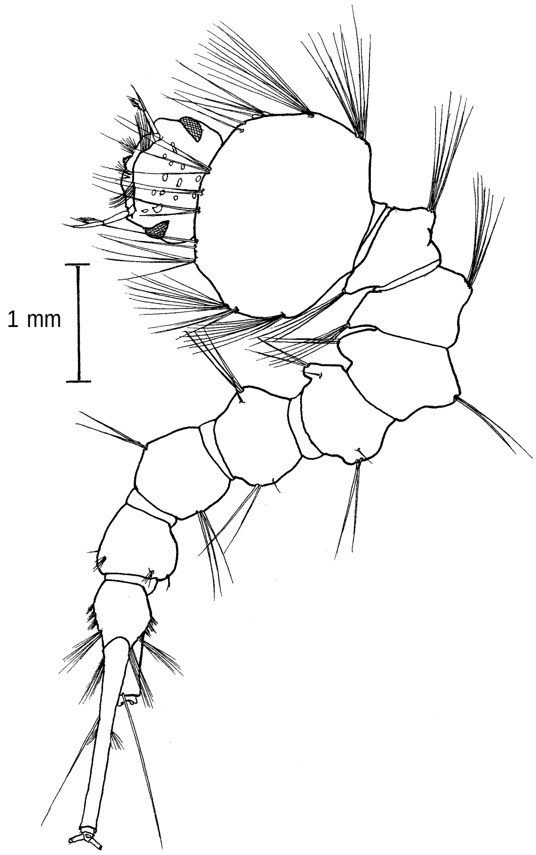

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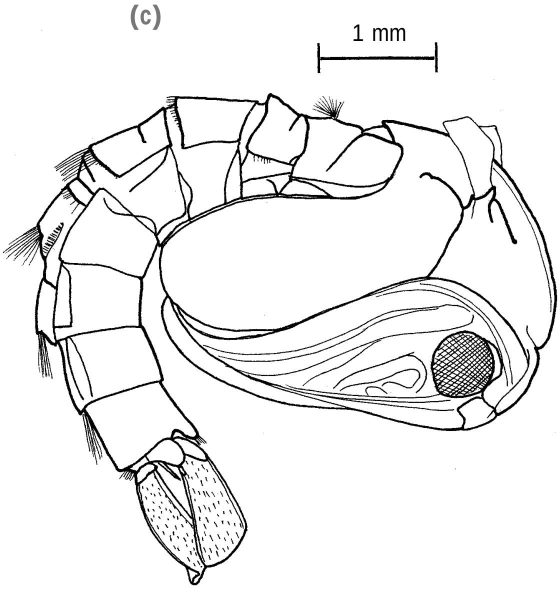


The mosquito larvae:

(a) *Culex* sp. and

(b) *Anopheles* and

(c) an *Anopheles* pupa (family Culicidae)

Size

Mosquito larvae grow to 6 mm in length.

Features

Larvae of mosquitoes are called 'wrigglers'. They have no legs and their thoracic segments are fused together and are wider than the head or abdomen. They are often quite hairy and the position of hairs is an important feature for identification. They have slender antennae and 'mouth brushes' on the head. Many species have a siphon that extends from the tip of the abdomen, and can be protruded through the water meniscus, providing contact with the air above and thus enabling the larva to obtain oxygen from the atmosphere. Pupae are called 'tumblers'; they have a large head under which is tucked the segmented abdomen.

Diet and feeding

Most larvae feed on suspended particulate matter, including microscopic animals and organic debris. They use the mouth brushes on the head to create currents to bring food particles within reach. Some scrape algae and detritus from surfaces and a few species are predators. Pupae do not feed. Adult males and females of some species feed on nectar, using sucking mouthparts. Other female adults take blood meals from animals and humans, using sharp, serrated mouthparts that can easily penetrate skin. A blood meal is essential for the maturation of their eggs.

Locomotion

Both larvae and pupae are active swimmers. The larvae wriggle through the water, thrashing in a 'figure-of-eight' motion. The pupae also wriggle their abdomens to move through the water.

Gas exchange (breathing)

Larvae obtain oxygen from air taken into the tracheal system via the spiracle on the end of the abdomen, which is often associated with a sclerotised tubular extension that acts as a siphon. One genus, Mansonia, takes oxygen from tissues of aquatic plants and its siphon is modified to pierce the stems of plants.

Pupae respire with the help of a pair of respiratory horns attached to the top of the head. They sit below the surface of the water with the horns attached to the surface film.

Life cycle and reproduction

Adult mosquitoes mate on the wing. Eggs are laid in rafts or singly on the water; they may also be laid on soil just above the waterline or in depressions. Eggs hatch within a few days, but some lie dormant for many years until drought breaks and the depressions fill with water. For some species, an optimum water temperature is required for the development of the eggs and larvae. This temperature range is usually 25-30°C. Generally larvae take 7-10 days to mature, although some species may take weeks or months.

When the adult is ready to emerge from the pupa, the pupal skin splits open and the adult emerges onto the water surface or may climb up onto vegetation before flying away. Adult females usually live 2-4 weeks, but some species live up to three months; females usually live longer than males.

Habitat

Larvae of mosquitoes can be found in still waters and they often prefer smaller, more sheltered water bodies. They usually live just below the surface, but may swim deeper when disturbed. They occur in fresh and saline waters, but often are present in stagnant waters and can colonise any container that holds water for a few days. Adults usually rest in the shade by day and fly around at night. Members of the genus Aedes bite primarily during the daytime and can transmit dengue fever. Mosquito larvae are commonly found throughout South Australia.

Critter facts

Adult mosquitoes of both sexes feed on sources of plant sugar, such as nectar, but most female mosquitoes need a protein source to allow their eggs to develop. They get this protein from a blood meal. As a result, they can spread disease. Three types of infection can be transmitted by mosquitoes:

- parasitic nematodes or filarial worms, which cause lymphatic filariasis
- protozoa or plasmodia, the kind of organisms responsible for malaria
- arboviruses, so named because they are viruses spread by arthropods; these include yellow fever, dengue fever, Ross River virus, Murray Valley encephalitis and myxomatosis.

