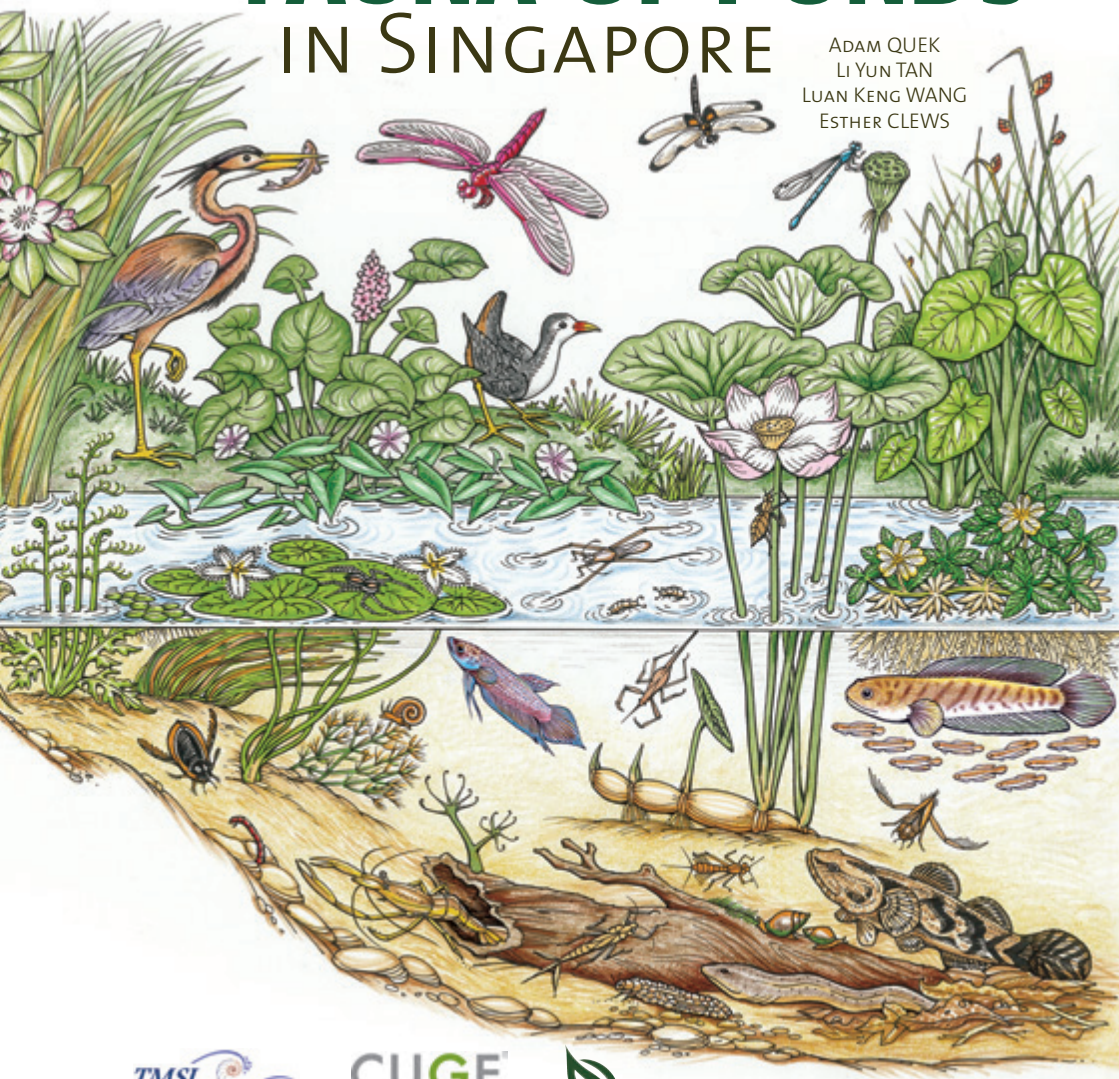
# A Guide to FRESHWATER FAUNA OF PONDS in Singapore

Adam QUEK
Li Yun TAN
Luan Keng WANG
Esther CLEWS



TMSI Tropical Marine Science Institute
National University of Singapore
CUGE Centre for Urban Greenery and Ecology
National Parks

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## PHOTO CREDITS

Macroinvertebrate photographs used in this guide are primarily selected from the EMID, TMSI (Inland Waters) image archive, taken by Stephen Moore (Landcare Research, New Zealand), Ang Yuchen (Department of Biological Sciences, NUS) and Tan Li Yun (EMID). These images are reproduced from specimens collected from ecological projects over the last six years, with permission from Public Utilities Board (PUB) of Singapore, National University of Singapore (NUS) and University of Canterbury (Christchurch, New Zealand).

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# Introduction

A freshwater pond at Labrador Nature Reserve.

Ponds are natural or man-made 'standing' water bodies with relatively slow flow, distinguished from lakes by their smaller size (typically <20,000 $m^2$) and shallow depth (<8 m) allowing for the development of plants across the entire area of the pond. Globally, ponds are numerous, typically outnumbering lakes by 100 to 1 and occurring in virtually all environments, from polar deserts to tropical rainforests. In Singapore, ponds are also numerous. They can be found in public areas such as nature reserves and town parks as well as private areas such as schools, golf courses, and private residences. The popularity of ponds as features within Singapore's green spaces is a demonstration of the value of the recreational, social, aesthetic, and ecological functions they provide in the land-scarce and mostly urbanised environment.

Despite their small size, collectively pond systems are exceptionally richer in biodiversity than other freshwater bodies (e.g. reservoirs, lakes, streams), constituting biodiversity 'hot spots' within a landscape. Ponds can support a diversity of fauna through provision of a range of habitats in a relatively small area. Different levels of inundation through to open water across the land-water interface provides a complex vegetation structure encompassing riparian or 'bank-side' terrestrial vegetation, amphibious plants that cross the terrestrial-aquatic boundaries, aquatic 'littoral' pond-edges typified by emergent plants through to plants floating on open water. Alongside dead wood and leaf litter, this variety of living plant types provides nursery areas, refuges as well as food for aquatic animals. Ponds also act as a source of water and food for birds, reptiles, and mammals. In urban environments, ponds are especially important in supporting biodiversity by providing refuges for fauna and flora outside of nature reserves and other waterbodies.

The pond community is mostly concentrated in the littoral zone; the area that extends from the water-edge that receives the greatest abundance of sunlight that is essential for photosynthesis. The littoral zone is characterised by a thriving rooted plant community dominated by emergent and submerged plants. Living among the vegetation is a cornucopia of animals including insects, crustaceans, molluscs, amphibians, and fish. The pond-bed itself forms another habitat dominated by bottom-feeding fish, and burrowing or surface-dwelling invertebrates, depending on the composition of the bed material which may be sand, silt, leaf-litter, decomposing plant matter, and/or rocks.

In the absence of external disturbances, the diverse biological community maintains nutrient balance within a healthy pond. This is achieved through the communities' capacity to provide biomass (through reproduction and growth) and nutrients (through decomposition), and to remove nutrients (through uptake/mineralisation processes, interspecific competition, and consumption). However, even natural ponds located within protected areas are at risk from threats such as urban pollutant run-off and air pollution. Threats and impacts from potentially invasive species arise semi-naturally through infiltration, but there are also deliberate introductions through release from private aquaria. One of the most serious issues for managed and public ponds in Singapore is the introduction of nutrients through over-application of fertilisers, input of grass cuttings and collected leaf litter, and even from overfeeding of waterfowl and fish (See the *Guidelines on Water Quality Assessment and Management for Tropical Ponds* for more information on the management of pond water quality). The increased input of nutrients can lead to 'algal blooms'—an undesirable proliferation of microalgae in waterbodies that can result in ecological, economic and, in the case of toxin-producing species, health impacts. Under extreme circumstances, the bacterial decomposition of algal biomass can reduce oxygen levels to the extent that aquatic animals die.

