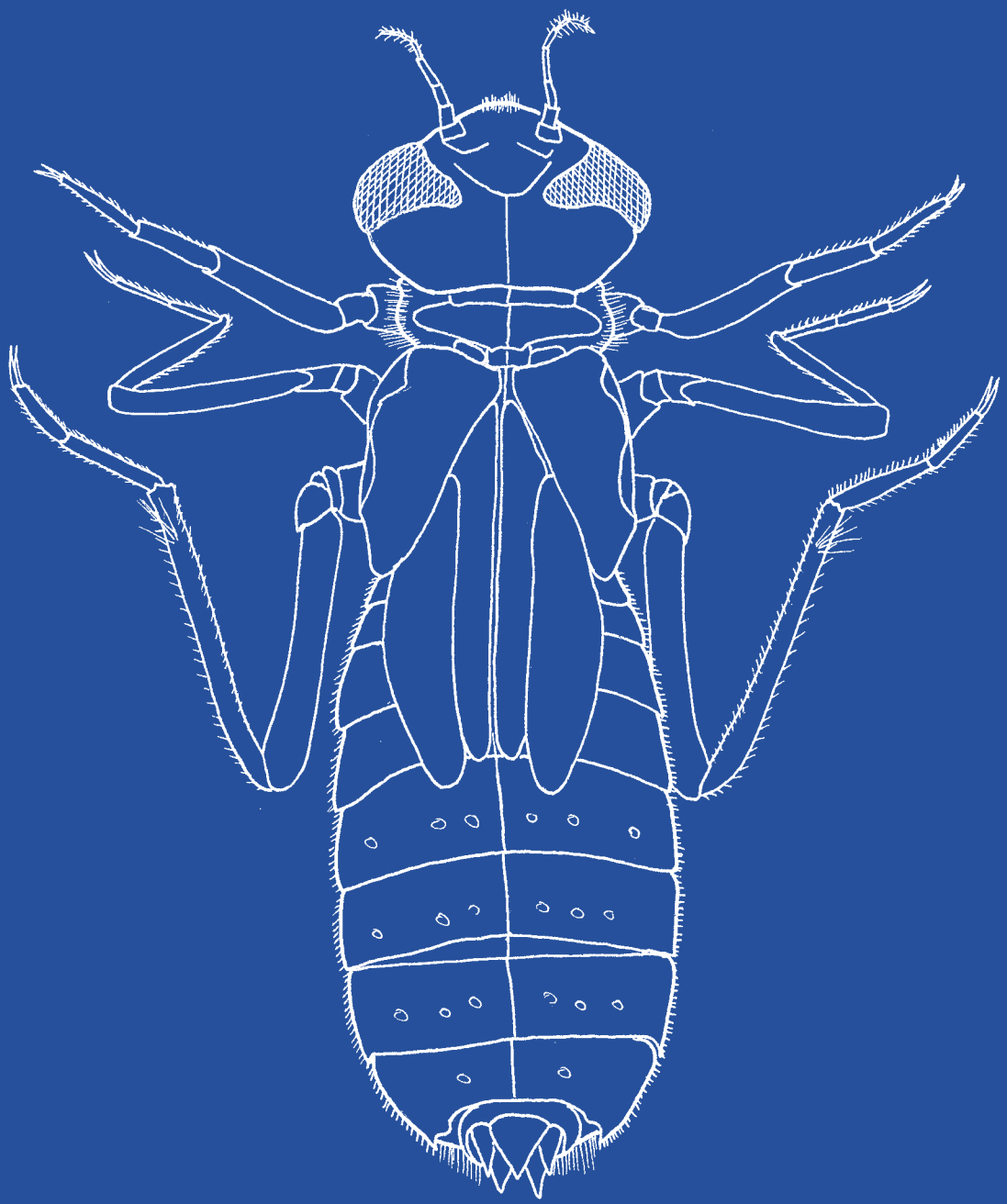
ENVIRONMENT PROTECTION AUTHORITY

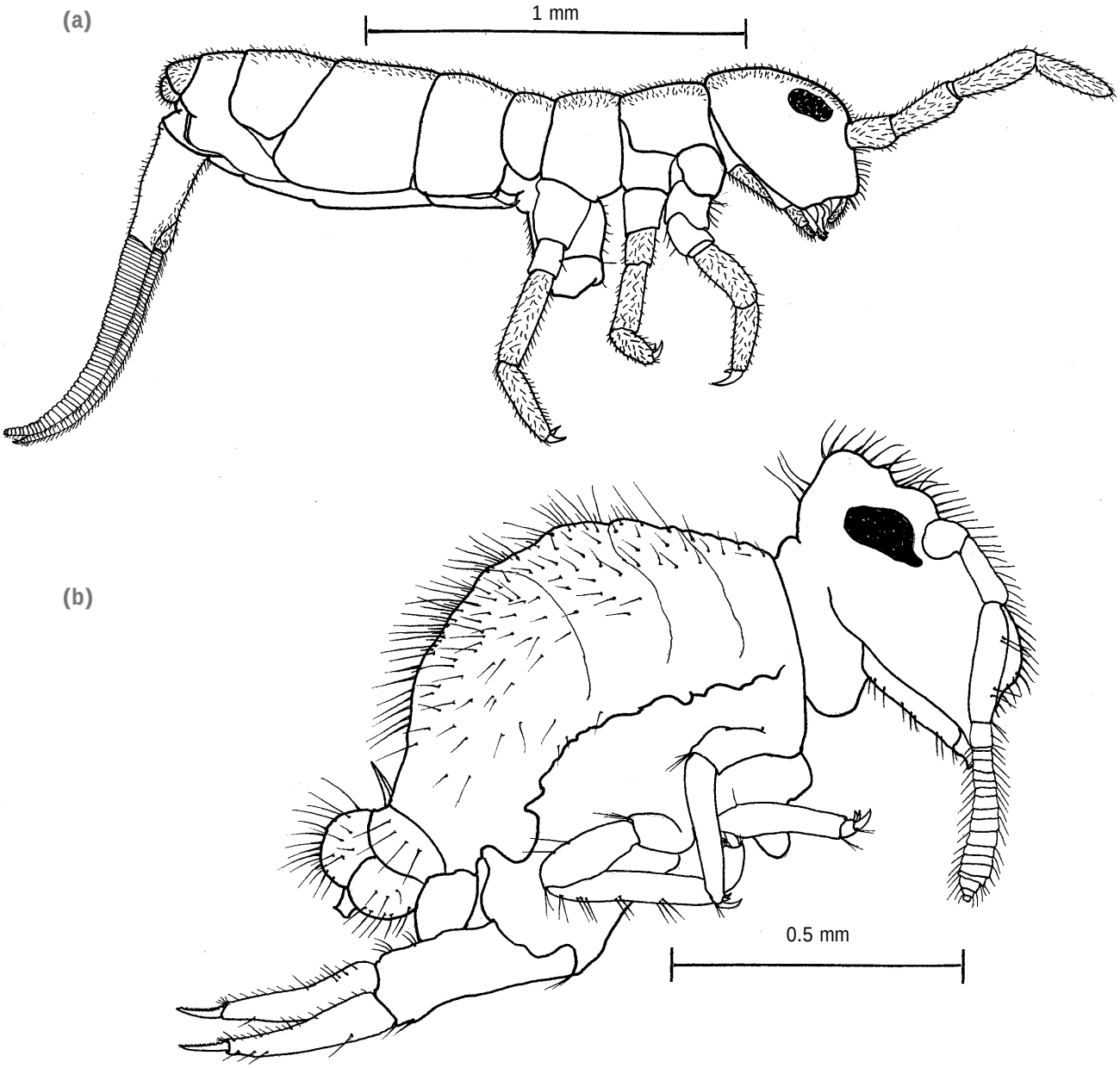
Insects and springtails



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.

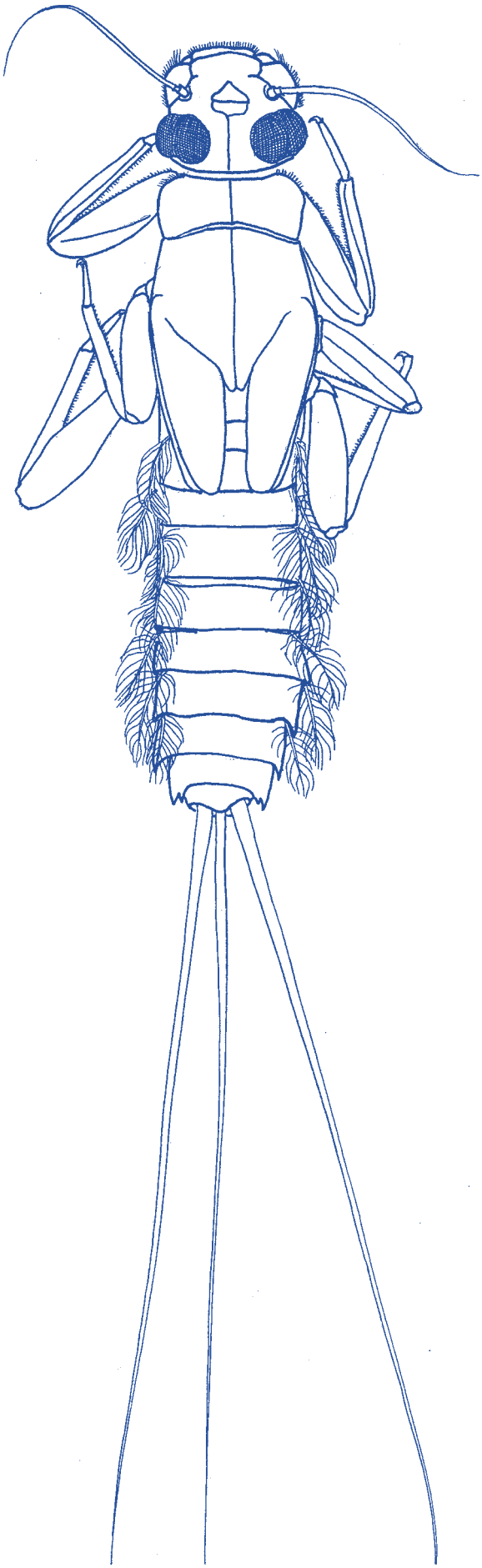
Some insects have a three-stage life cycle (undergo a complete metamorphosis), and the stages are called 'larvae', 'pupae' and 'adult'. Others have just a two-stage cycle (incomplete metamorphosis), the stages known as 'nymph' and 'adult'.