Mosquito-borne diseases can be devastating: malaria alone kills over a million people a year in the tropics. In Australia, the impact of these diseases has been limited, with rare outbreaks usually restricted to northern Queensland. Viruses are mostly species specific: for example, the *Anopheles farauti* complex can transmit malaria, dengue fever is transmitted by *Aedes aegypti*, and encephalitis is transmitted by *Culex annulirostris*. However, strong host specificity is not always the rule. Ross River fever can be transmitted by species of both *Culex* and *Aedes*.

Mosquito transmission of disease can also be advantageous for humans. Mosquito vectors help spread myxomatosis and the calici virus, two biological control agents for rabbits in Australia.

Not all female mosquitoes attack mammals. Some will take blood from birds, reptiles, frogs or fish.

Identification

Most people are familiar with mosquito larvae and call them ‘wrigglers’ because they wriggle when moving through the water. Some can be recognised by their long siphon. *Anopheles* species, by contrast, have quite short siphons. They also have strong hairs attached to the sides of the body. The pupae have very large heads in comparison with the rest of the body. They may be confused with non-biting midge larvae, but mosquito larvae do not have a pair of prolegs near the head. The less common Dixidae larvae also look like Culicid larvae; however, they are usually bent into a U shape. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification, while the key on page 114 will help you get to family.

Classification and sensitivity

Phylum Arthropoda

    Class Insecta

        Order Diptera (3)

            Family Culicidae (1)

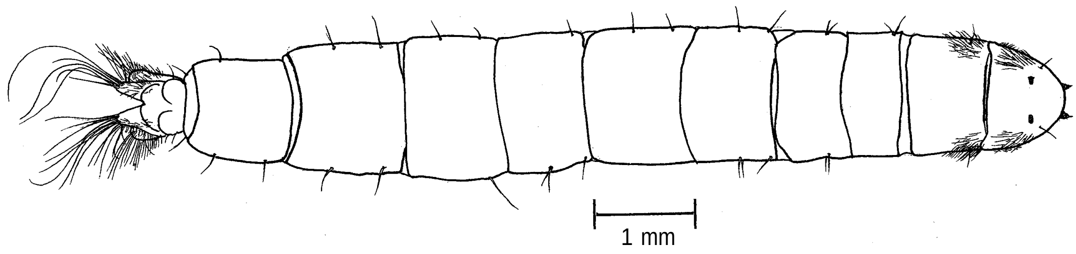
References

Hawking & Smith 1997, p 160; Williams 1980, p 238; Gooderham & Tsyrlin 2002, pp 122-123.

Family Tipulidae—crane flies

Background

The family Tipulidae is extremely large, with over 13,000 species known worldwide. Three subfamilies and 704 described species are known to occur in Australia. Not all Tipulid larvae are aquatic. At least thirty-three species occur in South Australia. Fossil records date back to the Upper Cretaceous period, about 135 million years ago.



The larva of a crane fly (family Tipulidae)

Size

Tipulid larvae grow up to 50 mm long. Adult wingspans range from 4 mm to 80 mm.

Features

Tipulid larvae have a pair of darkened spiracles on the last abdominal segment, which can be surrounded by up to six fleshy lobes. The spiracles are protruded from the water to obtain air. Most tipulid larvae have an elongate cylindrical body. The head varies from completely sclerotised—brown and hardened—to very reduced, with only a few rods present. Generally the head is almost entirely withdrawn into the thorax. The larvae are generally white to brown in colour. Many have thickened lateral bands on the ventral surfaces of the abdominal segments. These bands are known as 'creeping welts' and help the larva to gain traction whilst moving.

Diet and feeding

Tipulid larvae generally feed on decaying organic matter, plant fragments and also micro-organisms.

Locomotion

Tipulid larvae crawl in a 'peristaltic' manner, using their creeping welts for traction. The last instar is usually the most active stage.

Gas exchange (breathing)

Some species remain submerged and obtain oxygen by diffusion through the body wall. Others protrude their spiracles above the surface at regular intervals. Adults obtain oxygen from the air, via their tracheal systems.

Life cycle and reproduction

Males sometimes form mating swarms. Mating occurs on the wing or after landing and can last several hours. Females drop their eggs from the air onto the water surface or place them onto other particularly moist surfaces. The egg stage is quite brief, lasting only a few days to two weeks. There are four larval instars, of which the first three are short in comparison to the last. The whole larval life can take up to a year.

Larvae leave the water to pupate in the moist soil at the edge of the water. The pupal stage lasts 5-12 days. Adults of some species live only a few days. Temperature and moisture level are factors that affect the length of the life cycle. Many aquatic tipulid species have a life cycle of one year in cooler climates and six months in warmer climates.

Habitat

Tipulid larvae can be found in most still or flowing waters. They range from aquatic to semi-aquatic and tolerate a wide range of salinities. They are often associated with plant material and detritus and some are active burrowers. They can be found commonly throughout South Australia, even in slightly polluted waters.

Critter facts

Very little is known about the larvae in Australia. Not many larvae have been identified to genus level. Adults of Australian tipulids are quite well known, so the surest way to identify larvae is to rear them in the laboratory to the adult stage.

One tipulid species found in Alaska reproduces only once every five years due to the cold climate.

Identification

Tipulid larvae are easily recognised by the presence of up to six lobes at the end of the abdomen. A few species do not have these lobes, however, and these may be confused with other Diptera. The general key on page 20 of The Waterbug Book should get you started on dipteran identification, while the key on page 114 will help you get to family.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Diptera (3)

Family Tipulidae (5)