It is obvious that major threats to ponds relate to human activity, and stem from an under-appreciation and lack of understanding of these valuable aquatic resources in an increasingly urbanised Singapore. It is hoped that information in this guide piques the interest and imagination of the reader, motivating the start of a long-lasting love affair with the biological communities that inhabit ponds.

A pond with an abundance of algae (indicated by the green-coloured water).

## Alien Species

Alien species are plants, animals, and microorganisms that are exotic, non-indigenous, or introduced with respect to Singapore's freshwater ecosystems. Species can be regarded as 'invasive' when they become widespread or very abundant to the point that they adversely affect aquatic communities through direct or indirect competition with native species. Invasive species can take competitive advantage over native fauna either in the absence of natural predators or because they are able to more effectively exploit food resources.

Most of the alien species are introduced into Singapore via the ornamental (pet and aquarium) and live food trades. One of the most common resident turtle in Singapore's ponds, the Red-eared Slider (*Trachemys scripta elegans*) was introduced in Singapore as early as the 1960s by the aquarium trade. Many of the species have been intentionally released into Singapore's ponds by, for example, pet owners who have lost interest or are unable to continue to care for their pets, people hoping to gain spiritual merit through 'mercy releases' of animals bought from the pet trade, or people aiming to 'improve' the habitat by introducing attractive ornamental species. Others may be unintentional releases, for example the exotic Apple Snail (*Pomacea canaliculata*) was most likely introduced into Singapore together with the exotic aquatic plants acquired through ornamental trade.

Some other examples of introduced pond animals include Koi or Common Carp (*Cyprinus carpio*), and American Bullfrog (*Lithobates catesbeianus*). For further information on alien fish species, see the NParks website for current lists of the status of fish species and Yeo and Chia (2010) for the status of introduced species in Singapore.

A freshwater pond at Sungei Buloh Wetland Reserve supporting a wide variety of aquatic plants and animals.

Among the pond-dwellers, macroinvertebrates and fish are probably the most visible and include the most charismatic species. The name 'macroinvertebrates' comes from '*macro*' meaning 'big' in Greek and '*invertebrate*' which means 'without a backbone', so macroinvertebrates are basically big (0.5–50 mm) spineless creatures! Seemingly similar ponds can be very different in their macroinvertebrate and fish residents. This is because different groups of macroinvertebrates are able to tolerate different ranges and types of environmental conditions. This biological characteristic means that macroinvertebrates and fish are particularly useful in the ecological assessment of ponds, since they live in water for prolonged periods and can only occupy areas that are suitable to their survival. For example, aquatic communities including dragonflies, mayflies and caddisflies are generally indicative of relatively clean water and a more 'healthy' ecosystem.

## Macroinvertebrates

Aquatic macroinvertebrates are found in all but the most extreme and inhospitable freshwater environments. Macroinvertebrates living in ponds consist primarily of shrimps, snails, worms, and insects. Some insects such as beetles and bugs complete their entire life cycle in water whereas others including dragonflies, mayflies, and midges have aquatic larval stages and emerge as winged adults that live in the terrestrial environment around ponds.

In addition to being food resources for fish and birds, macroinvertebrates can influence nutrient cycles, production, decomposition and translocation of materials in pond systems. Burrowers, such as aquatic worms and midge larvae loosen the soil to enable establishment of rooted aquatic plants. Grazers and filter feeders, such as snails, shrimps, and some mayfly nymphs feed on algal films and particulate food matter, keeping the producer population in check and providing cleaning services to the ecosystem. Shredders, such as some caddisfly larvae and snails, reduce large pieces of debris into small pieces that allow them to be recycled more efficiently. Predators, such as dragonfly nymphs, beetles and aquatic bugs, prevent the populations of other macroinvertebrates from expanding beyond the carrying capacity of the ecosystem.

## How to Collect Macroinvertebrates

Aquatic macroinvertebrates are not easily spotted from the banks. Collecting them requires the use of a net with small mesh size (<0.5 mm) to systematically 'sweep' the shallow edges of the pond whilst standing on the bank. Care must be taken to continually move the net forwards or in a figure-of-eight motion so that animals cannot swim out of the net.

Aquatic invertebrates are found in the sediments of the pond bed as well as underneath floating plants, among emergent aquatic plants, and around their roots. Aquatic animals head for shelter when they sense disturbances, so the harder you sweep at the hard-to-reach places, the more likely you will get an assortment of macroinvertebrates. Gentle agitation of the sediments and plants using the net frame will scare the animals out of their hiding places and into the net.

This method of collection can be standardised by the time taken to sweep a fixed area around the edge of the ponds so that invertebrate communities from different ponds can be compared.

The sample collected within the net will contain invertebrates but also some pond debris, sediments and plant material. The next job is to separate out the invertebrates from the debris so we can see what they are. These animals can most easily be seen against a well illuminated, white background.

Please note that permissions and collection permits from the National Biodiversity Centre (NParks) must first be sought and approved before any invertebrates samples are collected in Singapore.

Use of net to 'sweep' the sides of the pond to catch invertebrates.

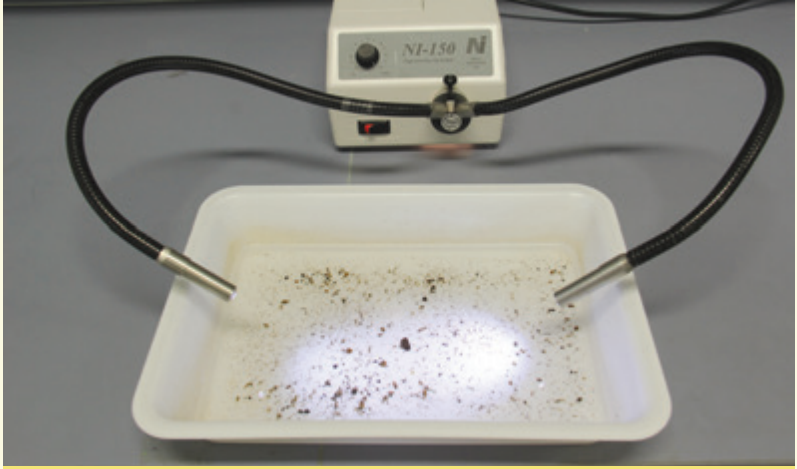
## 'Live' sorting and identification on site

It is possible to distinguish the different orders of invertebrates on site by transferring the sample from the pond net into a white tray. First, take a portion of the debris collected with the net and put it in a white tray. Diluting this 'bug soup' with clear water and gently moving debris away will enable you to see the animals as they move. They can be extracted using spoons, forceps, or sucked up into plastic pipettes then transferred to a separate container of water. These individual specimens can then be viewed under a hand lens or microscope for more detailed identification.

## Identification in the laboratory

To see the features that are used to identify invertebrates to family-level, it is often necessary to use a low-power microscope to magnify the specimen by 4 to 10 times its actual size. For identification of some groups, such as mayflies, it is important to see the shapes of their gills. Live mayflies continually move their gills. Their activity can be slowed down when they are put into carbonated water which effectively puts them to 'sleep' (narcosis). Alternatively, the specimens are preserved for formal identification.

When there are a great number of invertebrates to identify or many samples to compare for ecological assessment, samples can be preserved on collection and identified to family- or species- level in the laboratory. Invertebrates can be killed and temporarily preserved in 70% ethanol. Similar to the process for identification on site, the sample is washed with water and the invertebrates separated from detritus and extracted for identification using a low-power microscope to see features required to separate them into their respective families. These specimens can now be preserved in 90% ethanol for long term storage, as reference material or for further identification to genus- or species- level.




Invertebrates can be separated from plant debris and sediments in a white tray under good illumination, and extracted for further identification.

A dragonfly larva in a petri dish of water ready for identification under a low-power microscope.