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

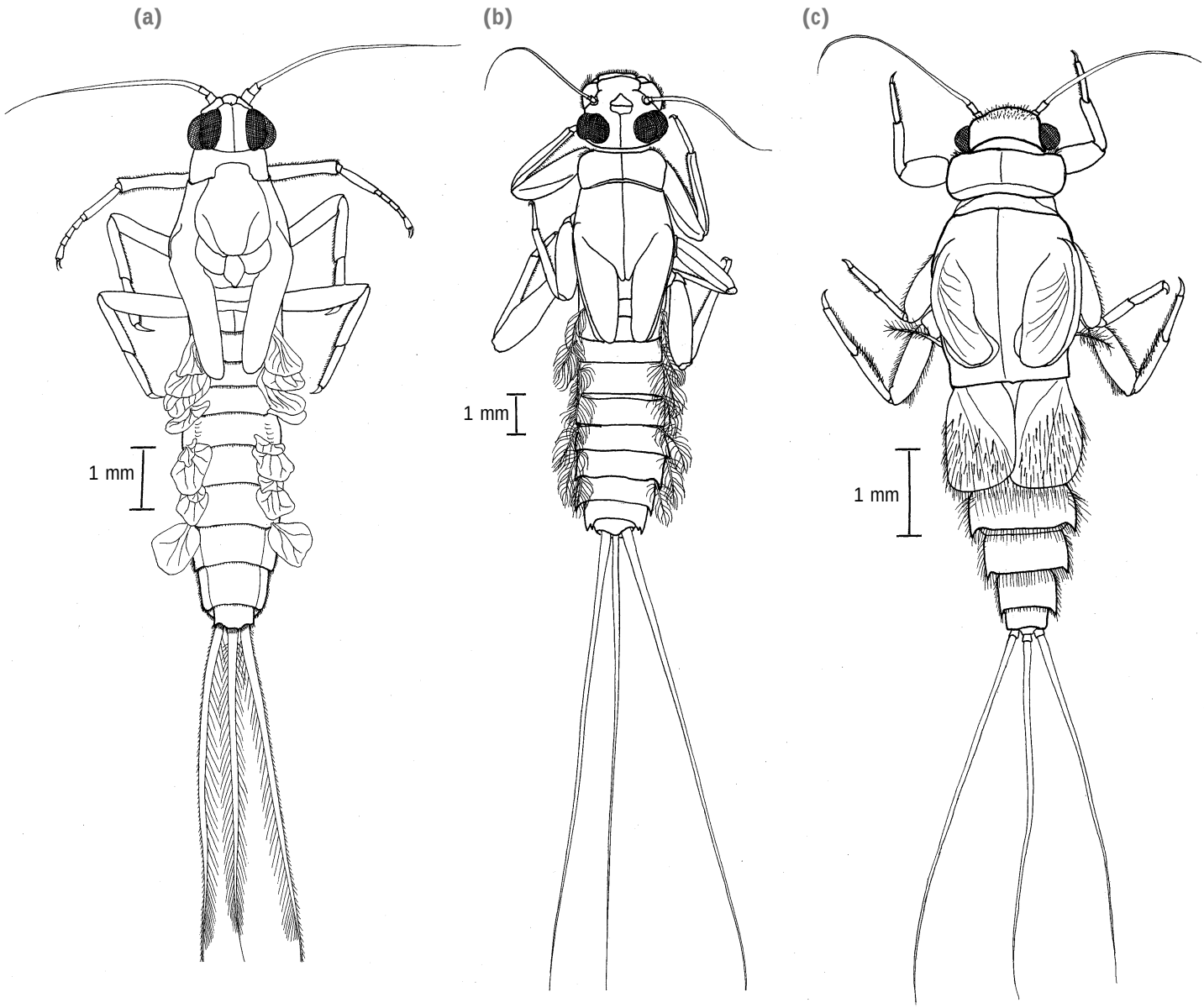
References

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)

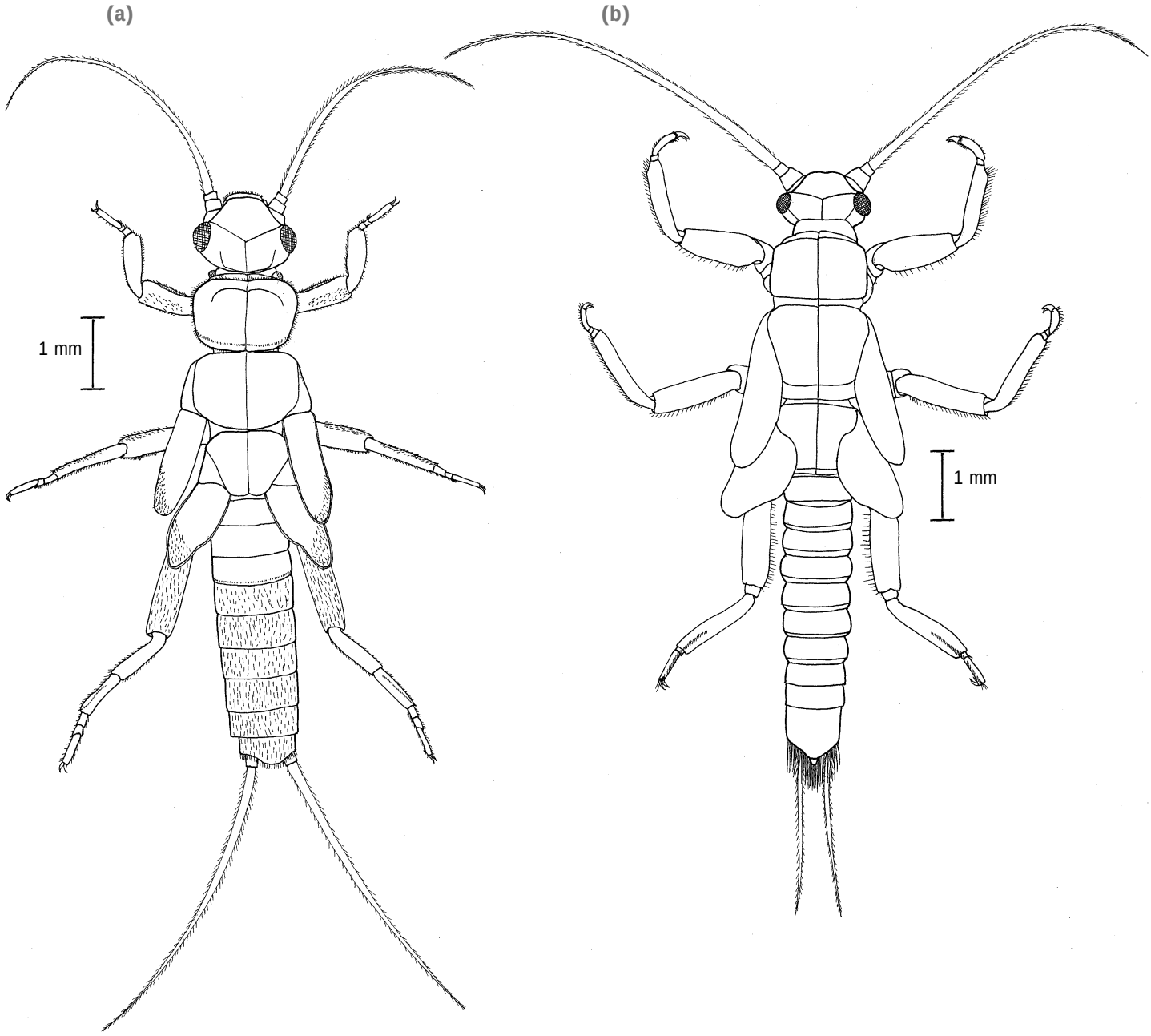
References

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.



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)