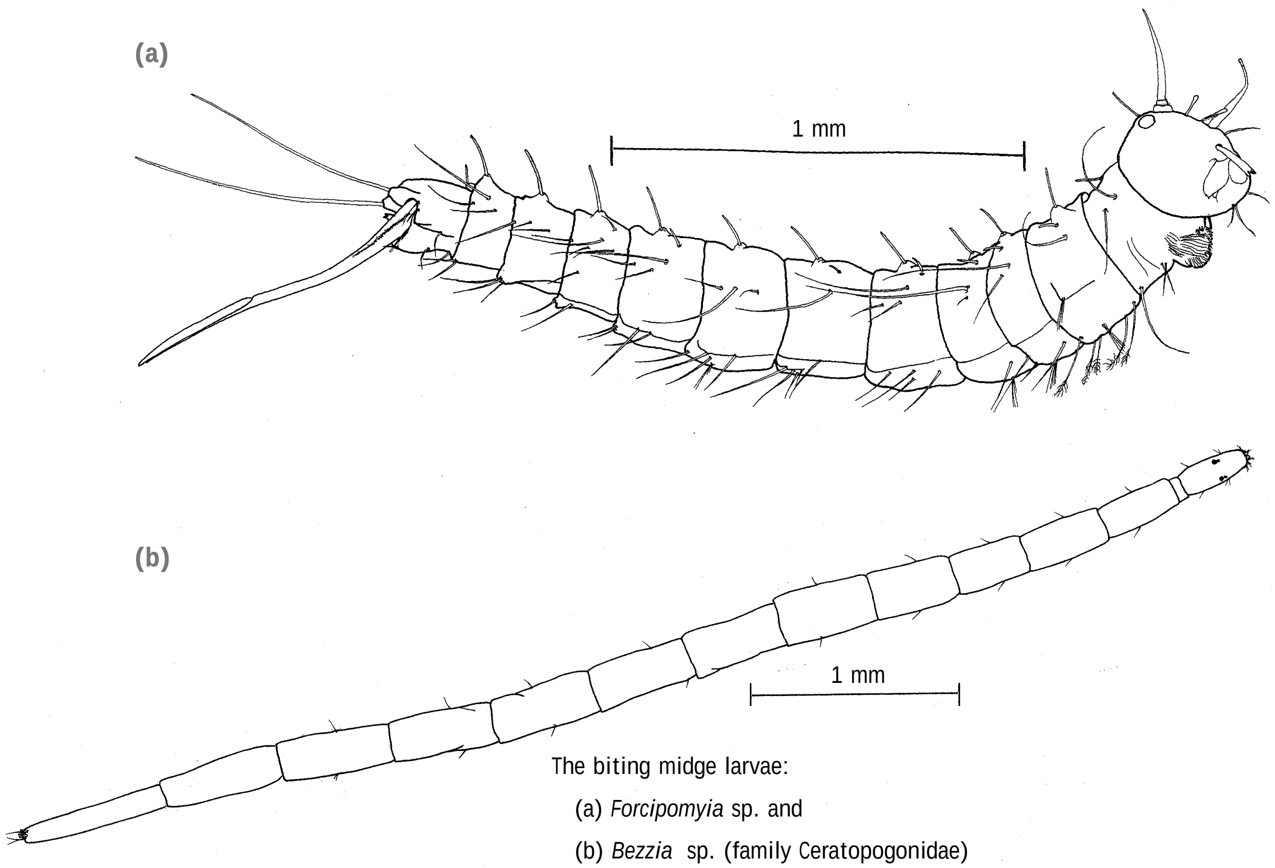
References

Hawking & Smith 1997, p 161; Williams 1980, p 236; Gooderham & Tsyrlin 2002, pp 124-125.

Family Ceratopogonidae—biting midges

Background

This family includes approximately 5000 described species worldwide. There are four subfamilies of Ceratopogonidae in which the larvae and pupae are aquatic and the adults are terrestrial. Only three of these have been recorded from South Australia so far. Adults bite vertebrates, including humans. Over 205 fossil ceratopogonid species have been found, dated to as far back as the Lower Cretaceous period, around 65 million years ago.



The biting midge larvae:
(a) *Forcipomyia* sp. and
(b) *Bezzia* sp. (family Ceratopogonidae)

Size

Ceratopogonid larvae grow up to 12 mm long. Adults can have wingspans of up to 5 mm in length, but most are much smaller.

Features

Most Ceratopogonidae larvae are narrow, elongate animals without prolegs and with segments shaped like beads. The sclerotised head protrudes quite obviously. These larvae are often pale, although some species have faint colour patterns. One subfamily, Forcipomyiinae, has fleshy, hairy lobes along the body. This subfamily also has prolegs at the front and rear of the body.

Diet and feeding

Some Ceratopogonidae larvae feed on algae and detritus and others are predators. All adults have piercing mouthparts adapted for predation and sucking blood. They have been known to feed on humans, birds, foxes, cattle and wallabies: adult females start feeding about four days after emergence. Some adults are not blood suckers and instead play an important role in the pollination of many plants.

Locomotion

Ceratopogonidae larvae swim well in a distinctive snake-like manner. The pupae are unable to swim, but move through the water by twisting their abdomens.

Gas exchange (breathing)

Ceratopogonidae larvae obtain oxygen by diffusion through the surface of the body.

Life cycle and reproduction

Ceratopogonids reproduce sexually. Eggs are laid on moist substrate either singly, in scattered groups, or in gelatinous masses, depending on the species. The eggs can take up to a week to hatch. Larvae go through four instars. The final instar larva transforms into an aquatic pupa.

The pupal stage lasts between three and five days. Adults can live up to two months after emergence. After mating, females find a blood meal and start depositing eggs about five days after they have fed. Some species have one generation per year, others have two. Ceratopogonids overwinter as eggs or larvae. In temperate climates, adults emerge late spring or early summer.

Habitat

Biting midge larvae can be found in wet sand and mud at the margins of streams, lakes or ponds. They can be found in both fresh and saline waters. They are quite common throughout South Australia and are occasionally found in polluted water bodies.

Critter facts

The adults of one species of Ceratopogonidae attach themselves to dragonfly wings and suck blood from the wing veins. Another species feeds on blood from the abdomens of female mosquitoes after they have taken a blood meal. Like mosquitoes, ceratopogonids are able to transmit arboviruses.

Along with the black flies, adult biting midges from the genus *Culicoides* are known to transmit the tropical disease mansonellosis. This disease has flu-like symptoms and can affect the lymph nodes. Species of *Culicoides* readily bite humans and are the most important ceratopogonids in terms of human health and disease transmission.