## FRESHWATER FISH

Fish are one of the most charismatic groups of animals found in nearly all aquatic environments. They are an important biota within any pond community. Not only are they culturally important, aesthetically pleasing, and provide food or recreation for us, fish are also important in keeping the ecosystem in balance. Occupying different trophic niches, fish can be generally divided into herbivores, omnivores, predators, and detrivores. Herbivores, such as gouramies, are important in maintaining plankton and aquatic plant populations. Predators, such as arowana and fighting fish, and omnivores (generalist/opportunistic feeders) such as cichlids can keep populations of aquatic insects and smaller fish in check. Detrivores are typically burrowing or cryptic fish (such as catfish), that loosen sediments to feed on detritus, releasing nutrients that can be utilisable by aquatic plants. A healthy pond should have a range of types of fish to maintain food webs and cycling of materials, preferably without exotic or invasive species.

## How to Collect Freshwater Fish

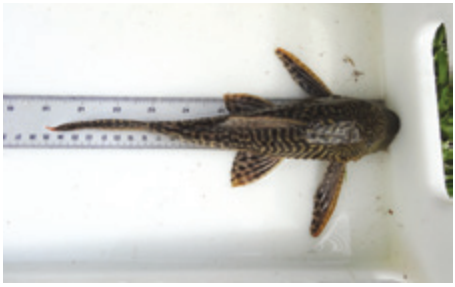
Fish are fast-moving and can move into the deeper water or under shelter when they sense danger. Baits such as small pieces of bread or fish pellets can be used to attract them to the surface. One of the ways to collect fish involves casting a net from the bank into the water, and using a net to 'sweep' fish from the hard-to-reach areas close to the edge of the pond. Cast netting is effective for catching bigger fish swimming close to the surface of water, while sweep net is more effective for capturing smaller and cryptic fishes hiding under shelter. Fish caught in the nets should be carefully removed and transferred to a pail of water for further identification.

*(top left, clockwise)*: As the cast net is thrown, it spreads out and sinks to the bottom of the pond. It is slowly hauled back to the shore. Fish caught are carefully removed from the net and transferred to a pail of water.

Visual surveys can be used to get an idea of the fish species present within ponds. When the visibility permits, fish can be seen when they move, or are encouraged to move to the surface of the water. A torchlight can be shone into the pond to aid identification of fish in deeper water. The collection of fish using nets is a skilled task that takes time to master. For formal ecological assessment and comparison, methods for collection whereby species are identified and counted to give numbers of each species per unit effort. A unit of effort may be a fixed number of cast net throws or sweep net searches standardised by time and area. Quantified sampling (species counts/effort) provides information on the proportions of different fish with in the pond community. Taking measurements of the size of each fish can tell us whether there are young as well as older cohorts of fish in the pond.

As with invertebrates, permissions and collection permits must first be sought and approved before any fish are captured. Fish handlers must also have licences issued by Agri-Food & Veterinary Authority of Singapore (AVA) in accordance to the Animals & Birds Act: Animals and Birds (care of Use of Animals for Scientific Purposes) Rules 2004 and the National Advisory Committee on Laboratory Animal Research (NACLAR) guidelines for working with vertebrates.

*(left)* A sweep net is extended from the pond's edge and swept towards the shore. *(right)* The net is examined for small fish, which are transferred to a pail of water.



The length of each fish can be measured before releasing it back in the water.

**NOTE:** The removal of any organism (plant or animal) is not allowed in public ponds, reservoirs and waterways in Singapore. Permission is required from the National Biodiversity Centre (NParks) before any collection can take place.

## HOW TO USE THIS BOOK

*A Guide to Freshwater Fauna of Ponds in Singapore* is designed to enable the user to readily identify pond-dwelling aquatic invertebrates and fish against an ecological backdrop. This guidebook will cover native as well as non-indigenous macroinvertebrates and fish commonly found in Singapore's ponds.

The successive chapters on aquatic invertebrates and fish are arranged in taxonomic order (Phylum – Class – Order – Family – Species). General information is given for each of the major aquatic invertebrate phyla (Annelida, Mollusca and Arthropoda) and fish classes (Chondrichthyes and Osteichthyes). This includes diagnostic features and general life history of the group. Successively more specific information is provided up to family-level for invertebrates and species-level for fish. High resolution coloured photographs are used to highlight key diagnostic features of these biological groups. Key features required to identify each group are presented with reference to photographs of the animals. Depending on the availability of information, specific details will include common names, habitats utilised by the different groups and their feeding preferences.

This book aims to complement existing field guides to aquatic organisms in Singapore, and hopes to be of interest and use to park managers, community groups, anglers, aquatic pest control agencies, private consultants, as well as students and teachers of aquatic biology, ecology and conservation.

# Macroinvertebrates

## Phylum Annelida / Segmented Worms

Annelids, commonly referred to as segmented worms, consist of three major groups: polychaetes (bristle worms), hirudinea (leeches), and oligochaetes. The oligochaetes are a large group of annelid worms that include the more familiar terrestrial earthworms but also many species of aquatic worms. In freshwater environments such as ponds, the annelids are represented by aquatic oligochaete worms and leeches.

The bodies of annelids are comprised largely of repeated segments. Excretory, locomotory and respiratory organs are generally repeated within each segment. The only parts of the body with different types of segments are those at the head region that bear the mouth and the tail region that bear the anus.

The bodies of *annelids* are made up of repeated segments.

**Phylum Annelida**
Class Clitellata
Order Hirudinea
Leeches

Leeches appear worm-like with no distinct head or tail. They are characterised by a small sucker at its mouth and a large sucker at the end of the body. The large sucker is wider than the width of the body.

Leeches reside at the bottom of the ponds or attached to rocks and aquatic plants. They are predators of small aquatic organisms, such as midge larvae, aquatic worms, zooplankton, and snails. Some leeches are parasites, sucking the blood of fish for food. Leeches are able to swim freely in ponds but they can also use their suckers to attach themselves to the surface and move forward by elongating and shortening their body.

Leeches have a small sucker at the mouth opening and a much larger sucker at the end of the body.

## Phylum Annelida

### Class Clitellata

### Subclass Oligochaeta

Oligochaetes appear worm-like, with no distinct head or tail. They have distinct body segments that are uniform in size. They can be brown, pink or red in colour, and can range from 0.5–100 mm long.

Oligochaetes reside at the bottom of the pond, where they burrow into the debris or cover themselves in tubes made from silt or mud. They feed on pond debris around them, ingesting large amounts of the substratum, feeding on organic material (living or dead plant, animal and bacterial matter) in silt and mud.

*Oligochaetes* are worm-like in appearance with no distinct head or tail.

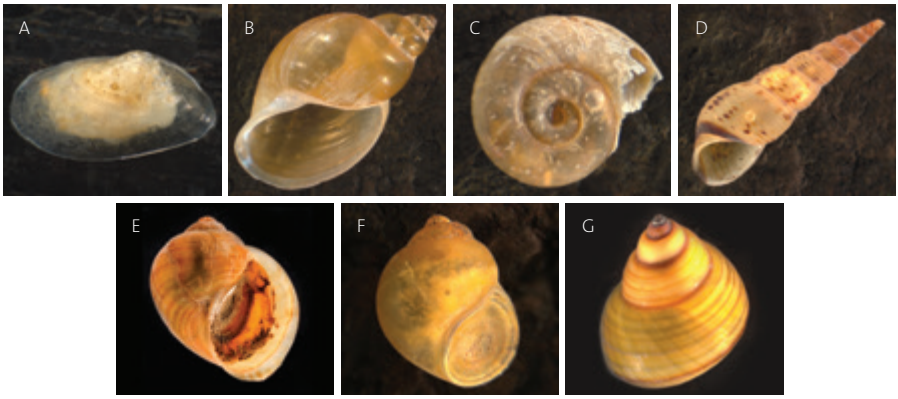
## Phylum Mollusca

### Class Gastropoda

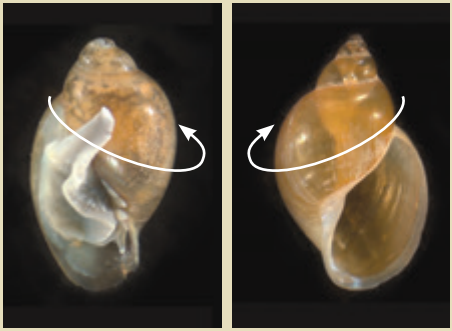
### Snails

Snails are characterised by the presence of a single calcareous shell that can completely cover and protect the soft body against predators. The calcareous shell can be either cap-shaped or in coiled form. Shells can spiral, from the tip to the opening of the shell, in a clockwise or anticlockwise direction. The soft body of snails consist of a muscular foot that allows them to attach and move across the surfaces. They are predominantly herbivores, grazing on plant materials and algae.