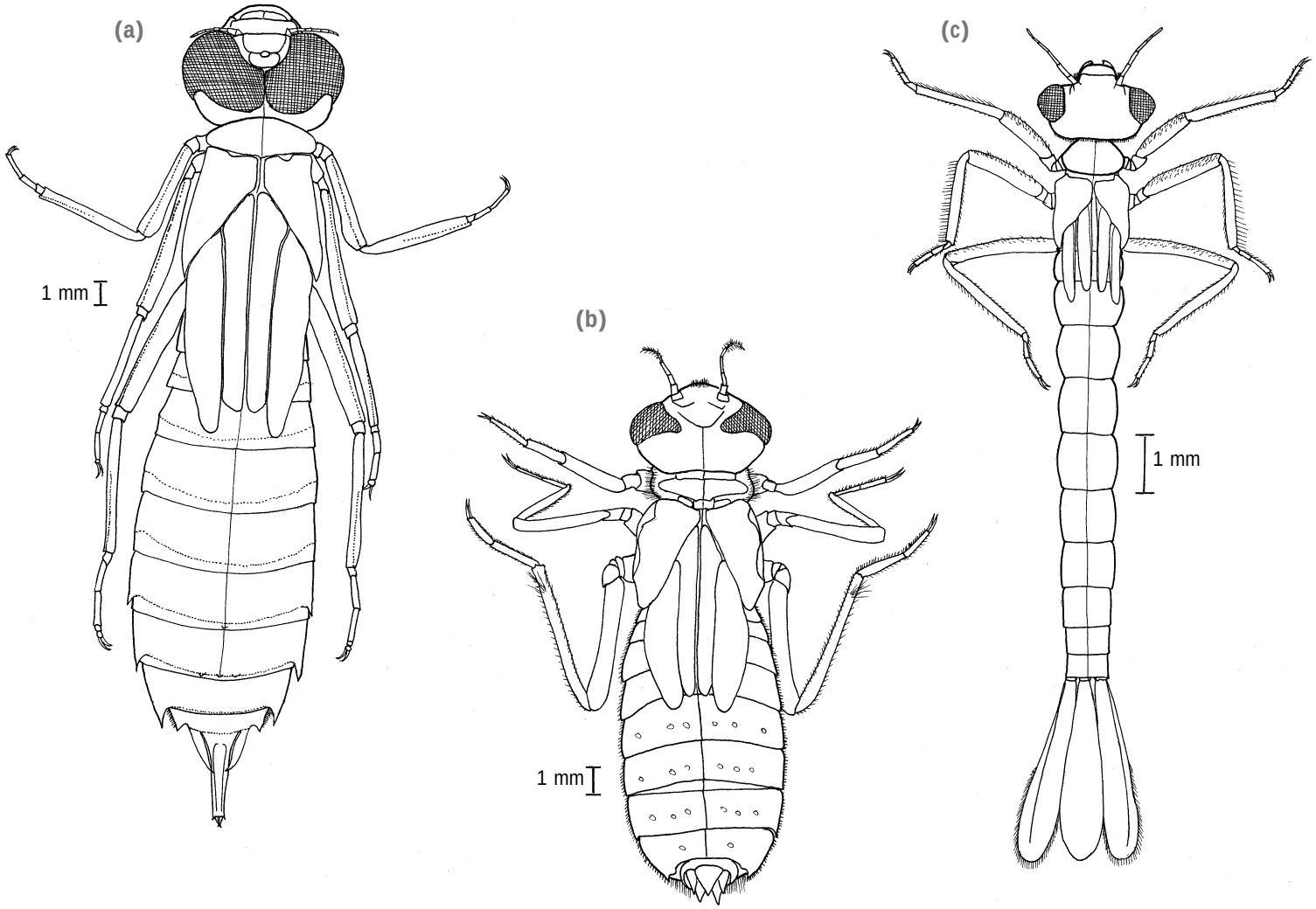
References

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

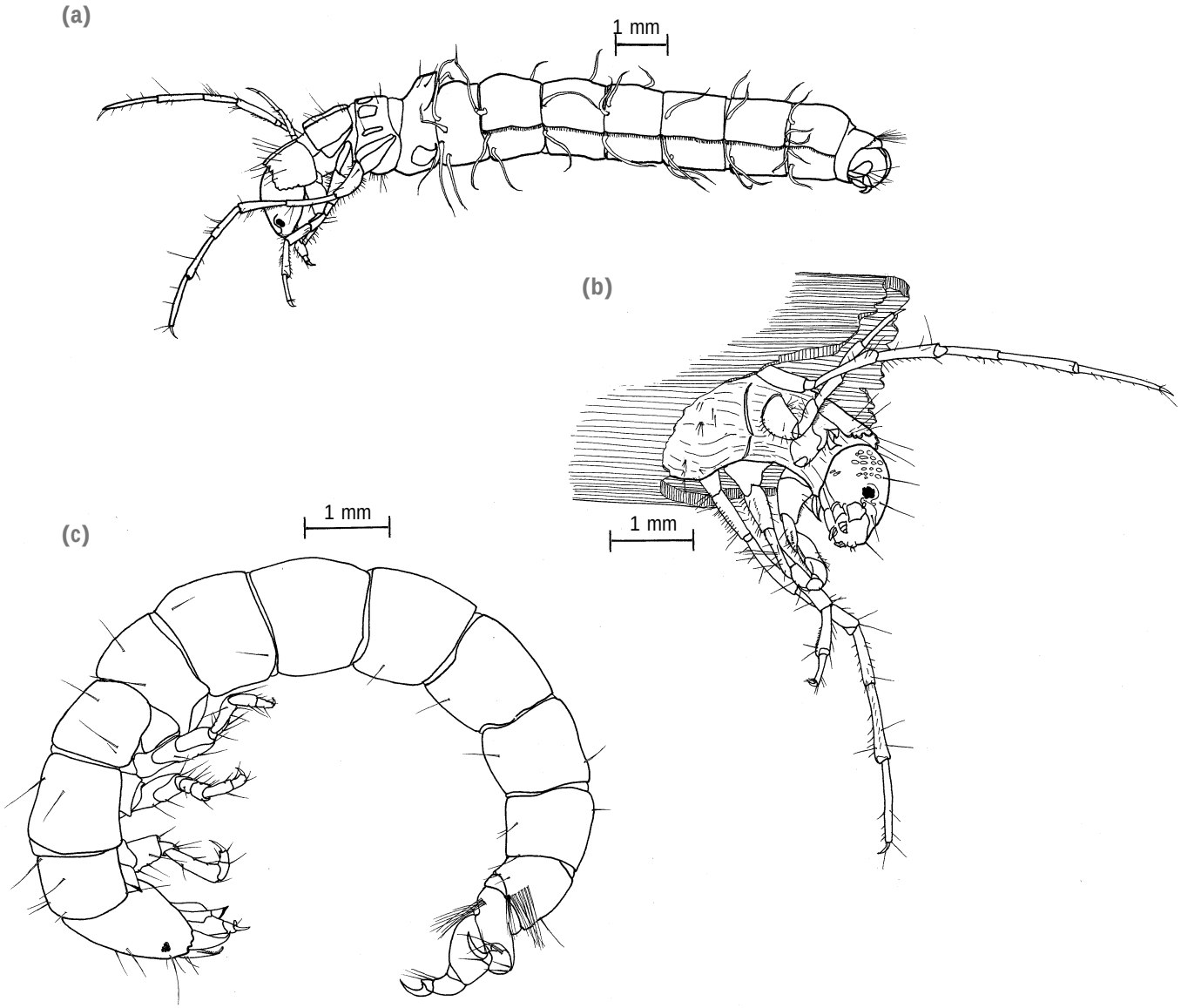
References

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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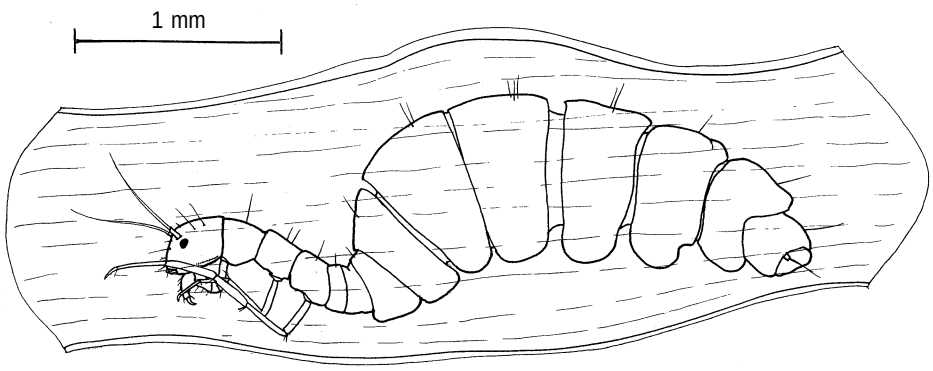

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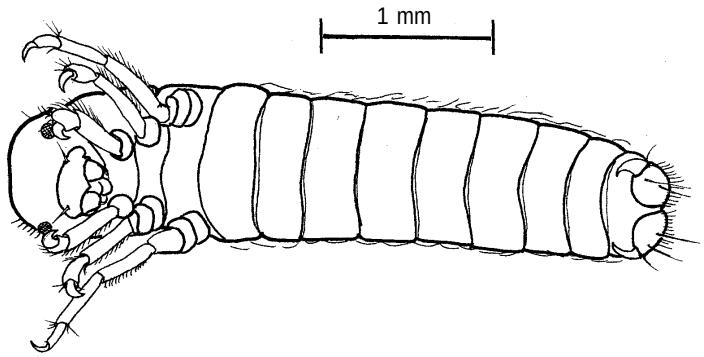

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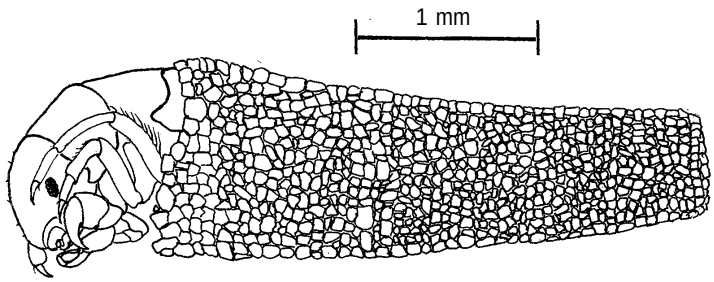


The caddis fly larvae:

(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

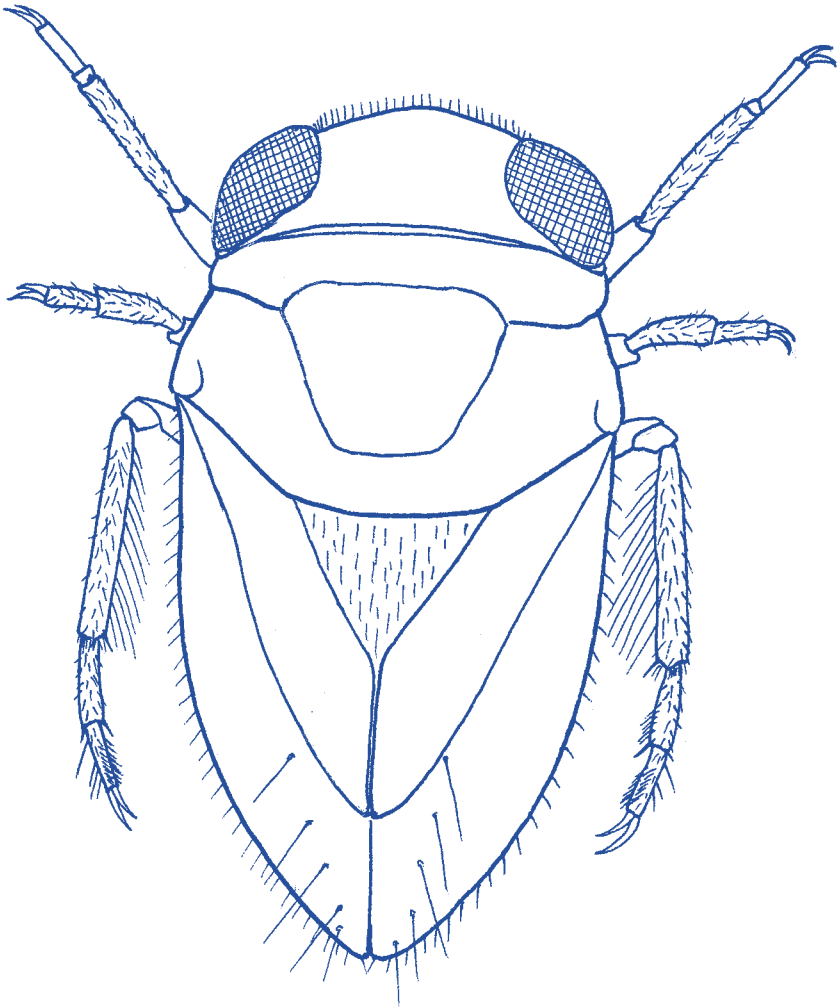
Order Trichoptera (8)

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)

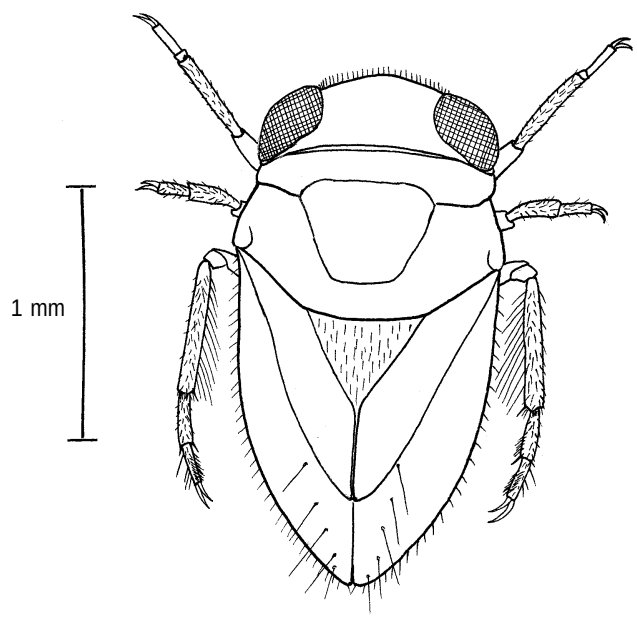
References

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)

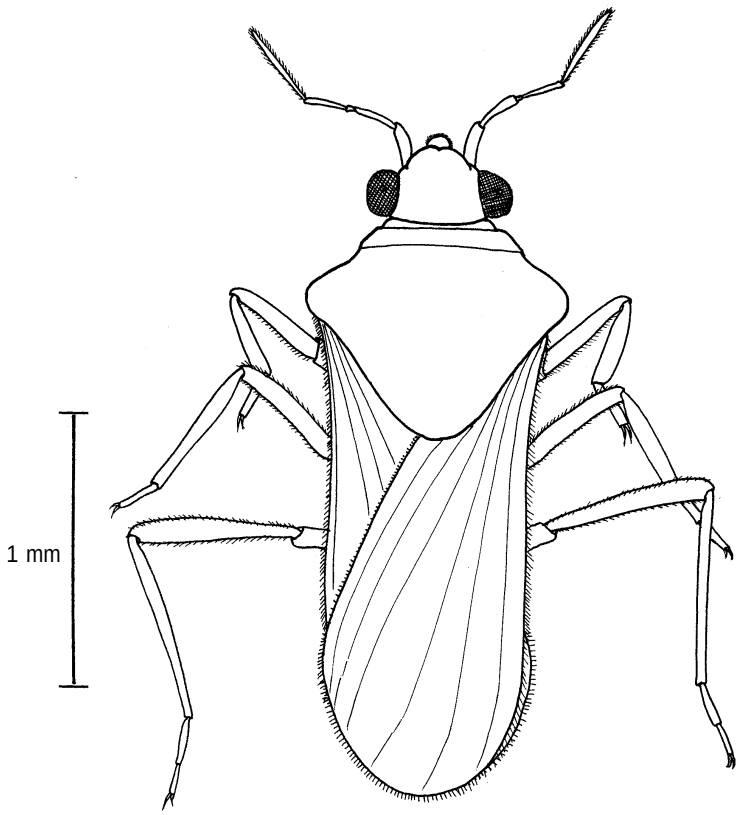
References

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)

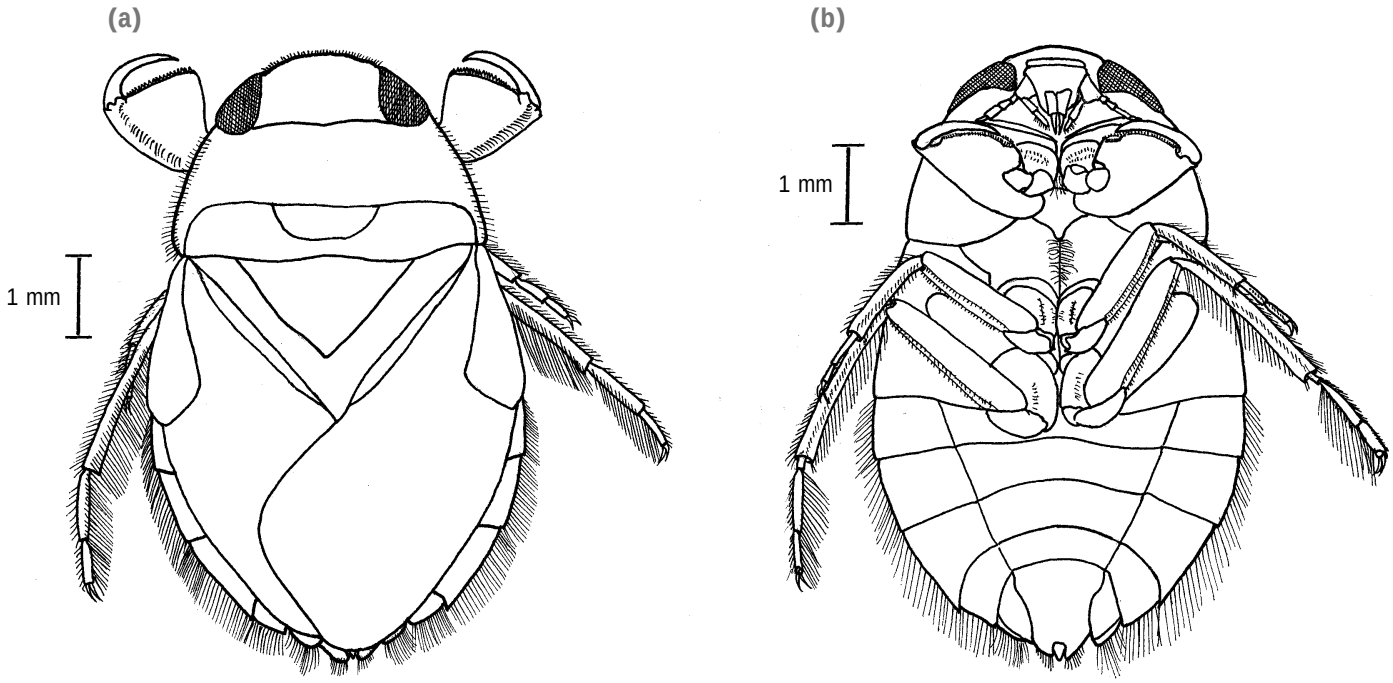
References

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)