Identification

Larval ceratopogonids may be confused with oligochaetes and nematodes due to their long, thin, straight bodies. However, ceratopogonids have obvious sclerotised head capsules, which are sometimes darker in colour than the rest of the body. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification, while the key on page 114 will help you get to family.

Classification and sensitivity

Phylum Arthropoda

    Class Insecta

        Order Diptera (3)

            Family Ceratopogonidae (4)

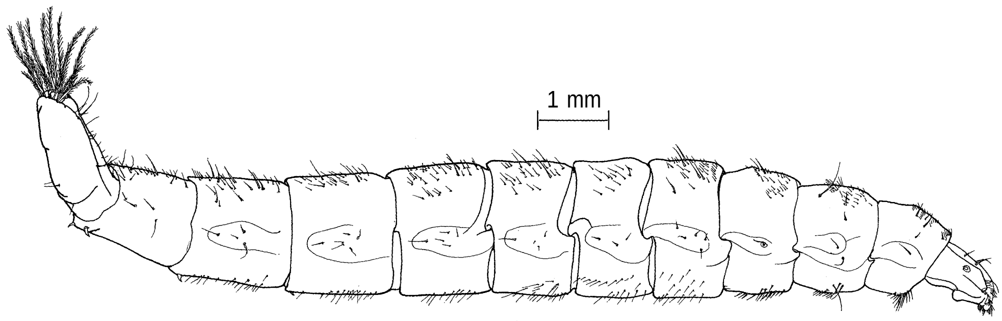
References

Hawking & Smith 1997, pp 164-165; Williams 1980, p 248; Gooderham & Tsyrlin 2002, p 119.

Family Stratiomyidae—soldier flies

Background

Stratiomyidae are found throughout the world. Over 2000 species are recognised worldwide, the family being very diverse in tropical regions. All adults are terrestrial. In Australia, a single genus, *Odontomyia,* has some species with aquatic larvae. As little work has been done on the identification of larvae, the number of species in South Australia is unknown. Fossils of stratiomyids have been found in Spain, dated to the Lower Cretaceous period, about 65 million years ago.



A larva of a soldier fly (family Stratiomyidae)

Size

Larvae can grow up to 30 mm, although most species are much smaller.

Features

Stratiomyid larvae have flattened bodies that are broadest in the middle segments and narrower at the ends. The leathery body surface (cuticle) is hardened by calcium carbonate, and a circle of hydrophobic hairs surrounds the spiracles at the end of the body. The head is well sclerotised and can be partly retracted into the body.

Diet and feeding

Stratiomyid larvae feed on decaying organic material, algae and other debris.

Locomotion

Stratiomyids are poor swimmers and move quite slowly. They usually crawl along the sediment.

Gas exchange (breathing)

Stratiomyid larvae obtain oxygen from air taken into the tracheal system through spiracles that they position at the surface of the water. The ring of hydrophobic hairs around the spiracles prevents water from entering.

Life cycle and reproduction

Females lay up to 200 eggs in a group in the water. The larvae hatch after a couple of weeks and go through several instars before pupation. The final instar larvae pupate within the last larval skin.

When ready to pupate, larvae leave the water in search of a suitable place, sometimes wandering for several days. The pupal stage lasts up to four weeks before the adult emerges and flies off. There is one generation per year. Adults live for only a few days and it is thought that the females mate on the day that they emerge from their pupal skins.

Habitat

Aquatic soldier fly larvae can be found in shallow regions of ponds and streams and also in tree holes. They can be found in fresh and saline waters and are able to tolerate polluted water. Relatively common, they can be found throughout South Australia.

Critter facts

Adult soldier flies resemble wasps, but do not bite or sting humans. The terrestrial larvae of soldier flies are often found living in manure and compost bins.

Identification

Most stratiomyid larvae are easily recognised by their leathery, flattened body and circle of hairs at the posterior end. The shape of the body makes it difficult to mistake this dipteran for any other. Sometimes, large stratiomyids appear to be light purple in colour. They have a sclerotised head that is usually visible, but may be partly retracted inside the body. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification, while the key on page 114 will help you get to family.

Classification and sensitivity

Phylum Arthropoda

Class Insecta

Order Diptera (3)

Family Stratiomyidae (2)

References

Hawking & Smith 1997, pp 158, 169; Williams 1980, p 249; Gooderham & Tsyrlin 2002, p 128.

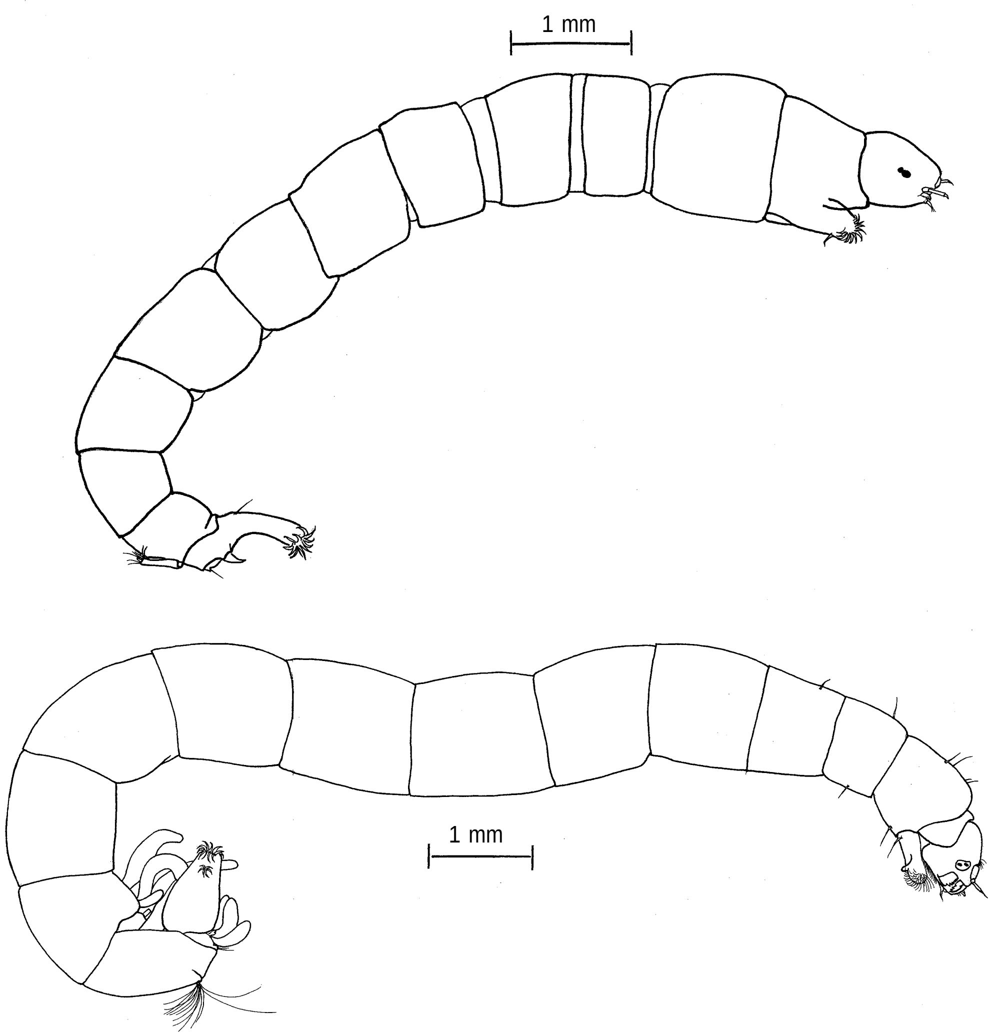
Family Chironomidae—non-biting midges and bloodworms