Snails in ponds are from two major groups, the air-breathing snails (order Hygrophila) and gill-bearing snails (orders Architaenioglossa, Neotaenioglossa, and Cerithimorpha). Air-breathing snails can keep a pocket of air in the body cavity to allow them to breath underwater. Gill-bearing snails use their gills to draw oxygen from the water. They also possess a cover called an 'operculum' that closes the opening of the shell completely.




The shapes of the snail shell include cap (A), ovately-conic (B), disc (C), turret(D), apple (E), egg (F) and broadly conical (G).



Shells can have either an anticlockwise spiral *(left)* or clockwise spiral *(right)* when viewed from the top *(apex)*

## Phylum Mollusca

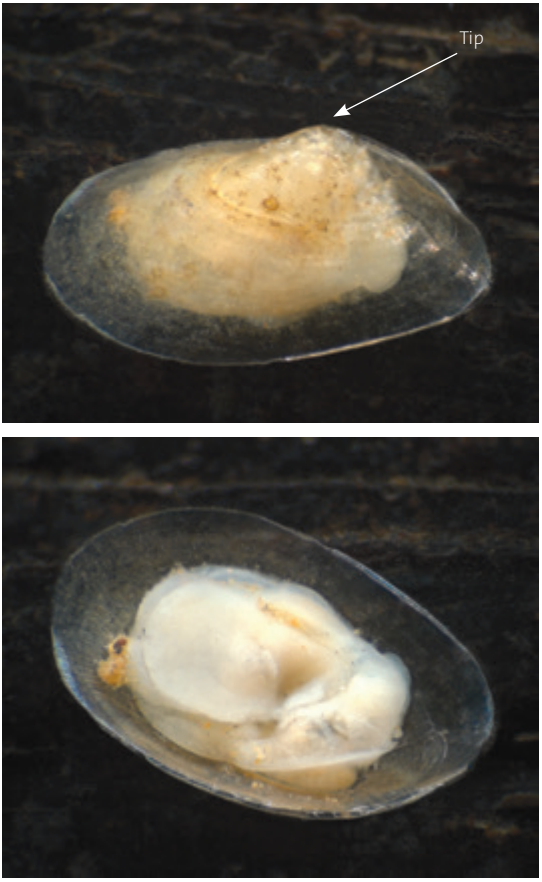
Class Gastropoda

Order Hygrophila

Family Ancylidae

Limpet Snail

Ancylids are air breathing snails. They reside at the bottom of the ponds, attaching themselves to flat surfaces, such as rock, wood or aquatic plants. Ancylids are characterised by an uncoiled cap-shaped shell with a large opening at the bottom. The tip of the shell is located off-center to the right.




Anyclid shells are a cap-shaped snail with a large opening at the bottom. The tip of the shell is located off-center to the right.

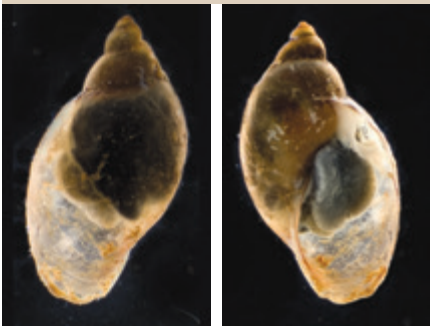
## Phylum Mollusca

Class Gastropoda

Order Hygrophila

Family Lymnaeidae

Pond Snails



Lymnaeids are air breathing snails, and are characterised by a cone-shaped shell that is coiled in a clockwise spiral. They reside at the pond bottom, moving on pond debris, mud or silt. They can also be found near the surface of water by controlling their buoyancy and floating upside down on the water surface.

Lymnaeids possess a conic-shaped shell that is coiled in a clockwise spiral.

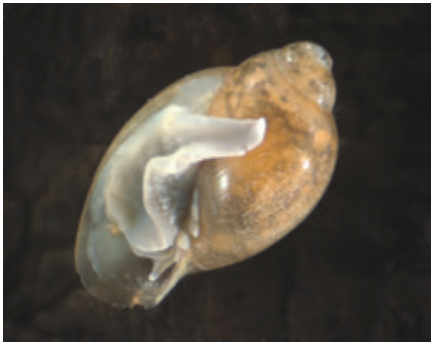
## Phylum Mollusca

Class Gastropoda

Order Hygrophila

Family Physidae

Bladder Snails; Tadpole Snails



Physids possess a thin, ovately-conical that is coiled in an anticlockwise spiral.

Physids reside at the bottom of the pond amongst aquatic vegetation. They have shells that are coiled in an anticlockwise spiral. The physidae shells are smooth, thin and translucent, showing the soft-body visibly within the shell.

Physidae snails are likely to be exotic and introduced to Singapore through the aquarium trade. They are believed to have escaped to the waterways and are now established throughout freshwater systems in Singapore.

## Phylum Mollusca

Class Gastropoda

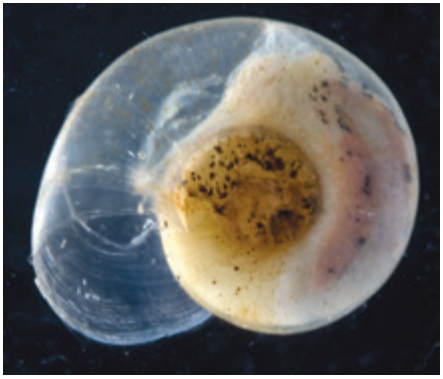
Order Hygrophila

Family Planorbidae

Ram's Horn Snails

Planorbids are air-breathing snails, characterised by disc-shaped shells that are coiled in an anticlockwise spiral. Typically, planorbids such as *Gyraulus* sp. are flattened but some planorbids such as *Americana carinata* have more elongated shells, with a much larger opening than *Gyraulus* sp. The coil of these shells, however, is still in the disc form, coiling on one axis.

Planorbids live at the bottom of ponds, attached to aquatic plants or on algal films which they feed on.



Ram's Horn Snails of the *Gyraulus* genus are so-called because their shells are flattened in a spiral similar to that of the horns of male sheep.


The Carinate Americana (*Americana carinata*) have shells that are elongated, but the coiling is still more or less disc-shaped and on one axis.

## Phylum Mollusca

Class Gastropoda

Order Architaenioglossa

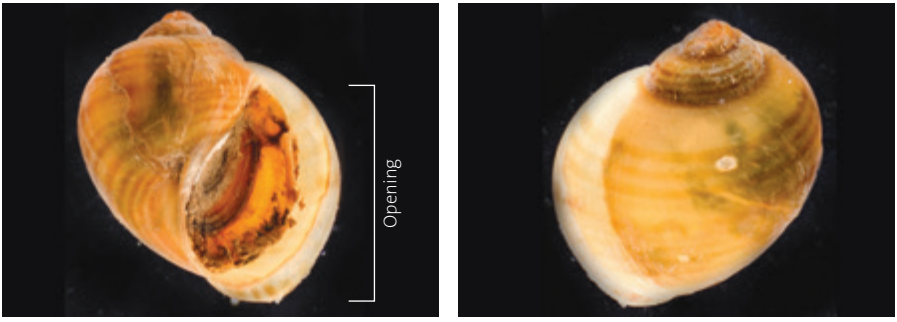
Family Ampullariidae

Apple Snails

Ampullarids are characterised by an apple-shaped shell that is coiled in a clockwise spiral. The shell is thick and has a wide opening on the right to the tip of the shell. They are the largest snails in the freshwater systems in Singapore, with shells larger than 10 cm in length.