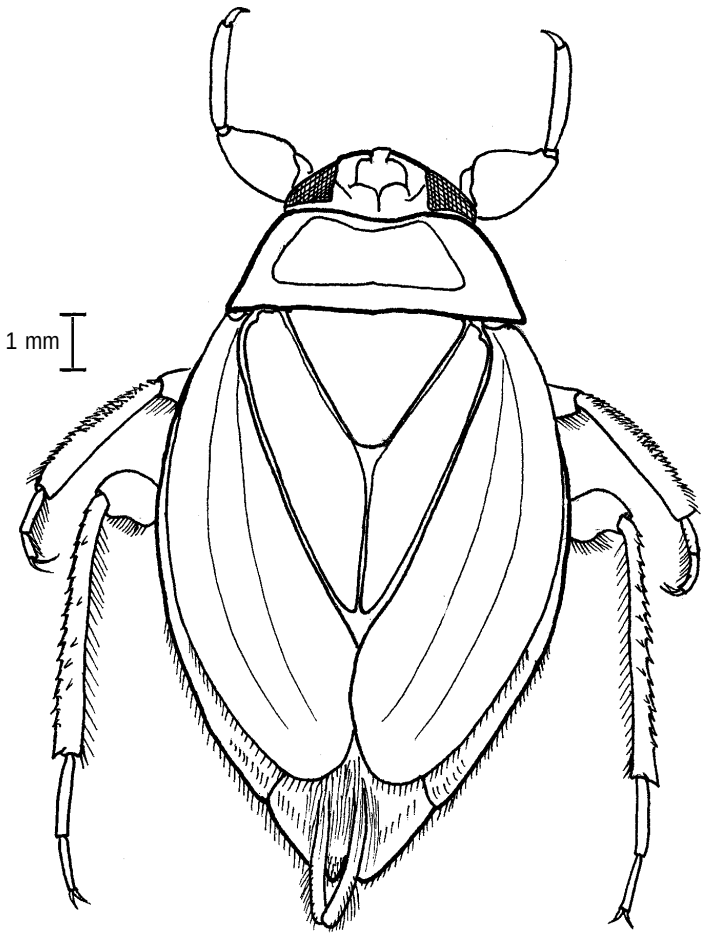
References

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)

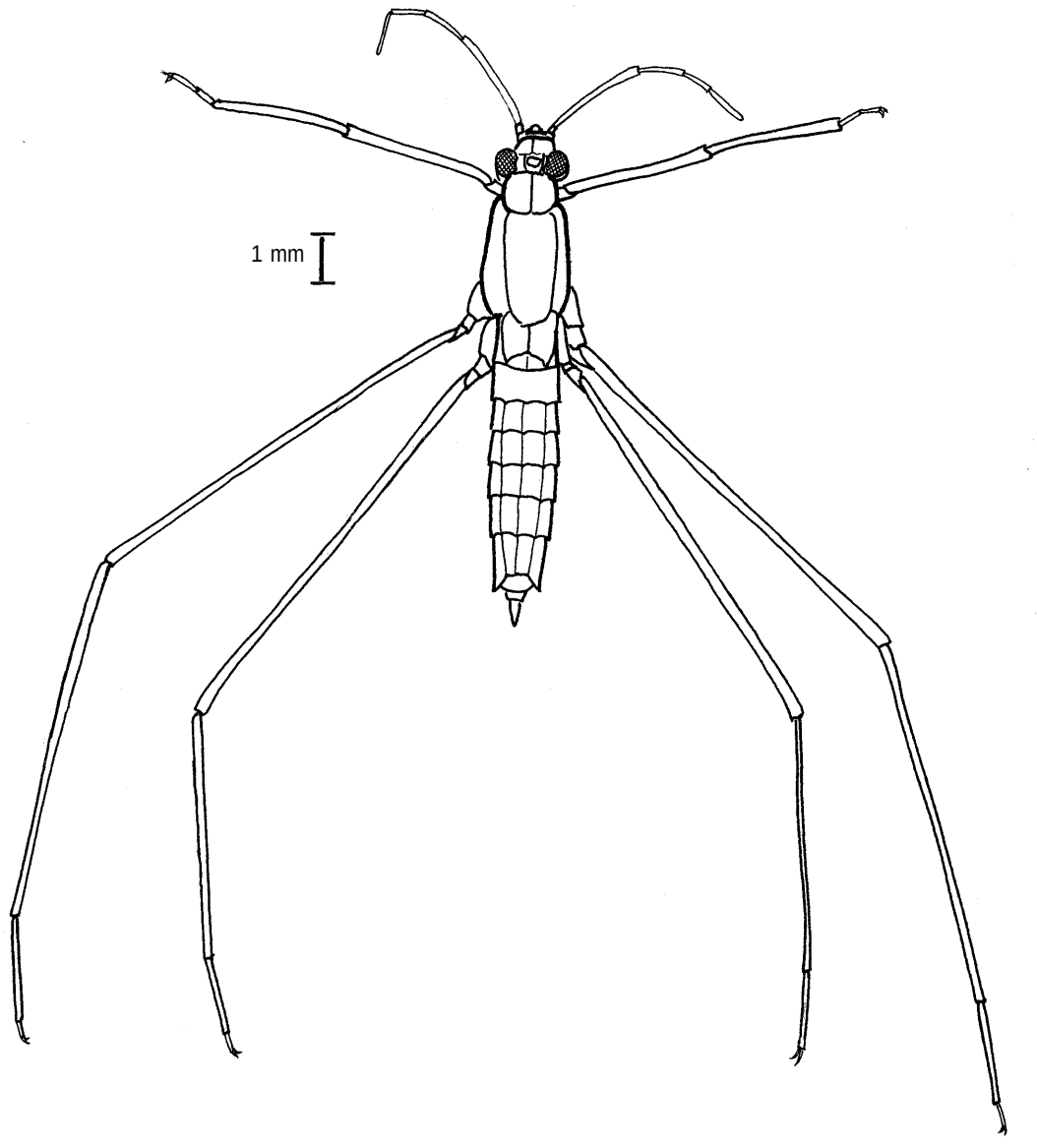
References

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)

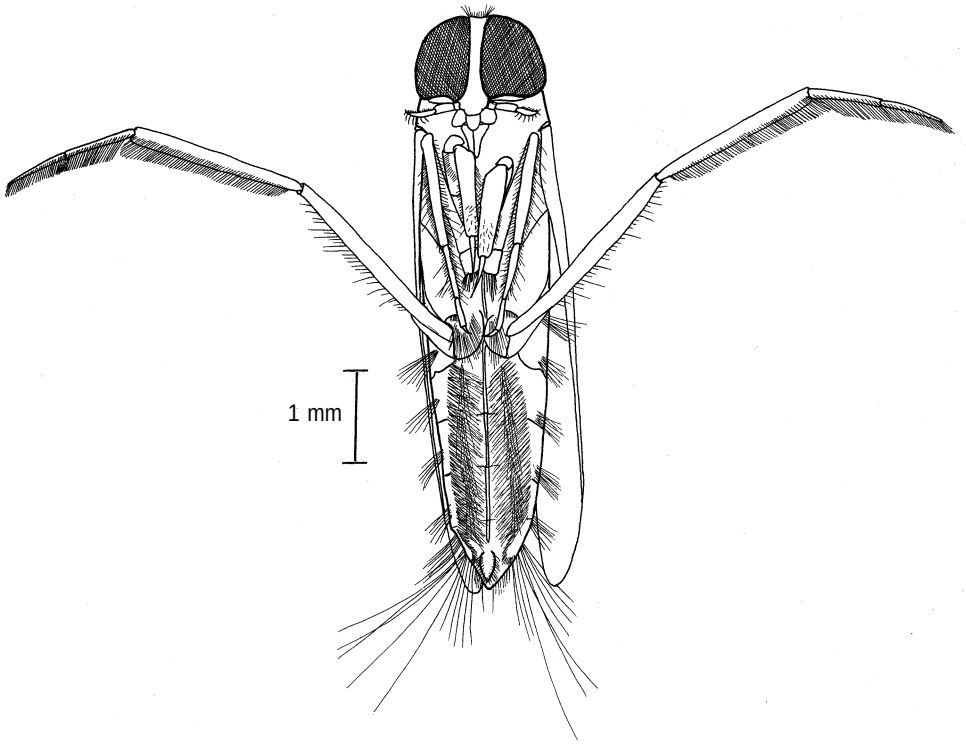
References

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)

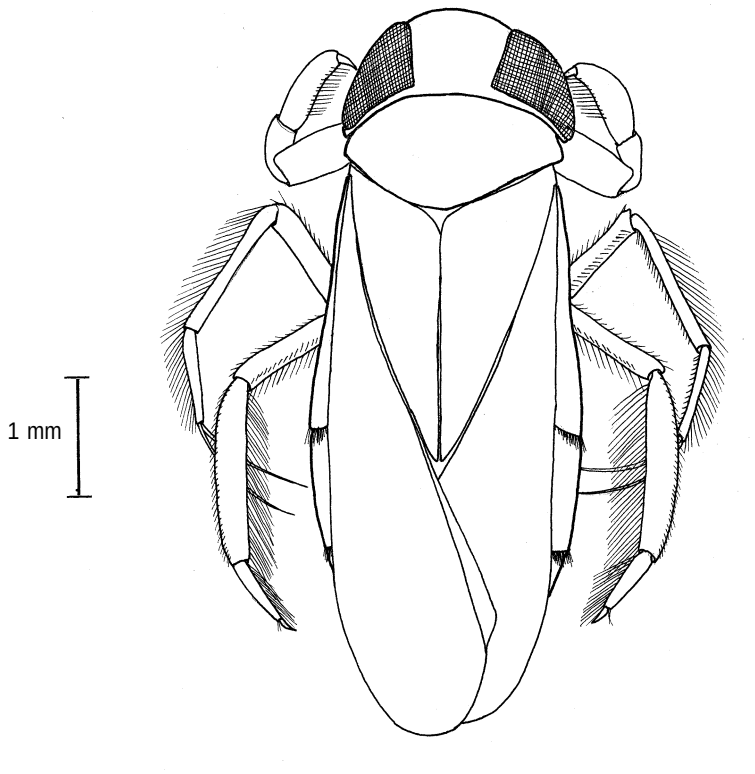
References

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)

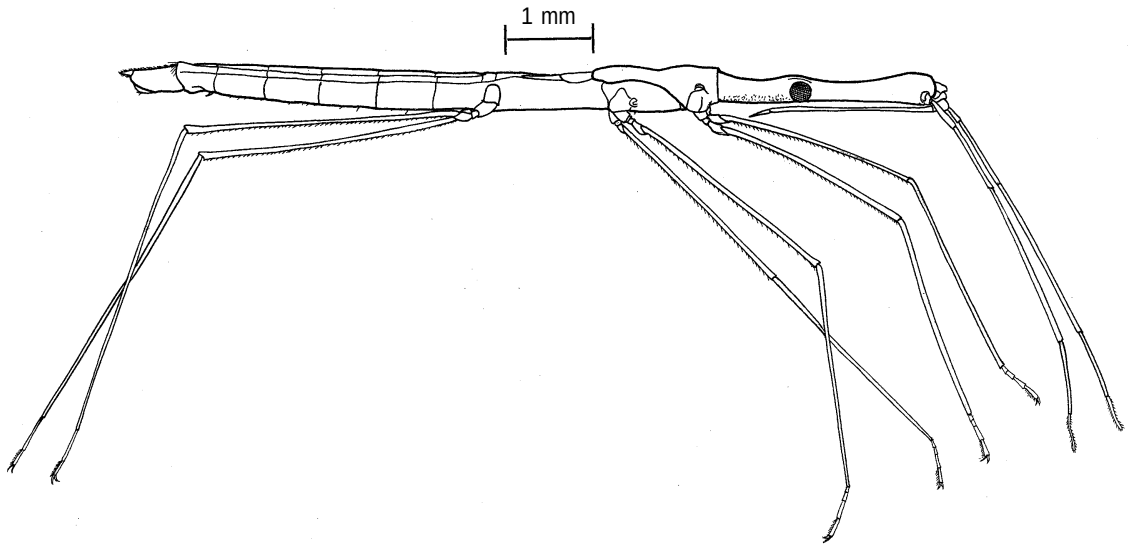
References

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)