Background

Worldwide, there are approximately 20,000 species of Chironomidae. This includes terrestrial, marine and freshwater forms. Six subfamilies are known from inland waters in Australia and one family is marine intertidal. Over 200 species are recorded for Australia. All six of the inland aquatic subfamilies and at least 52 genera occur in South Australia. They are probably the most common and diverse insect group in the inland waters of South Australia. The oldest fossil record of chironomids is from the Upper Cretaceous period, 130 million years ago.

(a)

(b)



The non-biting midge larvae (family Chironomidae):
(a) *Procladius* sp. (subfamily Tanypodinae) and
(b) *Chironomus* sp. (subfamily Chironominae)

Size

The largest chironomid larvae grow to 30 mm in length, but most are much smaller than this. The wingspan of adults ranges from 1.6 mm to 15 mm.

Features

Chironomid larvae are long, cylindrical, worm-like animals. Most have two pairs of prolegs: one pair on the first thoracic segment, just below the head, and the second pair on the last abdominal segment. Some species have ventral tubules, or 'blood gills', but most have anal tubules. They all have sclerotised head capsules with well-developed jaws and antennae. Some chironomid larvae are called 'bloodworms' as they are red in colour. Other chironomids can be green, white, yellow and some even have a bluish colour. Adults look similar to mosquitoes, but they do not bite.

Some chironomid larvae construct tubes using fine particles of sediment, and often they can be collected in the tubes. Other chironomids are free-living.

Diet and feeding

Depending on the species, chironomid larvae can be detritivores that feed on algae and detritus, or predators that feed on oligochaetes and small dipteran larvae, including other chironomids. Some are filter feeders and some scrape detrital material from their tubes. Chironomids have highly developed mouthparts.

Locomotion

Chironomids are poor swimmers, moving with a whip-like motion that almost forms 'figure eights'. They generally crawl along or burrow into the sediment.

Gas exchange (breathing)

Chironomidae larvae exchange gases by diffusion through the body surface. The chironomids known as bloodworms have haemoglobin, which has a high affinity for oxygen and allows the midges to survive in low oxygen environments. Some of these bloodworms also have gills at the end of the abdomen that aid in oxygen uptake.

Life cycle and reproduction

Worldwide, chironomid life cycles range from seven years in very cold areas to a few weeks in hot regions. Eggs are laid directly onto the water surface or onto emergent vegetation. Larvae from the same batch of eggs do not necessarily develop at the same rate. There are four larval instars. The final instar larva moults to a pupa. This pupa remains in the water until the emergence of the adult.

Adults often emerge together, forming large clouds. Adults have reduced mouthparts and do not need to eat, although some feed on liquid food sources such as nectar. They live for a few days to several weeks. Chironomids mate in aerial swarms or in skating swarms on the water surface or on solid substrates.

Habitat

The larvae of many species live in silk tubes that are attached to or buried in the substrate. Some species live only in fast-flowing water and build a net at the entrance of their tube to filter detritus from the water.

Chironomid larvae live in the sediments of virtually all aquatic habitats. They are found across all ranges of salinity and water flow and in both permanent and temporary waters. One genus, *Tanytarsus,* can cope with the low pH environments of acid streams polluted by acid mine drainage. Chironomid larvae are often found in large numbers in environments with low oxygen concentrations, but may also be found in large numbers in healthy environments as well. Chironomids can be found in almost every water body throughout South Australia. In healthy environments, the diversity of chironomids will usually be high, whereas usually only two or three species are found in poor environments.

Critter facts

Chironomidae are one of the most common and diverse group of invertebrates in South Australian waters. Internationally, larval chironomids have been recorded in densities as high as 70,000 per square metre. Chironomids often account for more than 50% of the species richness at aquatic sites. Two species are even recorded from Antarctica, being the southernmost records of larvae of non-parasitic insects. They are the dominant aquatic group in the Arctic and have also colonised the intertidal zone.

When chironomid adults emerge from Lake Victoria in Africa, local people catch them in nets and use them as a food source. They provide an important source of protein, and are made into cakes and eaten.

The mouthparts of chironomids have been studied to determine the effects of pollution on aquatic animals. Deformities of the mouthparts can be seen in midge larvae affected by heavy metal pollution and pesticides.

Identification

Larvae of Chironomidae look similar to those of Ceratopogonidae and Culicidae, but chironomids have a pair of prolegs just below the head as well as a pair at the end of the abdomen. Some are red in colour and are commonly called bloodworms. The general key on page 20 of *The Waterbug Book* should get you started on dipteran identification, while the key on page 114 will help you get to family.

Identification to at least subfamily is desirable for scientific work; however, this generally requires a dissecting microscope.