Ampullarids are found near the edge of the pond, hiding in water amongst aquatic plants or on land feeding on plants growing on the banks of the ponds. The Golden Apple Snail (*Pomacea canaliculata*) is an exotic snail that is considered a nuisance in Singapore, destroying plants around the ponds. They are well-established in ponds, laying clutches of up to 600 eggs at a time. These eggs clusters, which are pink or red in colour, are attached to objects above the water surface, making them highly visible.

Golden Apple Snails originated from South America and are believed to be threatening the native ampullarids, Shield Apple Snails (*Pila scutata*), which was once common in Singapore.




Ampullarids have apple-shaped shells with a big opening.

The pink egg clusters by the invasive Golden Apple Snails (*Pomacea canaliculata*) are highly visible.

## Phylum Mollusca

Class Gastropoda

Order Architaenioglossa

Family Viviparidae

Viviparids possess cone-shaped shells that are coiled clockwise with opening on the right.

Viviparids reside in the bottom of the pond, partially buried in the soft debris. Many viviparids are known to be filter-feeders.

Viviparids possess broadly conical shells that are coiled in a clockwise spiral with the opening to the right. The shells are thick. They are typically around 20 to 40 mm in length.

## Phylum Mollusca

Class Gastropoda

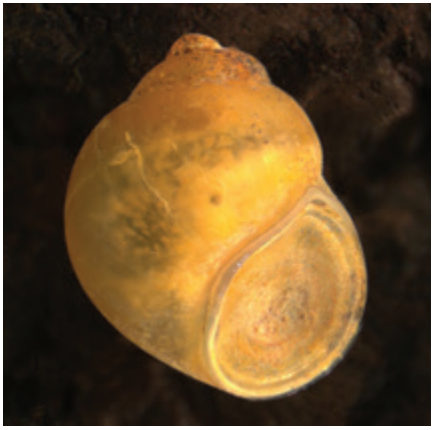
Order Neotaenioglossa

Family Bithyniidae

Bithyniids are gill-bearing snails that are characterised by their egg-shaped shells. The shell is coiled in a clockwise spiral with a wide opening to the right of the shell. Superficially they resemble miniature ampullarids, typically between 10 and 15 mm in length.

Bithyniids reside near the pond edge, on rocky surface, roots or amongst aquatic plants or debris. They graze on the algae or microorganisms present on the surfaces that they move across. Some bithyniids are filter feeders, feeding on microorganisms and algae present in the water.

Bithyniids possess egg-shaped shells that are coiled in a clockwise direction.



## Phylum Mollusca

### Class Gastropoda

### Order Cerithimorpha

### Family Thiaridae

Thiarids are gill-bearing snails with turret-shaped shells. The shells, which can be smooth or rough, are coiled in a clockwise spiral that opens to the right. In some thiarids such as *Thiara scabra*, juveniles have very pointy edges on the coils that wear down with time as the snail gets older.

Thiarid snails reside at the bottom of the pond, where they feed on algae growing on the surface.

Thiarids *(Melanoides tuberculata)* possess turret-shaped shells with a clockwise spiral.

Shells of the Pagoda tiara (*Thiara scabra*) shells can be either smooth *(top)* or rough *(right)*.

## Phylum Arthropoda

Arthropods are the most predominant group of animals in pond communities. They are characterised by jointed appendages and an external skeleton made of stiff chitin cuticle called an 'exoskeleton'. Unlike other animals, the 'skeletons' of arthropods cannot grow synchronously with their bodies. As the arthropod outgrows its exoskeleton, it sheds the layer altogether and form a new and larger exoskeleton. This process is known as moulting.

Arthropods are characterised by jointed legs and hard exterior skeleton (exoskeleton).


Many arthropods have distinct head, abdomen and thorax segments, most frequently presented as separate segments in the insect groups whereas in other arthropods such as spiders, the head and thorax is fused into a single segment, a 'cephalothorax'.

## Phylum Arthropoda

### Class Arachnida

Arachnids appear to have only two body parts, with the head and thorax section fused. Four pairs of jointed legs are attached to this section. They are the only arthropods that do not possess any antennae.

The mouthparts of arachnids are well-modified into claw-bearing appendages to help them feed on other animals. Predacious arachnids are known to inject venom into their prey to paralyse them while they feed.

Arachnids are characterised by four pairs of legs and the absence of antennae


Claw-bearing mouthparts enable arachnids such as this Jumping Spider (*Cosmophasis umbratica*) to hunt living prey.

## Phylum Arthropoda

Class Arachnida

Subclass Acarina

Mites

Acarina mites reside at pond bottom near the water edge and hidden amongst aquatic plants. They are characterised by a round body that does not show clear external division or segmentation. The four pairs of legs are lined with swimming hairs, allowing them to move in the water.

Acarina adults are predators that feed on small crustaceans, aquatic insect eggs or larvae. The larvae are parasites, feeding on their hosts until they are fully engorged. Hosts for Acarina larvae include adult dragonflies and mosquito larvae.

The round-bodied acarina mite does not possess any clear external segments. The legs are lined with swimming hairs that allow it to move in water.

## Phylum Arthropoda

Class Arachnida

Order Araneae

Spiders

Wolf Spiders are ambush predators that rest on plants at pond edge to hunt for insects, small fishes and tadpoles.

Araneae, which consists of all known spiders, are characterised by a narrow 'waist' between the abdomen and a fused head and thorax segment. Spiders possess fangs that allow them to inject venom into their prey to immobilise the prey, before feeding on them.

Only a few species of spiders are found in or around ponds. The Wolf Spider (family Lycosidae) and Nursery-web Spider (family Pisauridae) are semi-aquatic fishing species that reside at the edge of the ponds, hidden among plants. They are predators, feeding on pond animals, including surface-dwelling insects, small crustaceans, fishes, and tadpoles. They dive into the water to catch their prey.

The only spider in the world that spends its entire life underwater, *Argyroneta aquatica*, is not found in Singapore. They are found in Japan and regions of temperate Europe and Central Asia.

## Phylum Arthropoda

### Class Malacostraca

### Order Decapoda

Decapods are the most notable crustaceans in aquatic systems in Singapore. They are characterised as having five pairs of legs and a hard shell covering the thorax and parts of abdomen. They also have gills that they use to breathe underwater. Decapod eyes are attached to eyestalks.

Three groups of decapods are found in freshwater environment in Singapore, including crabs (suborder Brachyura), shrimps (infraorder Caridea) and crayfish (infraorder Astacidea). They differ from each other mainly in the number of pairs of pincers modified from the five pair of legs. For crabs, the first pair of legs are modified as pincers; for shrimps, the first two pairs of legs are modified with pincers; and for crayfish, the first three pairs of legs are modified with pincers. However, only shrimps and crayfish are found in ponds.

Both shrimps and crayfish have a fused head and thorax in front of a well-developed abdomen bearing appendages that are used for swimming or reproduction. They are active swimmers, pulling themselves forward with the abdominal appendages that are modified for swimming or by flicking their large fan-shaped tails.

Female shrimps and crayfish modify their abdominal appendages into a 'breeding dress' before mating to carry the fertilised eggs on her abdomen.

The three representatives of decapods found in freshwater environments in Singapore include crabs *(top left)* with one pair of pincers, shrimps *(top right)* with two pairs of pincers and crayfish *(bottom right)* with three pairs of pincers.

## Phylum Arthropoda

Class Malacostraca

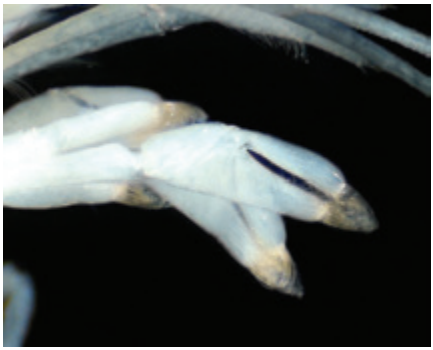
Order Decapoda

Infraorder Caridea

Family Atyidae

Atyids are typically found at the bottom of ponds or swimming under sheltered areas amongst aquatic plants.