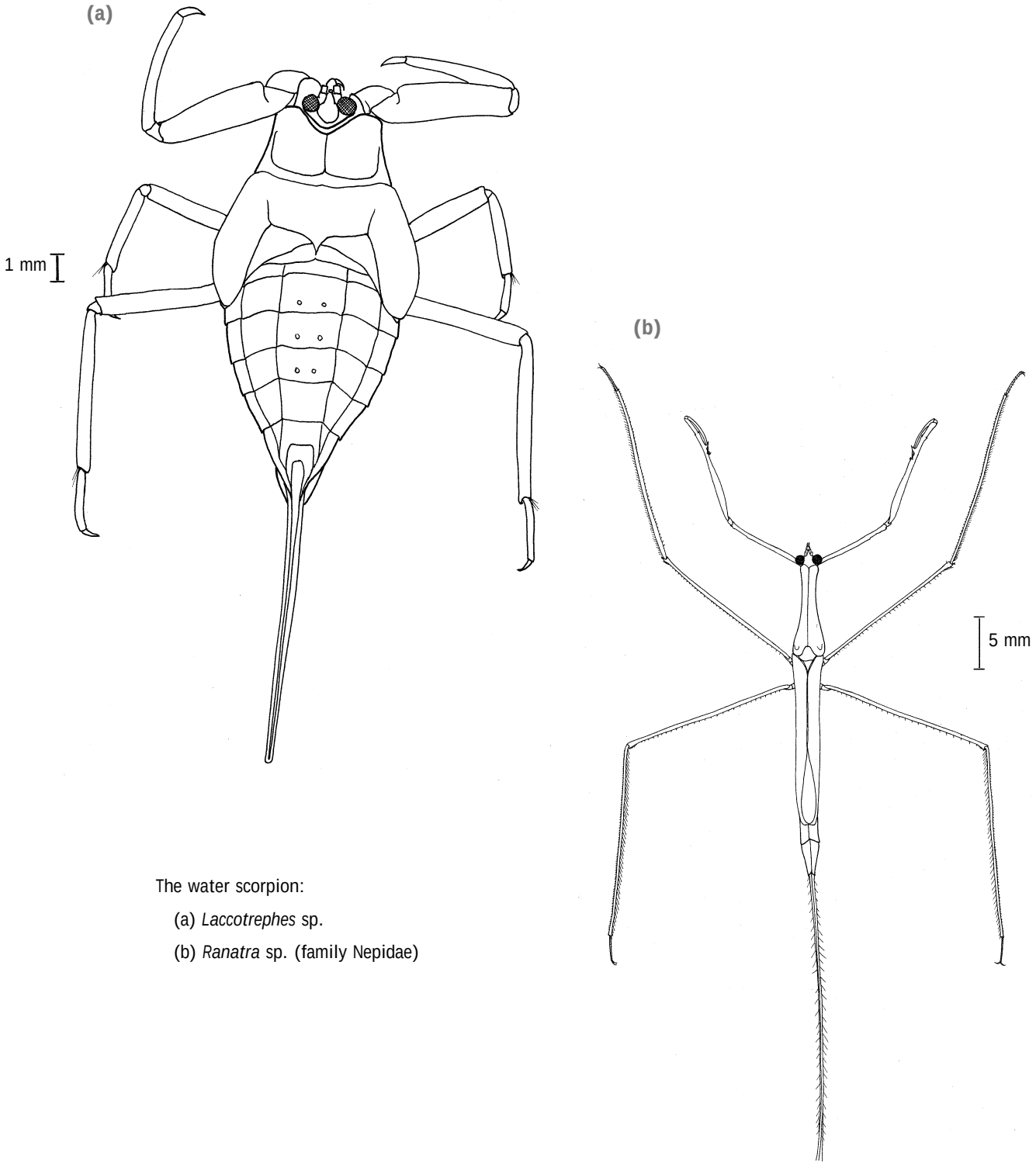
References

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

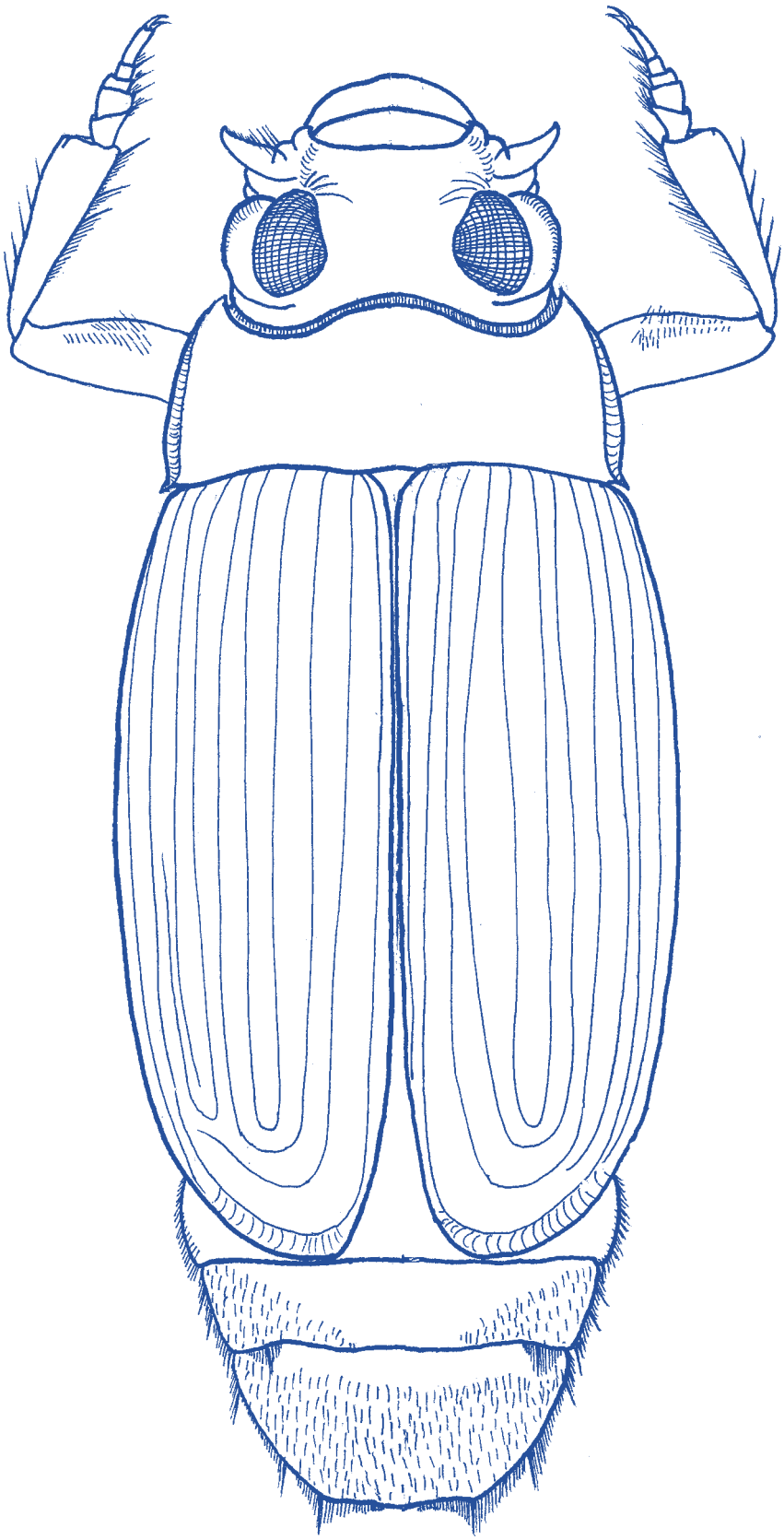
Order Hemiptera (2)

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)

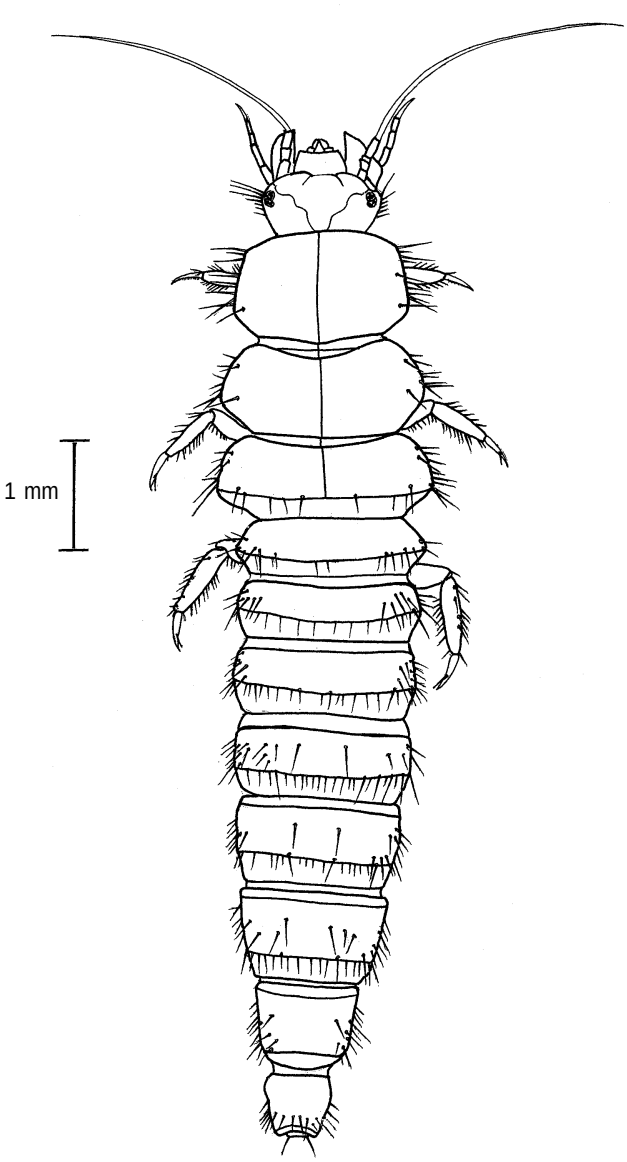
References

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)

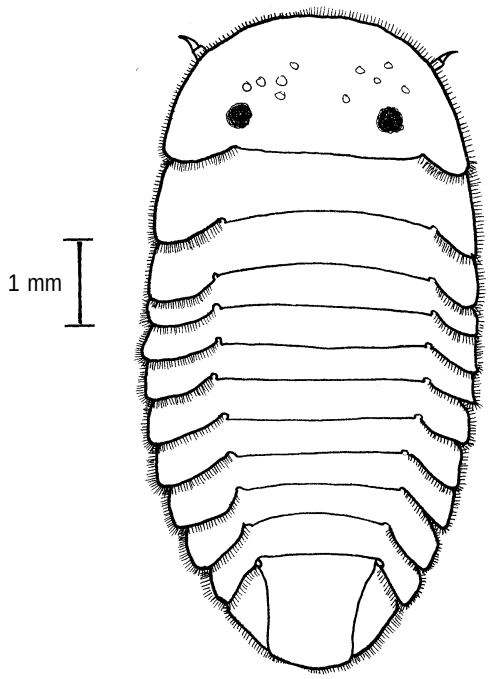
References

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)