Classification and sensitivity

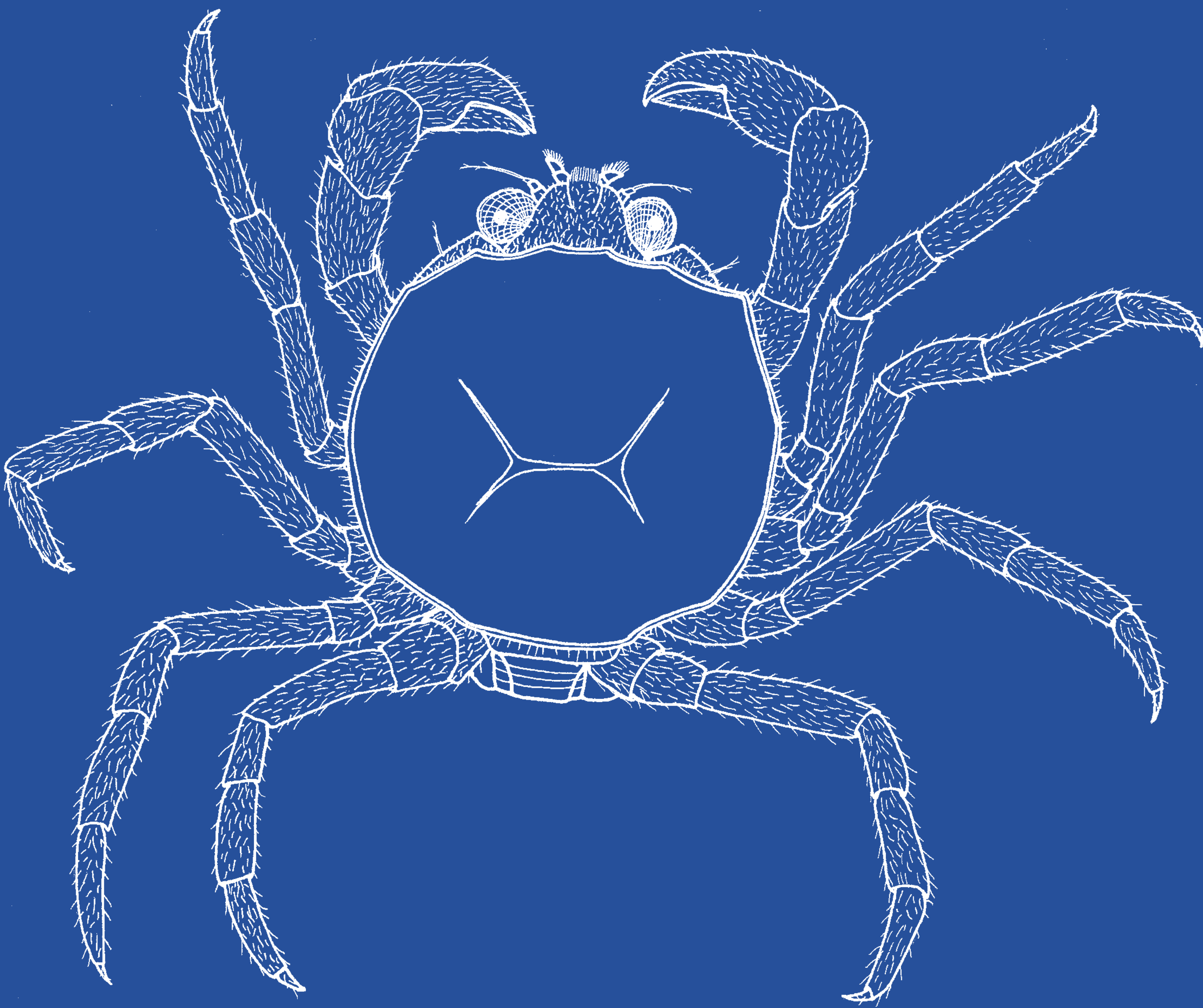
Phylum Arthropoda	
Class Insecta	
Order Diptera (3)	
Family Chironomidae	
Subfamily Chironominae	3
Subfamily Tanypodinae	4
Subfamily Orthocladiinae	4
Subfamily Diamensinae	6
Subfamily Aphroteniinae	8
Subfamily Podonominae	6

References

Hawking & Smith 1997, pp 174-175; Williams 1980, p 246; Gooderham & Tsyrlin 2002, pp 120-121.

E N V I R O N M E N T P R O T E C T I O N A U T H O R I T Y

Glossary and Bibliography



13 Glossary

abdomen	the part of the body containing the digestive organs; situated below the head and thorax of the animal
amoebocytes	simple cells that have the form and habits of an amoeba
anterior	the front portion of an organism
benthic	living on the sediment, at the bottom of a water body
bilateral symmetry	having two sides symmetrical about one medial axis
biofilm	a thin layer of microscopic organisms found underwater attached to sediment, aquatic plants and rocks
bioluminescent	a biological organism that is able to produce light
blood gills	blood filled sacs found in some insects that are used to take up salts
calcareous	covered by lime and calcium deposits
carapace	the hard exoskeleton that covers part of the body of an animal; found in Crustaceans
c**arnivore**	an organism that eats animals or flesh; secondary or tertiary producer
cephalothorax	the body region of a Crustacean that includes the head and thorax
cerci	long, thin, segmented appendages that are attached to the very end of the abdomen
chelicerae	appendages used for feeding
chitin	the major component of the exterior surface of an insect; a polysaccharide
choanocyte	a cell with a funnel-shaped rim around the base of a flagellum
cilia	hair-like structures that grow out of the body wall
collagen	a protein that occurs in tissue fibres and in the bones of vertebrates
copulation	sexual union between two organisms, usually one male and one female, although copulation can also occur between two hermaphroditic organisms
creeping welts	protrusions of the body of some insect larvae that appear as ‘bumps’
cuticle	the outer layer of skin, usually waterproof
deflexed	bent downwards. In the case of Coleopterans, the head is bent downwards and appears to be tucked slightly under the body.
desiccation	process of drying out
detritivore	an organism that feeds on organic matter of both plant and animal origin
deutonymph	the second instar phase of the development of an insect larva
dioecious	having separate sexes, that is, males and females are separate organisms
dorsal plates	part of the hard exterior on the back of beetles
dorso-ventral	from back to front; a dorso-ventrally flattened animal is thin between the back and the front of the animal.
ectocommensal	living on the outside of another animal. Either both organisms benefit from the arrangement or neither benefits but the host is not harmed.
elytra	the protective dorsal covering of the abdominal region of an invertebrate, particularly beetles; formed by sclerotisation of the fore wings, covering the back of the animal
erythrocruorin	a respiratory pigment that contains iron; found in many annelids and molluscs