Atyids have two equal sized pincers on their first two pairs of legs. These shrimps feed on debris by brushing the pincers over surfaces of rocks or aquatic plants, collecting food particles on the fine hair lining the pincers.

Atyids bear two pairs of short pincers that they use to brush food from surfaces.

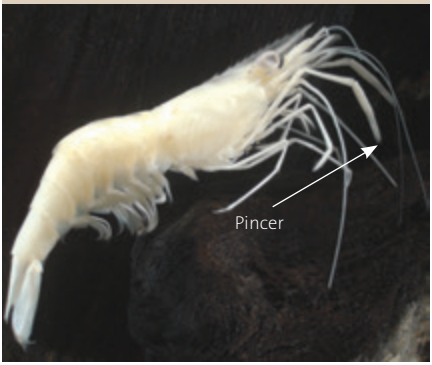
**Phylum Arthropoda**

Class Malacostraca

Order Decapoda

Infraorder Caridea

Family Palaemonidae




Palaemonids are found on the pond-bed close to the water edge, hiding amongst aquatic plants. These shrimps are omnivorous, feeding on plant and animal material, often becoming more predatory are they mature.

Palaemonidae are characterised by a well-developed second pair of pincers that are much longer than the first pair of pincers. Palaemonidae males develop larger second pairs of pincers than females. The second pair of pincers are so enlarged that they may even exceed the body length at maturity. The enlarged pincers are used for combating with other males during courtship to guard the female or in the defense of a territory.

Palaemonids possess a well-developed and long second pair of pincers that are used for self-defence.

**Phylum Arthropoda**

Class Malacostraca

Order Decapoda

Infraorder Caridea

Family Parastacidae

Freshwater Crayfish


The exotic *Cherax quadricarinatus* has a flattened body with a large, visible front pair of claws.

Parastacids are a family of crayfish characterised by a flattened body and three pairs of claws. The first pair is enlarged and is highly visible. They are the largest freshwater arthropods in ponds and can grow to over 70 cm long. They are found at the bottom of ponds, burrowing into debris or hidden amongst vegetation. Parastacids are omnivorous and feed on small aquatic animals and plant material.

In Singapore, parastacids are represented by one non-native species, *Cherax quadricarinatus*, which is native to Australia. It is exclusively imported for the aquarium trade. Accidental and deliberate releases of this species have led to the establishment of populations in ponds and reservoirs in Singapore.

## Phylum Arthropoda

### Class Insecta

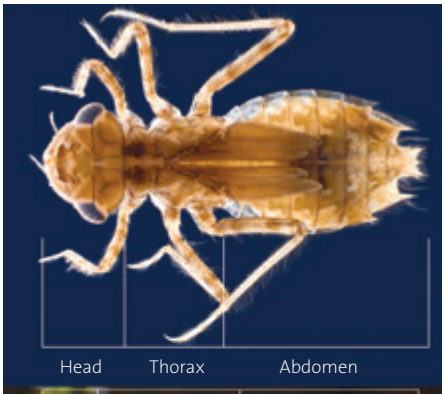
Insects are the most diverse and abundant group of animals in a pond. They occupy all areas of ponds; living amongst vegetation, in the substrata, attached to submerged objects, or swimming freely in the water.

Their life cycles are either complete with four-stages (egg, larva, pupa, adult) or incomplete with three-stages (egg, nymph, adult). Insects with complete life-cycles undergo an elaborate metamorphosis involving a resting, non-feeding pupal stage. Larvae of these insects are often quite morphologically distinct from adults. Insects with complete life-cycles include beetles, caddisflies, and true flies.

Insects with incomplete life-cycles undergo a lesser degree of metamorphosis, where the nymphs develop into adults through a series of moults, becoming progressively more like the adults in structure. Insects with incomplete life-cycles include dragonflies, mayflies, and true bugs.

Some insects such as water bugs (Hemiptera) and beetles (Coleoptera) spend their entire lives in or on the water but other insects such as dragonflies (Odonata) and mayflies (Ephemeroptera) have aquatic larvae and air breathing, winged adult forms.

Insects are characterised based on the adult forms having three body parts: head, thorax, and abdomen, a pair of antennae, and three pairs of thoracic jointed legs. The majority of the larval forms of insects found in freshwaters also share these characteristics. One notable exception are the diptera or 'true flies' that have segmented bodies and heads but are without jointed legs in their juvenile aquatic stages.




*(top)* A pair of antennae is attached to the head of an insect.

Dragonfly *(top)* and caddisfly *(bottom)* larvae have three distinct body parts; a head, a thorax and an abdomen, with three pairs of jointed legs attached to the three thoracic segments.

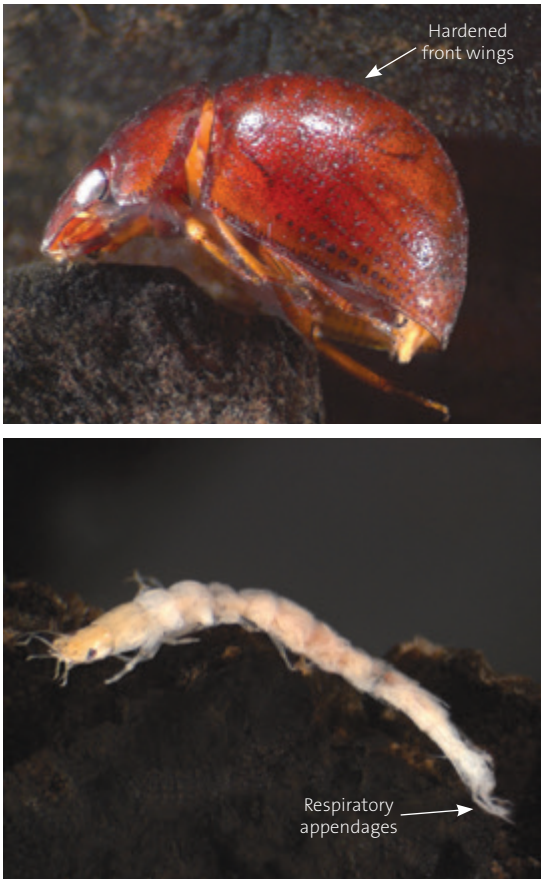
## Phylum Arthropoda

Class Insecta

Order Coleoptera

Beetles

Coleopterans (beetles) have a four stage life-cycle: eggs, larvae, pupae, and adults. Adult beetles are characterised by hardened front wings that cover their abdomen. They do not have gills. Instead, they carry an air bubble underwater to supply them with oxygen. Coleopteran larvae have three pairs of thoracic legs and respiratory appendages attached to the last abdominal segment.




Adult Coleoptera *(top)* possesses a pair of hardened front wings that cover its abdomen. Coleopteran larva *(bottom)* have respiratory appendages on the last abdominal segment.

## Phylum Arthropoda

Class Insecta

Order Coleoptera

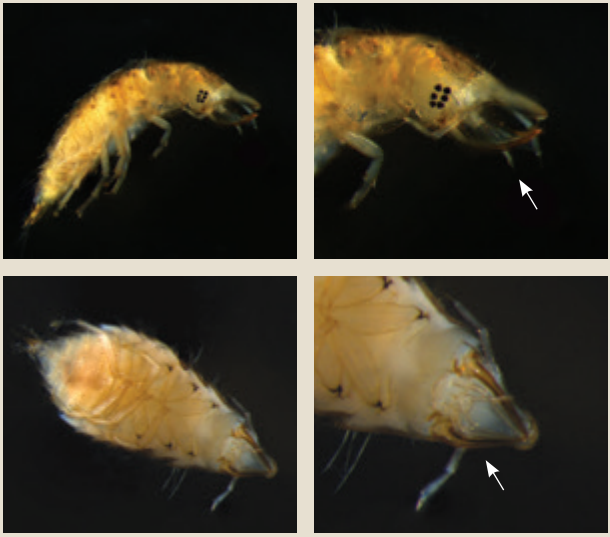
Family Dytiscidae

Diving Beetles

The oval shaped adult dysticid bears thread-like antennae on its head.