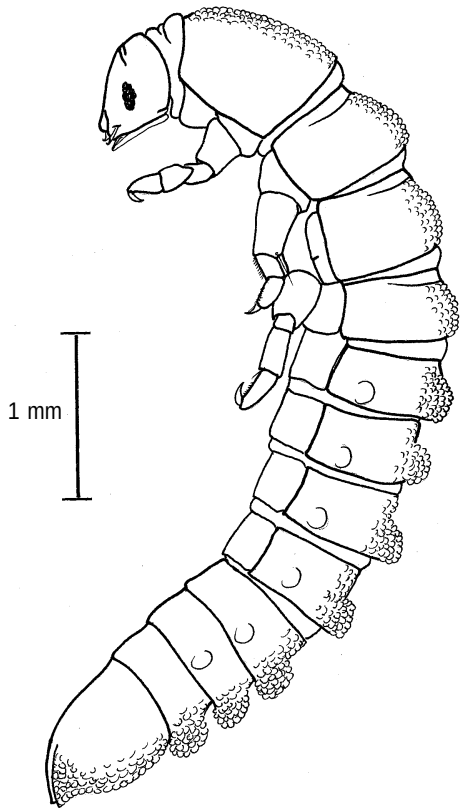
References

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)

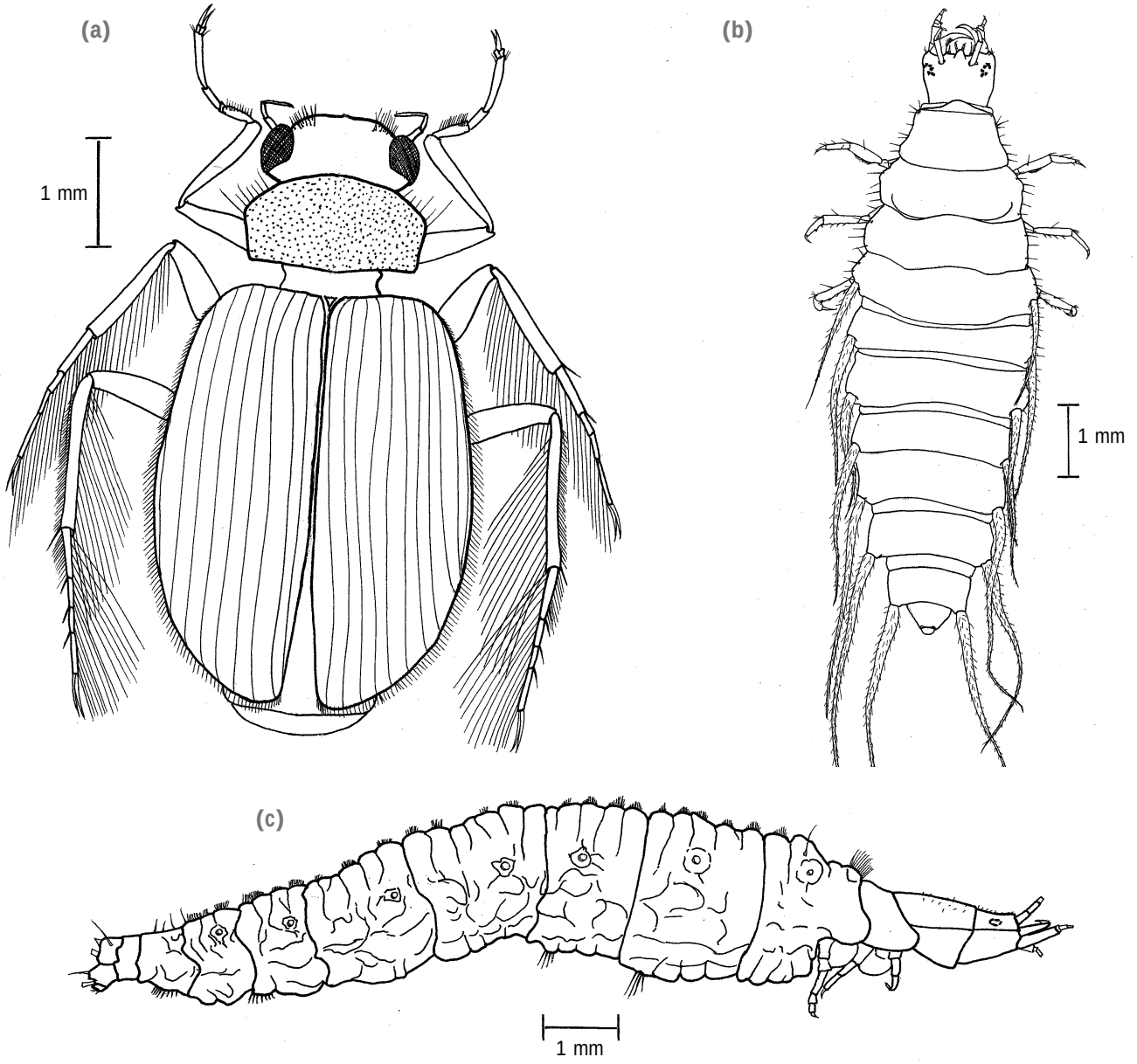
References

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)

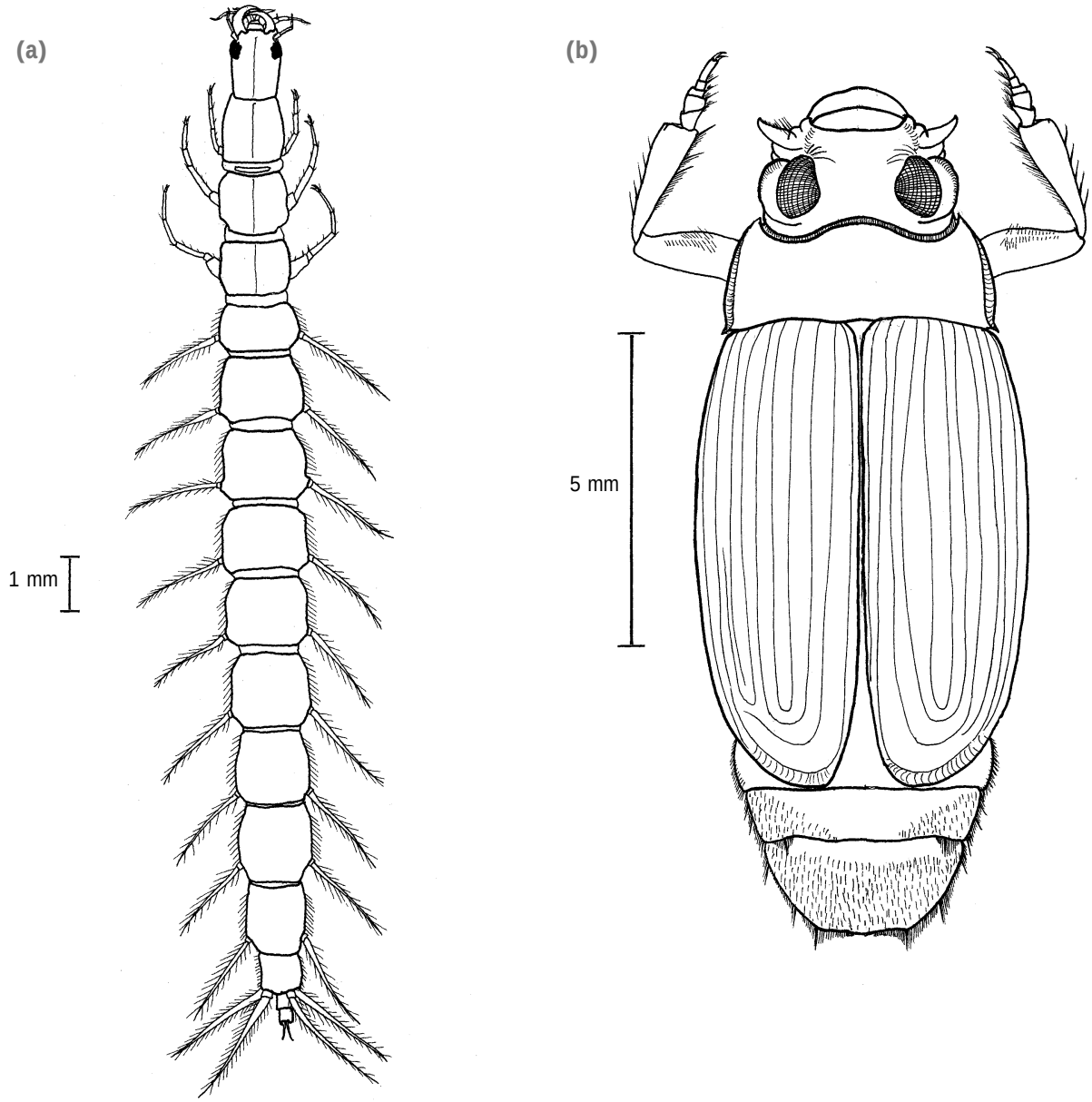
References

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)