estuarine	the water where a stream or river meets the ocean. This area can be affected by the tide. Estuarine areas are usually saline, almost as saline as seawater, but salinity can vary greatly, depending on the amount of flow from the freshwater stream.
exoskeleton	the hard supporting structure of an organism, usually made of chitin. In many organisms this exoskeleton is shed in a process called moulting.
flagellum	the thread-like process that arises from some cells
furcula	a forked process on the underside of a Collembola (springtail) that enables the animal to jump
gemmules	the resistant bodies produced by Porifera (sponges) through asexual reproduction
Gondwana	the connected southern land mass before continents separated and drifted apart to their present positions; the term 'Gondwanan origin' refers to a distribution that is mainly southern (in the southern hemisphere).
gonophores	a reproductive organ in some invertebrates
haemocyanin	a blue respiratory pigment, found in many molluscs and arthropods; contains copper
haemoglobin	a red respiratory pigment, present in many organisms, including humans; contains iron
halteres	small structures that replace the second pair of wings on the thorax in some insects
herbivore	an organism that eats plant matter; primary producer
hermaphrodite	having both male and female reproductive organs in the one organism
hydrophobic	does not like water; repels water
hypersaline	water bodies which have a salinity level greater than seawater
idiosoma	the body of a mite
instar	a stage of insect development, between moults
Johnston's organ	an organ situated on the second segment of the antennae of some insects
larva	the immature life stage of many invertebrates (plural is larvae)
labial mask	a mouth part of dragonflies and damselflies which is an extension of the lower lip
labium	the fused lower mouthparts of an insect; often has a pair of palps
lamellae	the thin plate-like divisions in gills
lipid	a fatty compound, insoluble in water
mandible	the jaw of an organism; used for biting, chewing or sucking
mantle cavity	the area between the soft flesh of a mollusc and the shell
marine	living in the ocean; can be near the shore or a long way from land
maxillae	mouth parts of some invertebrates
maxillary palp	a structure on the maxillae in arthropods
medusa	the jellyfish-like free-swimming life stage of a cnidarian
metabolism	changes in chemical substances in organisms which result in the production of energy
metamorphosis	the quite dramatic change in form and structure of some organisms from the embryo to the adult stage

mouth brushes	structures made of fine hairs used to filter water for food particles
multicellular	made up of many cells
nauplius	the juvenile stages of some crustaceans; the larval stage that hatches from the egg in some Crustacea. Nauplii have a small transparent body with three pairs of appendages that are used for swimming and feeding.
nematocyst	a stinging cell consisting of a sac full of fluid in which lies a coiled thread that is shot out on stimulation
ocellus	small simple eye or eye spots in some insects
omnivore	feeds on a mixed diet of both plant and animal material
operculum	hardened structure attached to the foot of a mollusc and used as a cover to the opening of the shell
ostia	channels in Porifera (sponges) through which water is drawn into the organism
oscula	channels in Porifera (sponges) through which water is expelled from the organism
oviduct	the tube that carries the egg from the ovary to the exterior of the body
oxidation	any chemical process involving the addition of oxygen and the loss of hydrogen
parasitic	invading the tissue of another organism, usually harming that organism
parthenogenesis	reproduction without fertilisation by a male gamete; the development of juveniles without the involvement of males
pedipalps	mouth parts found in arachnids
periphyton	organisms living and growing on water plants
peristaltic	muscular movement; consecutive contractions of muscle that produces a forward motion
pharynx	the anterior part of the digestive tract
phylogenetic analysis	study of the history of development of a species or group
plankton	small organisms found in the water column in either freshwater or marine environments, usually microscopic plants or animals, free to drift with the current of the water
plastron	an organ in some aquatic beetles consisting of tiny hairs used to trap air bubbles, enabling the beetle to respire underwater
polyp	an individual of a colony, usually has a tubular body and ring of tentacles at the top
posterior	the rear portion of an organism
prolegs	short outgrowths of the body that look like legs but have no joints
pronymph	the life stage before an insect becomes a nymph
prosoma	the front part of the body, a joint head and thorax
protozoa	microscopic organisms, often a food source for other aquatic invertebrates
pulmonate	refers to a type of snail that holds air inside its shell to breathe. The area between the body of the snail and the wall of the shell acts as a lung.
pupa	the life stage between the larva and the adult in some invertebrate life cycles (plural is pupae)
radial symmetry	having a plane of symmetry about each radius or diameter

radula	a short, broad strip of membrane with teeth, found in gastropods, used to rasp plant material or scrape food off of a substrate
rectal gill	an organ inside the final segment of the abdomen of a dragonfly larvae, used for respiration (gas exchange)
respiratory siphon	a tube found in some aquatic insects which enables them to take oxygen from the air while remaining under water
rostral prong	an extension of the mouthparts found in some male bugs
rostrum	in crustaceans this is part of the carapace that protrudes between the eyes. In other invertebrates it can act as a mouthpart and protrudes from below the eyes.
rotifers	microscopic organisms often used as a food source by other aquatic invertebrates
saline	containing high levels of salt. Inland water bodies are considered to be saline if the level of salt present in the water is almost that of seawater
sclerotised	the hardened and often dark parts of an animal, especially the exterior
sessile	does not move, remains fixed in one place
setae	a stiff hair-like structure
sphincter	a muscle that contracts and closes an orifice
spicule	minute needle-like body made of silica or calcium salts found in some invertebrates
spiracle	a hole in the body of an insect which is used for breathing; only found in some insects
stolon	branching stems that ultimately form a new individual
stylets	feeding tubes in some insects; may release digestive juices as well as ingest liquid food
stridulatory organs	organs that hemipterans use to communicate. Most commonly used to produce a mating signal, but can also be for other communication purposes. Usually the male has the stridulatory organ, usually positioned on a leg, and that part of the leg is rubbed against another part of the body to produce a sound at a particular pitch. The pitch varies between species and also varies according to the message the bug is sending.
subimago	the life stage between pupa and adult. The adult life stage is sometimes referred to as the imago.
symbiotic	living together, usually without harm to either organism
tarsi	plural of tarsus; the final segment on the insect leg
thorax	the part of the body to which the legs (and wings, if present) of the animal are attached
tracheal system	part of the respiratory system; a system of tubes that extends throughout the body of some arthropods, taking air into close contact with the tissues where gas exchange occurs, particularly oxygen uptake
undulating	wave-like motion
uropods	the appendages of a Crustacean attached to the end of the abdomen
ventral	the underside of the animal
water column	the vertical section of water between the sediment and the air
wingpads	the undeveloped wings seen in larvae of insects