In ponds, dysticids can be found hiding amongst aquatic vegetation at the edges of ponds in the shallows or freely swimming in open water. The bodies of adult dysticids are oval and elongated. They have thread-like antennae with uniform segments. Adults also have flattened hind-legs, like paddles that allow them to move quickly in water. They are active predators that prey on other aquatic insects, crustaceans, tadpoles and small fish. While hunting, adults dive in the water with an air bubble attached to the end of their abdomen. The air bubble provides oxygen to the beetle and decreases in size as more oxygen is used up. Adult dysticids surface from time-to-time to renew their air supply.

The bodies of dysticid larvae are long and streamlined, with the broadest section in the middle and pointed at both ends. Dysticid larvae have long, sickle-shaped mouthparts. These allow the larvae to hunt similar-sized prey, including crustaceans, chironomid larvae, and other small aquatic insects. Some may attack tadpoles and small fishes.



Dysticid larvae possess a pair of sickle-shaped mouthparts that are used to hunt for prey that can be as big as themselves.

## Phylum Arthropoda

Class Insecta

Order Coleoptera

Family Hydrophilidae

Water Scavenger Beetles

Adult hydrophilids reside at the bottom of ponds, hiding amongst plant debris. They are herbivores that use their chewing mouthparts to feed on plant material. They have long, oval bodies. Unlike diving beetles, water scavengers do not have specially modified swimming legs, making them less efficient, slower swimmers in contrast.

Hydrophilid larvae are white and worm-like, with short thoracic legs. The head and thorax of hydrophilid larvae are hardened, while the abdomen is unprotected. Unlike the adults, hydrophilid larvae are carnivorous, feeding on small insects and snails.

Adult hydrophilids are oval and long in shape.

Hydrophilid larvae are white and worm-like, with a hardened head and thorax (circled) and fleshy abdomen.

## Phylum Arthropoda

Class Insecta

Order Coleoptera

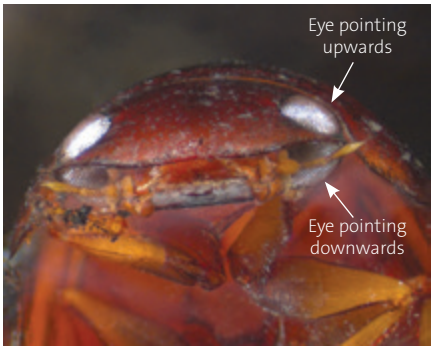
Family Gyrinidae

Whirligig Beetles

Gyrinid adults are fast swimmers that gyrate on the water surface. Their spinning movements as they scoot rapidly around the surface of ponds in search of food gives rise to their common name, Whirligig Beetles. They feed on other aquatic animals that live on the pond surface and will also take advantage of unfortunate insects that have fallen into the pond.

These beetles have an advantage over other predators since they have two sets of eyes. One pair of compound eyes points upwards and a second pair points downwards, allowing them to see above and below the water at the same time. This helps them to look out for animals that might attack them whilst they search for food. If they sense that they are under threat, they can dive quickly into the bottom of the pond using their short, flat mid- and hind-legs which allow them to paddle quickly in the water.

Gyrinid larvae are long and slender. They are characterised by large gills on their abdominal segments that allow them to breath underwater. Gyrinid larvae are often found hiding at the bottom of ponds, close to the water's edge amongst aquatic plants and other debris where they feed on aquatic worms and small insects.




Adult gyrinids have two pairs of eyes; one set points upwards and the other points downwards. These allow them to look for prey on the water surface at the same time as looking out for danger from below.


Gyrinid larvae are long and slender with large gills on their abdominal segments.

## Phylum Arthropoda

Class Insecta

Order Diptera

True Flies

Dipteran larvae are generally found amongst organic debris, aquatic vegetation, fine sediments, sand, mud, gravel, cobbles, on bedrock at the bottom of ponds. They appear to be worm-like and are characterised as the only group of insect larvae which are without either jointed legs or antennae. Dipteran larvae can generally be distinguished from worms by their heads which are either retracted into the body or present as external, hardened head capsules. Some larvae have rudimentary, stumpy 'prolegs' to aid their locomotion but none have the jointed legs characteristic of their adult forms.

Dipterans undergo a four-stage life cycle: eggs, larvae, pupae, and adults. Adults are short-lived. Some species may emerge spontaneously in large numbers, forming a large cloud of flying adults for a short period of time. This strategy of synchronous emergence increases the chances of individuals finding a mate.

Dipteran larvae appear 'worm-like' in the absence of legs and antennae.

## Phylum Arthropoda

Class Insecta

Order Diptera

Family Ceratopogonidae

Biting Midges

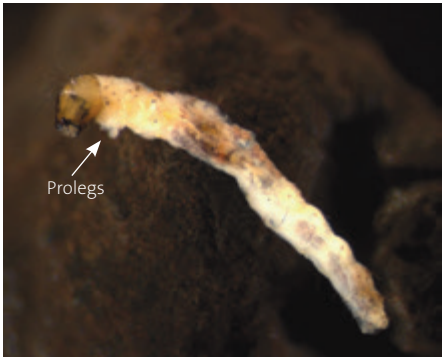
Adult ceratopogonids are aerial predators, nectar drinkers or even blood suckers found flying around water. They are known as the 'biting midges' because they have well-developed mouth parts which the females of some species use to feed on the blood of a host animal – including people. Their bite results in a small, itchy blemish.

Ceratopogonid larvae are aquatic and feed on plant and soil detritus, fungi, algae, or small invertebrates. They live in mud, debris, rotting vegetation or floating algal masses found at margins of ponds.

The larvae are long, slender and worm-like in appearance with distinctive bead-like segments. They move in water rapidly in a snake-like swimming style. Ceratopogonid larvae have a complete head capsule which does not retract into the thorax. The majority of biting midge larvae have heads in line with their body axis and are without prolegs on either the thorax or abdomen.

Some less common species of the subfamily Forcipomyiinae, have a head at right angles to their body axis and a pair of prolegs protruding from the thorax, just beneath the head. At first view, these ceratopogonids appear to resemble the non-biting midge larvae (Chironomidae). The key to differentiating between these two groups is to note that chironomids have two sets of paired prolegs; one set below the head and one set at the end of the abdomen and that forcipomyiinae have only a single pair of prolegs beneath the head and no second set of prolegs.

Long and slender ceratopogonid larva without any prolegs or antennae.




Forcipomyiinae have a head pointing downwards and one pair of fleshy prolegs on the thorax.

## Phylum Arthropoda

Class Insecta

Order Diptera

Family Chironomidae

Non-biting Midges

Chironomid larvae have long, segmented bodies. They have a complete head that points downwards and two pairs of fleshy prolegs on the first thoracic segment and last abdominal segment.

Chironomid larvae are most commonly found burrowing in sediments or amongst debris and aquatic vegetation at the bottom of ponds. They can build tubes with debris to protect themselves from predators. The feeding strategies of chironomid larvae are varied; many are detrivores or algal grazers but others are predatory even feeding on other chironomids and small aquatic animals.

Some chironomid larvae contain the red blood pigment haemoglobin (with high affinity for oxygen) which enables them to absorb oxygen from the water more readily. The red colouration gives them the common name 'bloodworms'.


Chironomid larvae with two pairs of fleshy prolegs on the thorax and abdomen.