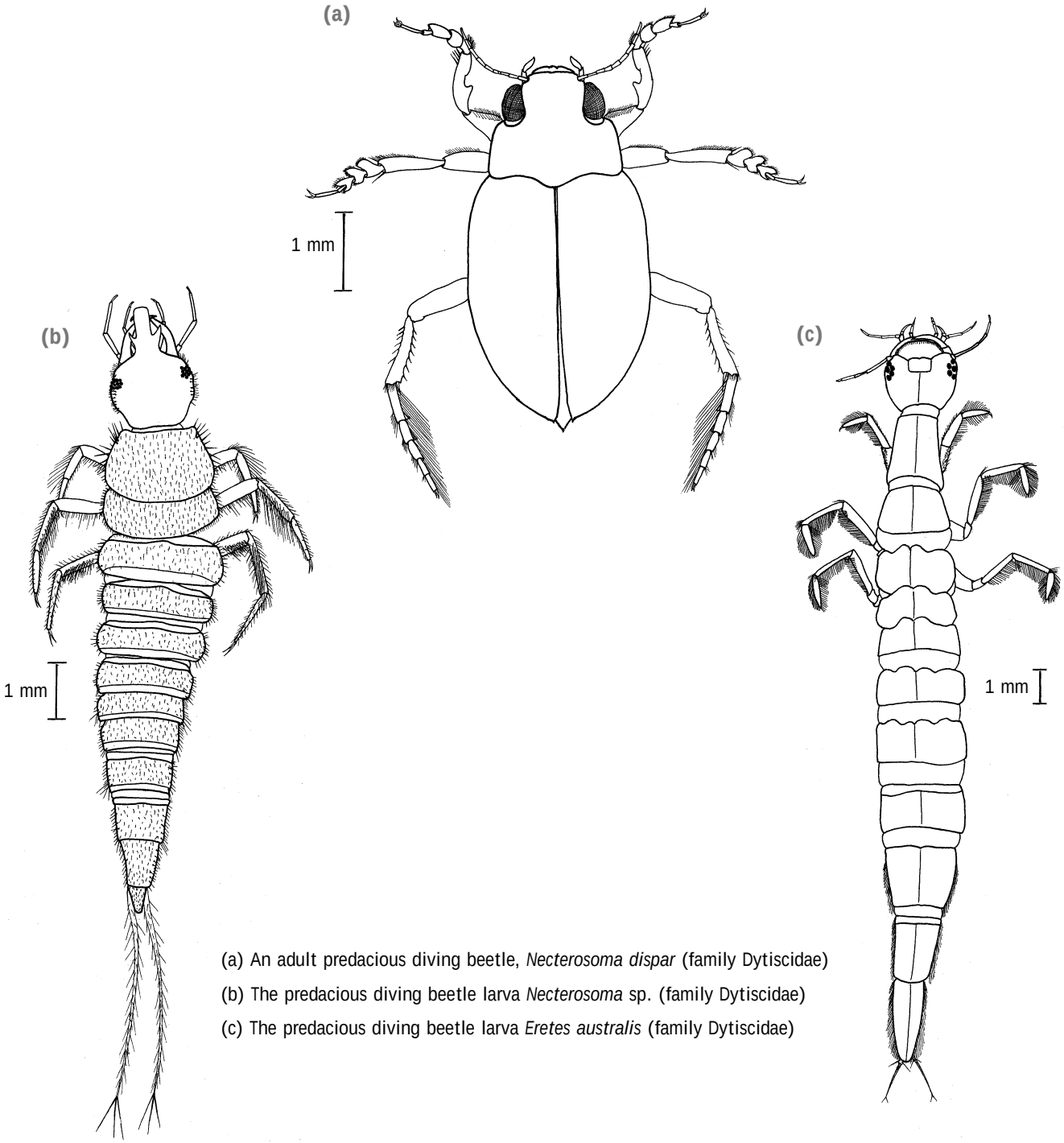
References

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

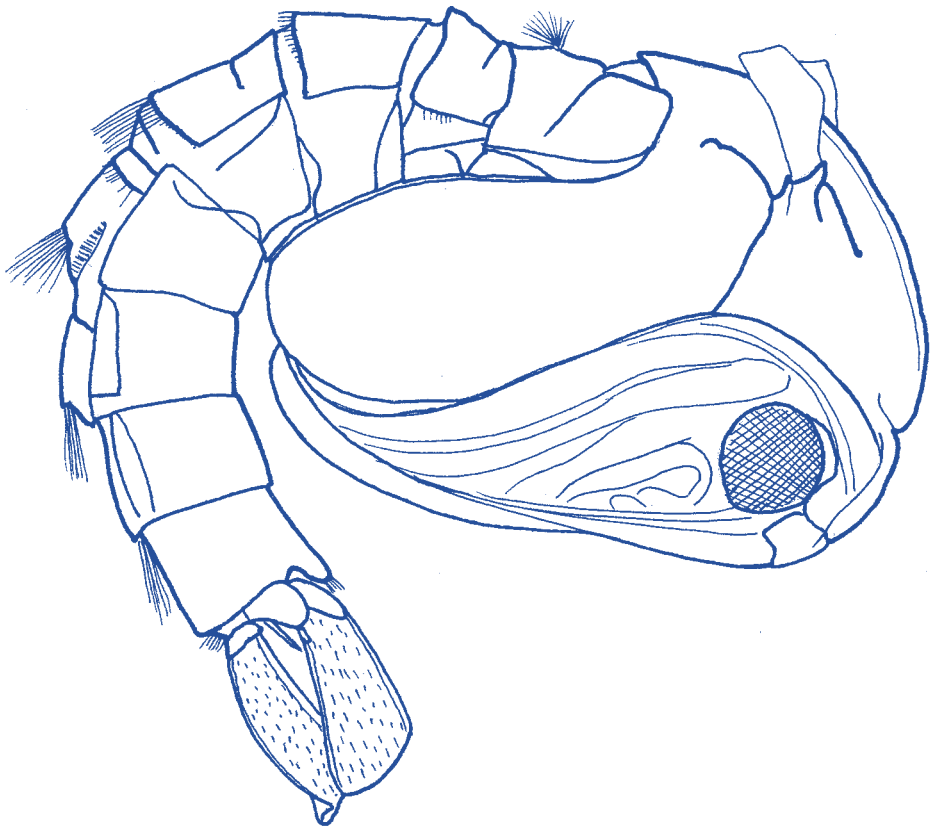
Order Coleoptera (5)

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)

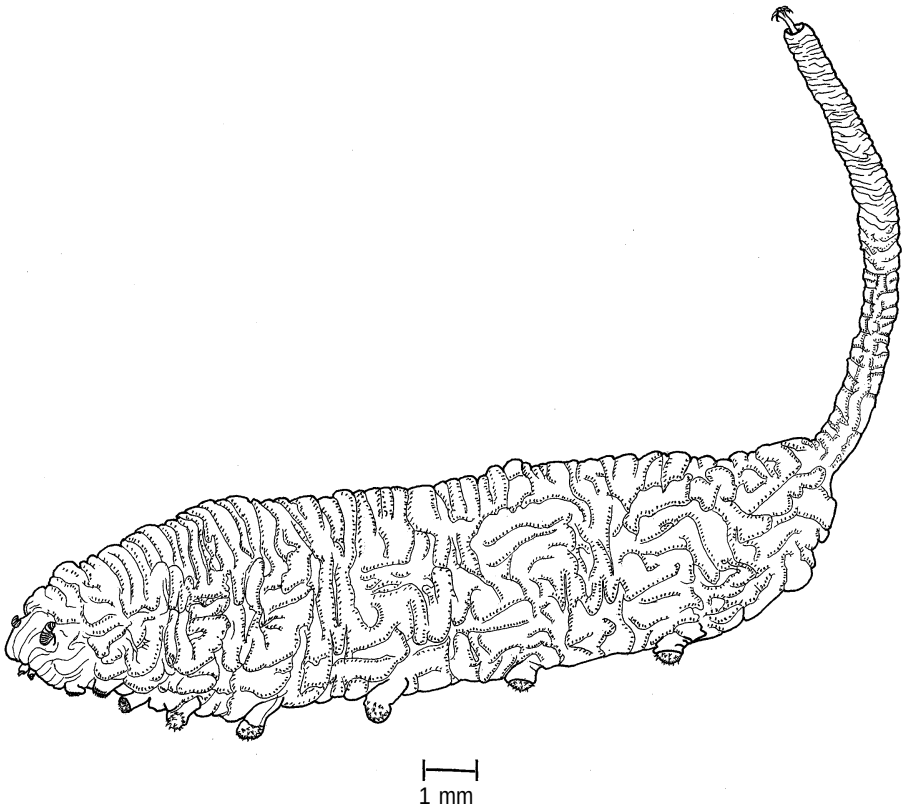
References

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)

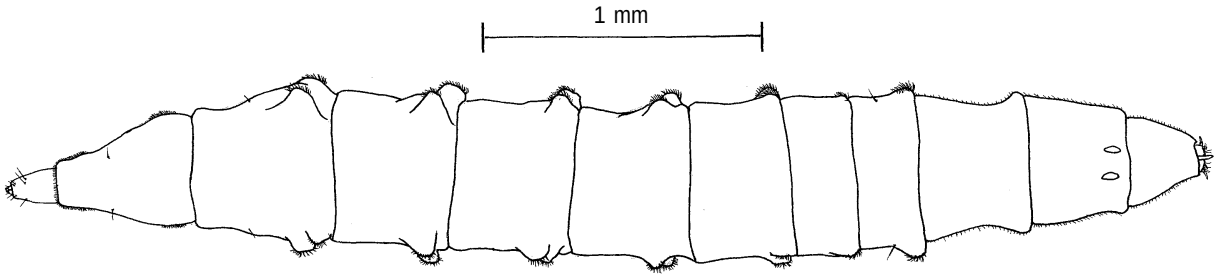
References

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)

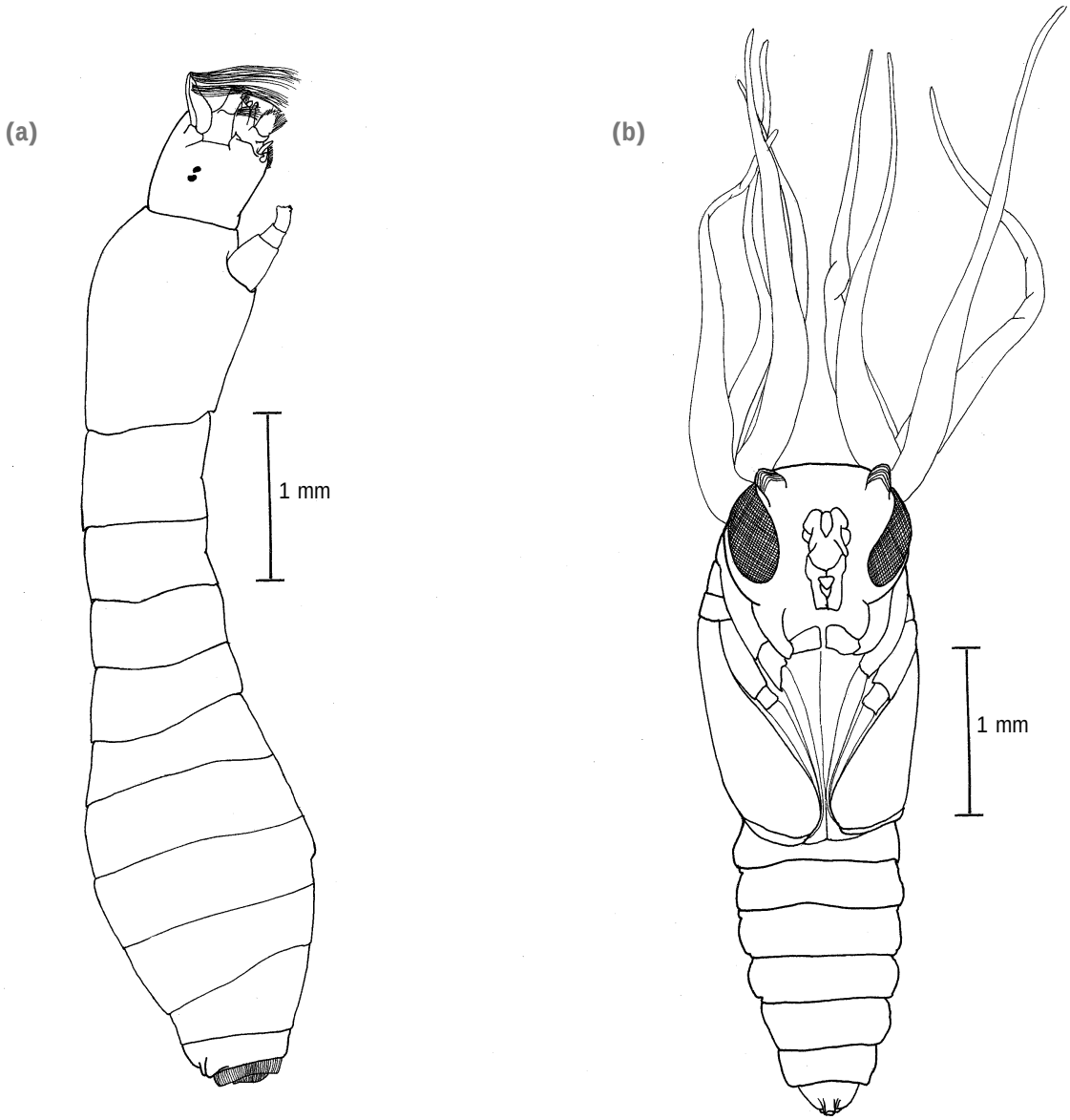
References

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.

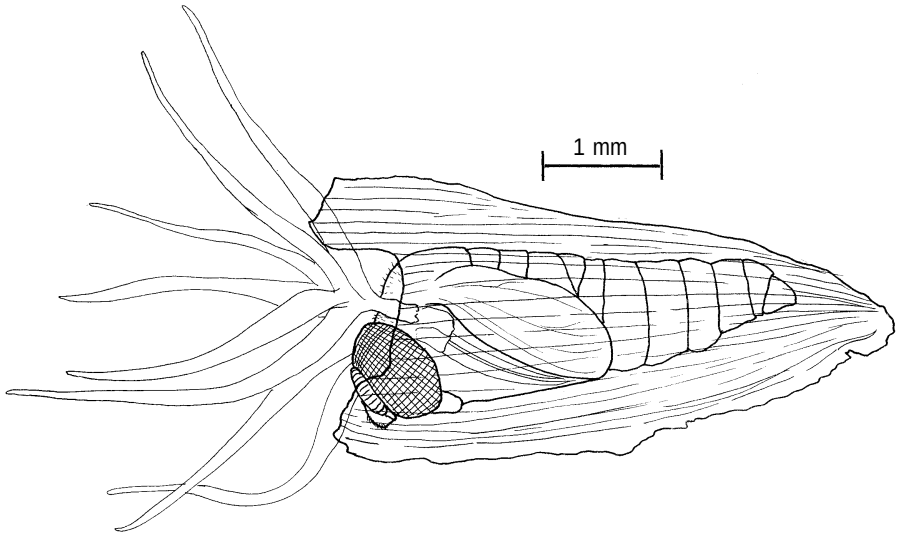


(a) The black fly larva *Simulium* sp.