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Internet addresses

The following Internet sites were used for reference while this manual was being written. Not all will be still be accessible; Internet users are encouraged to browse those that are, and to follow the links provided by them to discover more about our aquatic invertebrates.

http://www.lucidcentral.com/keys/lwrrdc/public/Aquatics/ **(Australian aquatic invertebrates Web keys)**

http://www.wlu.ca/~wwwbiol/bio305/Database/Belostoma.htm **(giant water bugs)**

http://tolweb.org/tree?group=Acari&contgroup=Arachnida **(mites)**

http://www.microscopy-uk.org.uk/mag/artdec99/mite5.html **(water mites)**

http://www.xs4all.nl/~ednieuw/Spiders/Argyronetidae/Argyronetidae.htm **(water spider)**

http://www.vernalpool.org/inf_fs.htm **(fairy shrimp)**

http://www.samuseum.sa.gov.au/water/shrimp.htm **(triops-shield shrimp)**

http://filebox.vt.edu/users/channum/triops_intro.htm **(triops-shield shrimp)**

http://www.museum.vic.gov.au/crust/amphbiol.html **(Amphipods)**

http://tolweb.org/tree?group=Isopoda&contgroup=Peracarida **(Isopoda)**

http://www.nzfreshwater.org/index_wildlife.html **(freshwater shrimp)**

http://pandora.nla.gov.au/pan/21803/20010913/members.optushome.com.au/chelmon/Shrimp.htm **(Australian freshwater shrimp)**

http://aqua.ucdavis.edu/dbweb/outreach/aqua/483FS.PDF **(freshwater prawn biology-Acrobat file)**

http://www.nativefish.asn.au/spiny.html **(freshwater crayfish)**

http://www.ucmp.berkeley.edu/phyla/metazoafr.html **(Metazoa-fossil record)**

http://zoology.byu.edu/crandall_lab/fetzner/crayfossil.htm **(fossil Decapoda)**

http://www.dlwc.nsw.gov.au/care/wetlands/facts/paa/plants/emergent.html **(emergent plants)**

http://www.biosci.ohio-state.edu/~parasite/taxonomic_platyhelminthes.html **(Phylum Plathyhelminthes)**

http://www.uni-oldenburg.de/zoomorphology/Biologyintro.html **(Copepods)**

http://www.cals.ncsu.edu/course/ent425/compendium/collem.html **(Colembola-springtails)**

http://www.earthlife.net/insects/collembo.html **(Order Colembola)**

http://www.senckenberg.uni-frankfurt.de/private/dkovac/abs17.htm **(waterbug secretion/grooming behaviour)**

http://www.colostate.edu/Depts/Entomology/courses/en570/papers_1994/rhodes.html **(chemical substances as defences)**

http://www.nhm-wien.ac.at/NHM/2Zoo/hemiptera/veliidae.rtf **(family Veliidae)**

http://www.earthlife.net/insects/gerromorpha.html **(water striders/pond skaters)**

http://www.alienexplorer.com/ecology/p94.html **(water measurer)**

http://www.zoo.org/educate/fact_sheets/waterbug/waterbug.htm **(giant water bug)**

http://www.flyline.com/1pieces/backswimmer.htm **(back swimmers and boatmen)**

http://www.enature.com/search/show_search_byShape.asp?curGroupID=4&shapeID=1011 **(water beetles)**

http://www.mdgekko.com/devonian/Ecology/upstream.html **(Devonian transformation)**

http://www.chebucto.ns.ca/Science/SWCS/ZOOBENTH/coleopte.html **(aquatic coleoptera)**

http://gsa.confex.com/gsa/2001AM/finalprogram/abstract_28081.htm **(Cenozoic fossils)**

http://caca.essortment.com/whirligigbeetle_rvea.htm **(whirligig beetle)**

http://www.ivyhall.district96.k12.il.us/4th/kkhp/1insects/divingbeetle.html **(predacious diving beetle)**

http://www2.ncsu.edu/unity/lockers/ftp/bwiegman/fly_html/diptera.html **(Diptera)**

http://www.cals.ncsu.edu/course/ent425/compendium/diptera.html **(Diptera)**

http://ohioline.osu.edu/b473/b473_21.html **(Syrphid fly larvae-rat-tailed maggots)**

http://www.alienexplorer.com/ecology/p39.html **(rat-tailed maggots)**

http://www.gardensafari.net/english/flies.htm **(Diptera)**

http://www.sel.barc.usda.gov/diptera/syrphid/syrphid.htm **(Diptera)**

http://www.chebucto.ns.ca/Science/SWCS/ZOOBENTH/tipulida.html **(crane fly)**

http://hbs.bishopmuseum.org/fossilcat/fossstratio.html **(soldier fly-fossils)**

http://www.squirmy-worms.com/soldfly.html **(soldier fly)**

http://www.dpi.qld.gov.au/beef/3323.html **(sugarcane soldier fly)**

http://www.museums.org.za/bio/spiderweb/pisauridae.htm **(fishing spiders)**

http://www.wnrmag.com/stories/1999/apr99/spider.htm **(fishing spiders)**