(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)

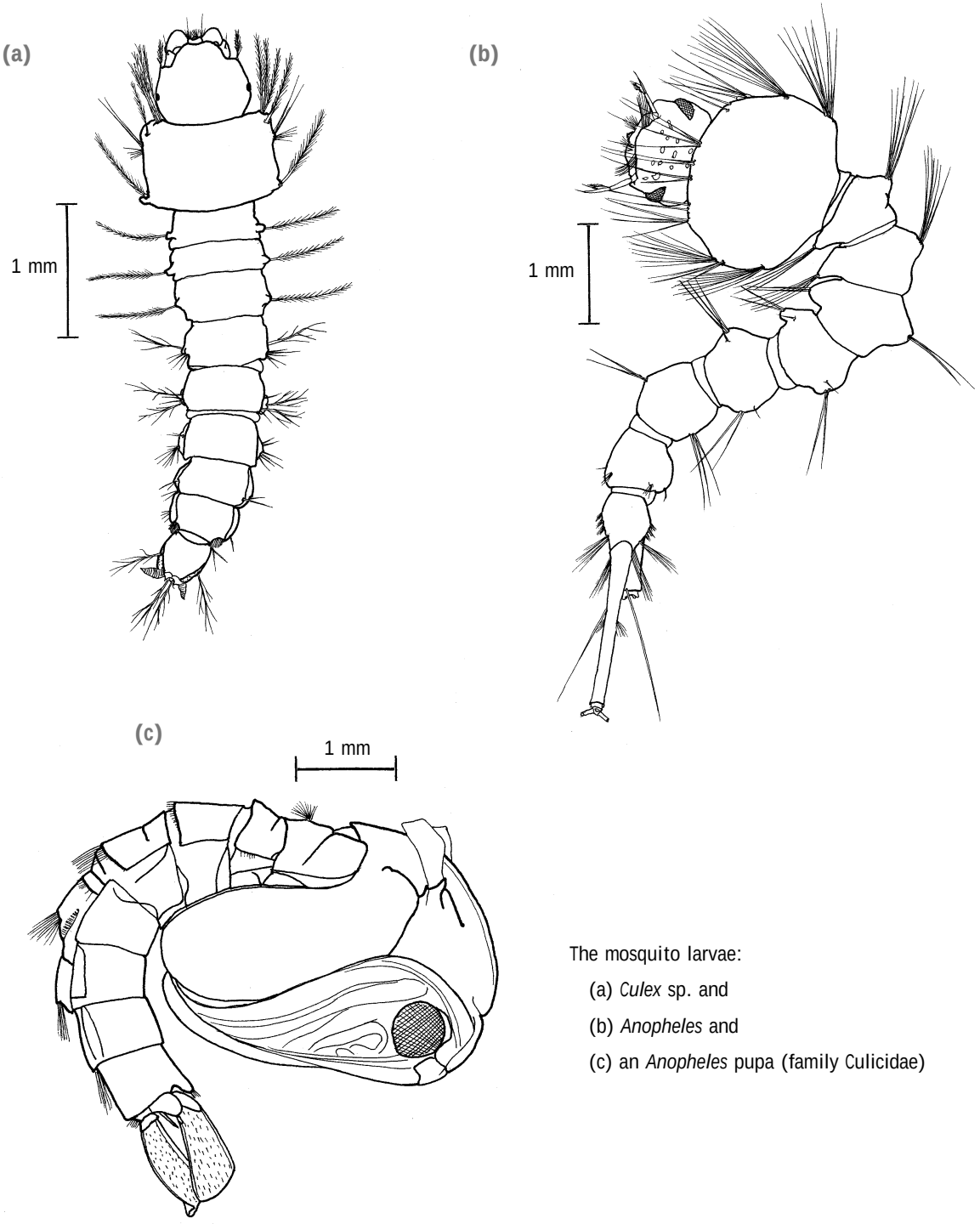
References

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.



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)

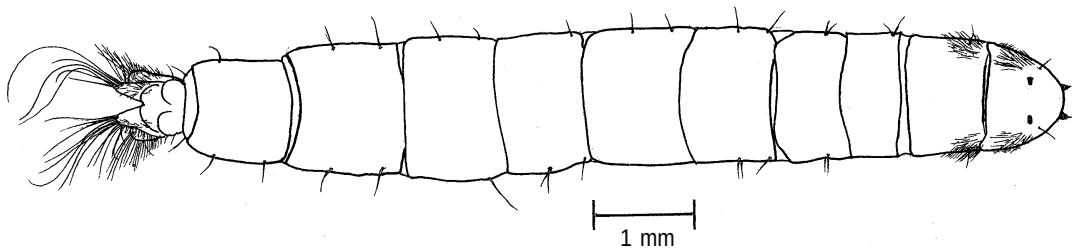
References

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)

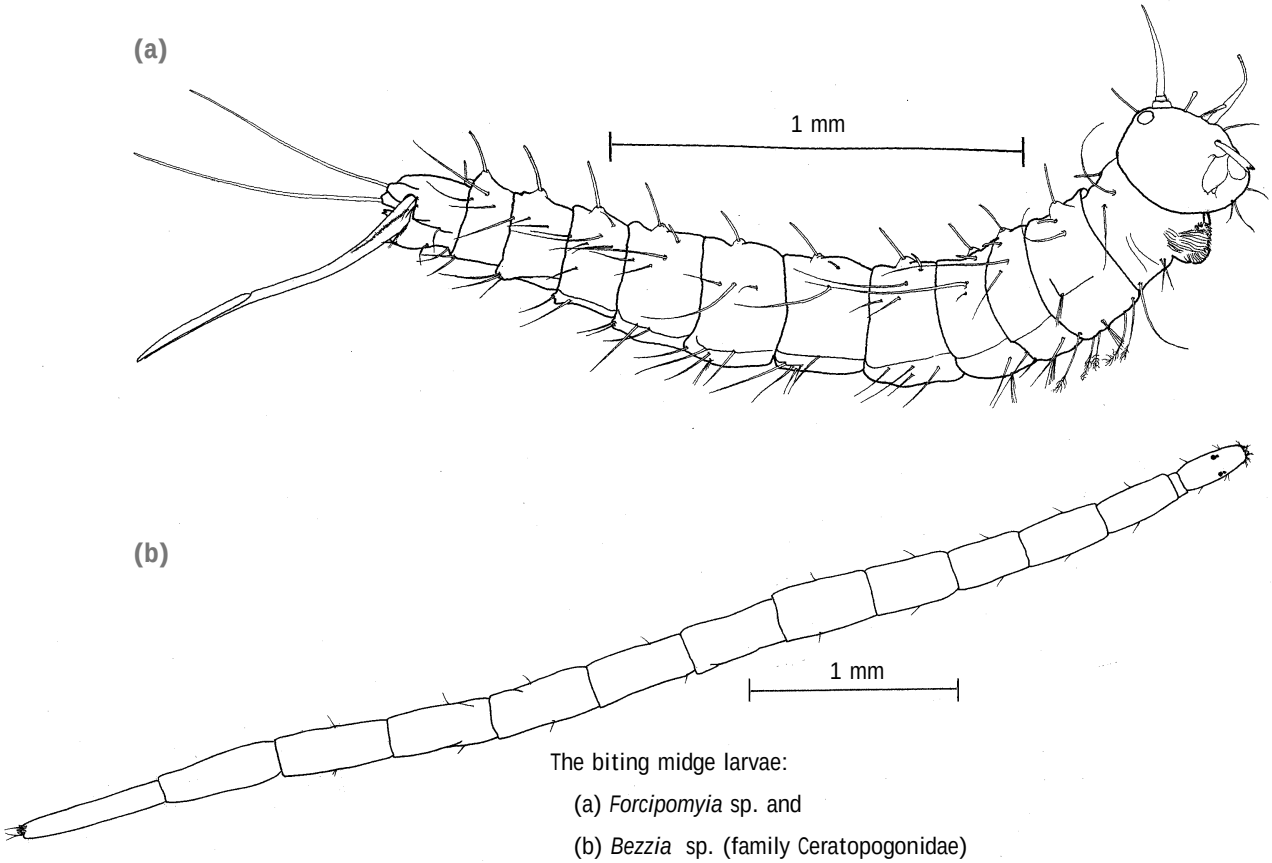
References

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)

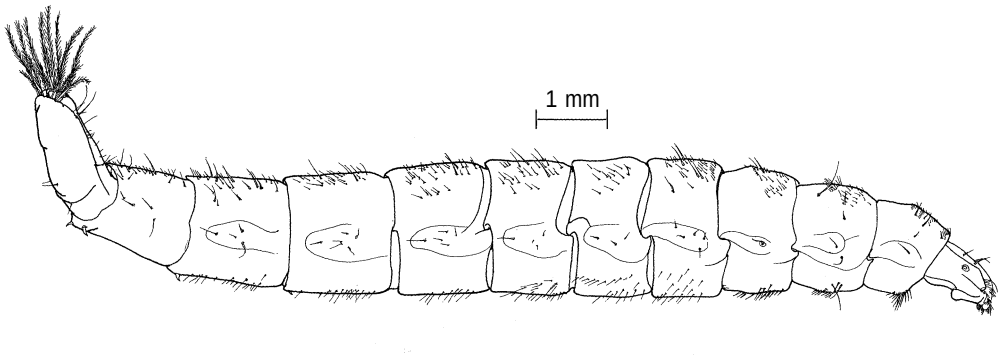
References

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)

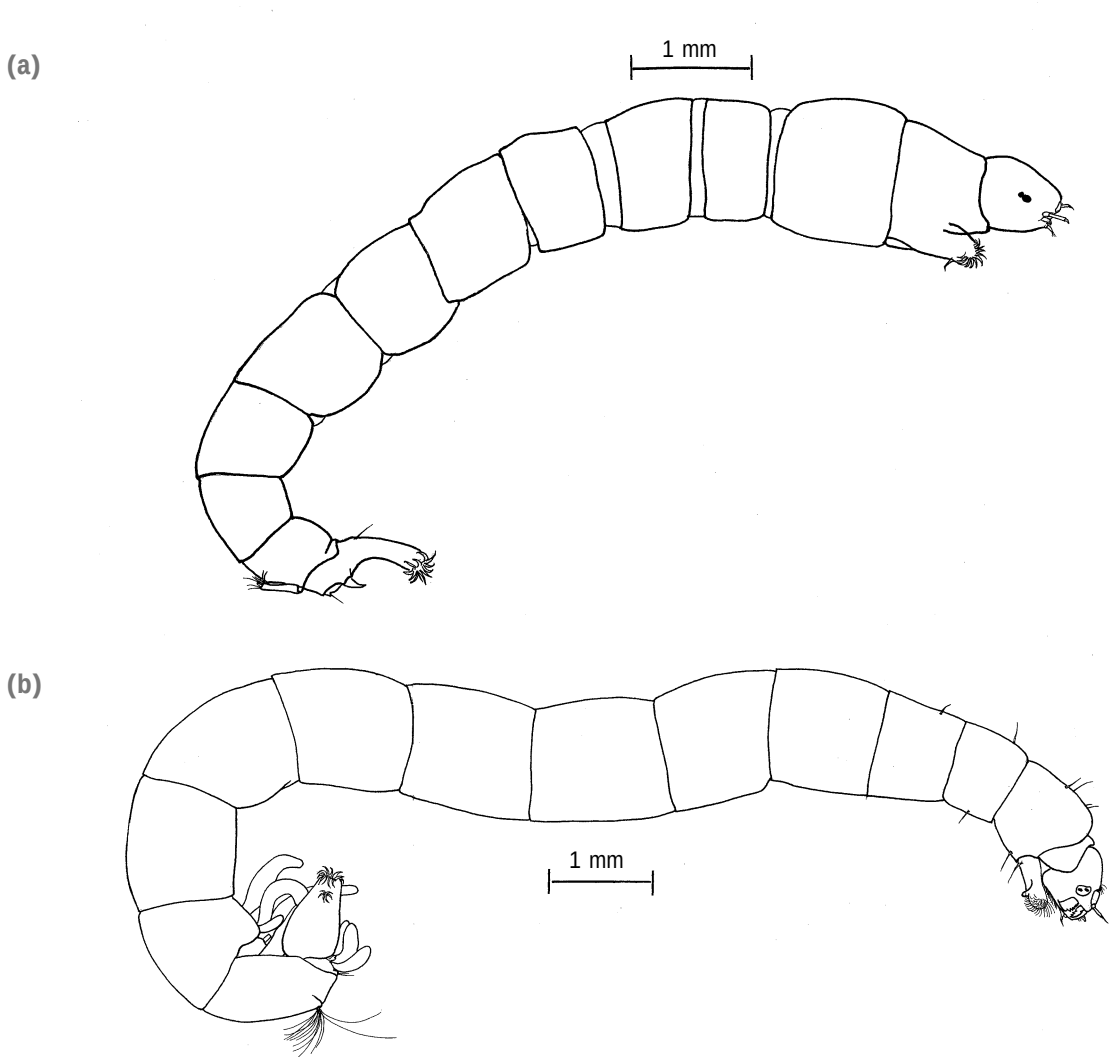
References

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.



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.