## Phylum Arthropoda

Class Insecta

Order Diptera

Family Culicidae

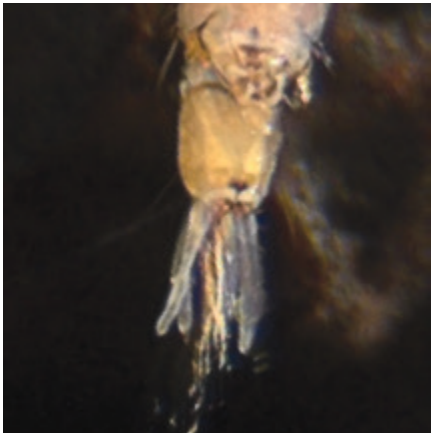
Mosquitoes

Adult mosquitoes are known pests to humans and potential vectors for diseases such as malaria, dengue and encephalitis transmitted through their bites.

Culicid larvae have an enlarged fused thorax (without distinct segments) that is wider that the segmented abdomen. Their head is in line with their body axis. Culicid larvae have no prolegs but can be recognised by the presence of respiratory appendages that are located at the end of the abdomen, through which they can breathe in atmospheric oxygen.

Being air-breathers, culicid larvae live suspended from the water surface, close to vegetated margins or amongst floating vegetation. Most larvae feed on small algae and detritus. They are active swimmers and are able to avoid predation by diving rapidly when disturbed.


Culicid larvae have an enlarged thorax that is wider that the abdomen.



Respiratory appendages present on the last abdominal segment enable the culicid larva to breathe while suspended on the surface of water.

## Phylum Arthropoda

Class Insecta

Order Diptera

Family Tipulidae

Crane Flies

Tipulid larvae are some of the largest invertebrate larvae found in ponds, measuring up to 50 mm in length. They are found in the bottom substrata; in mud and amongst plant material. Tipulid larvae have worm-like, long bodies and initially appear to be headless. However, they do possess a complete head that is retracted into the thorax. Tipulid larvae are characterised by the presence of respiratory appendages and fleshy lobes located at the end of the abdomen. They do not have prolegs.

Tipulid larvae are air-breathers but can remain submerged for a period of time. The fleshy lobes present on the abdomen trap a film of air, allowing tipulid larvae to breathe while underwater. Once the air is used up, they move towards the surface positioning the abdomen out of the water to breathe.

The feeding strategies of tipulid larvae are varied. Some are predators, while other species feed on decaying organic matter, plant fragments, and microorganisms.

Tipulid larvae have fleshy lobes that trap a film of air, allowing them to breathe whilst submerged.

## Phylum Arthropoda

Class Insecta

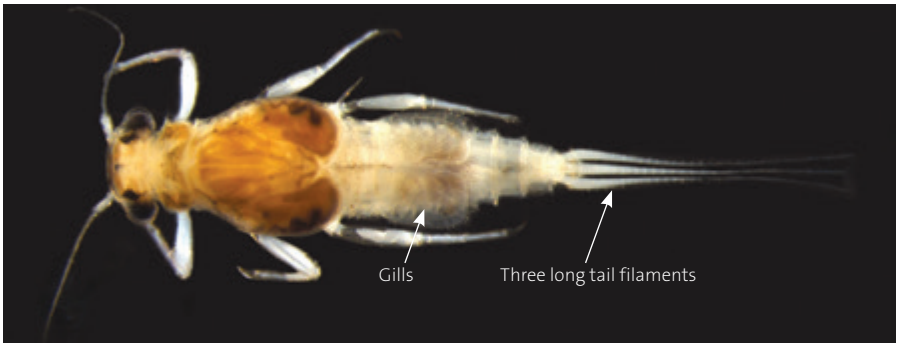
Order Ephemeroptera

Mayflies

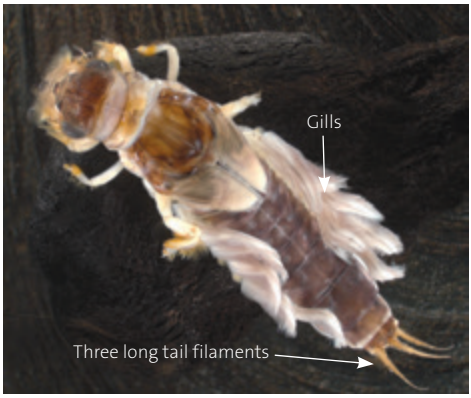
Ephemeroptera nymphs are found either free swimming within the water or at the bottom of ponds burrowing into logs, mud, gravel, leaf litter or other pond debris. They are predominantly herbivores that feed by scraping algae from the surfaces of debris though some burrowing forms feed by filtering food particles from the water.

Mayfly nymphs are usually most easily recognised by the three long tail-like filaments attached to the last abdominal segment. They also bear gills on abdomen that allow them to breathe underwater.

Ephemeroptera have a three-stage life cycle: eggs, nymphs, and adults. Their common name, 'Mayfly', originates from their synchronous emergence during late spring in May in northern temperate countries, when thousands of nymphs emerge as flying adults.




Ephemeroptera nymphs have three long tail filaments attached to the last abdominal segment *(top)*. Gills on their abdominal segments allow them to breathe underwater *(right)*.



## Phylum Arthropoda

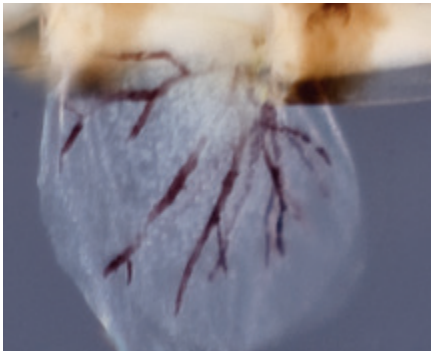
Class Insecta

Order Ephemeroptera

Family Baetidae

Swimming Mayflies

Baetid nymphs can be seen swimming in the water or found hidden among aquatic plants or within pond debris at the bottom of the edges of ponds. They feed on detritus and algae scraped from surfaces of leaves, rocks and sediments. Baetid nymphs have streamlined bodies that allow them to swim quickly for short-distances in the water to evade predators or to seek new feeding grounds. Both sides of the abdomen are lined with short leaf-like gills, helping them to breathe underwater. Their heads point downwards.

Baetid nymphs have streamlined bodies with a head that points downwards *(top)*. Both sides of the abdomen are lined with leaf-like gills *(right)* that allow them to breathe underwater.

## Phylum Arthropoda

Class Insecta

Order Ephemeroptera

Family Caenidae

Caenid nymphs have a flattened body with a rectangular head that points downwards.

Caenid nymphs reside at the pond bottom amongst plant material, such as leaf litter and roots. They feed on fine particulate detritus and microorganisms growing on the surface of submerged plants. These nymphs are small, typically around 4 to 6 mm in length.

Caenid nymphs have a flattened body, with a rectangular head pointing downwards. They possess abdominal gills that differ in shape. Gills on the first abdominal segment are fine and reduced in size. On the second abdominal segment they are modified into large hardened plates or 'gill covers' that cover the uniform, plate-like gills on segments 3-6.

Caenid nymphs beat their gills to create a water movement over their bodies, allowing them to receive oxygen from the moving water. The pair of hard gill covers the succeeding gills from becoming clogged by fine particles in the water.


Three different types of gills can be found on a caenid nymph. Reduced gills are found on the first abdominal segment (A), rectangular gills on the second abdominal segment (B), which cover the uniform, plate-like gills on succeeding abdominal segments 3–6 (C).

## Phylum Arthropoda

Class Insecta

Order Ephemeroptera

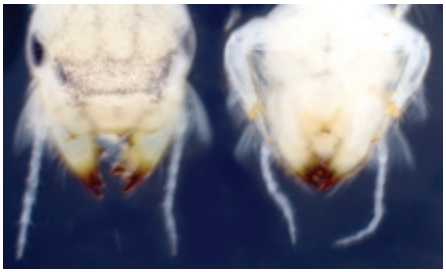
Family Polymitarcyidae

Wood Burrowing Mayflies

Polymitarcyid nymphs are found inside and around soft, decomposing logs and branches at the bottom of ponds. They are characterised by large modified mouthparts that look like tusks. Polymitarcyid nymphs use their large tusks to burrow into soft, wet wood creating tunnels in which they hide and feed. While in hiding, the filter-feeding polymitarcyid nymphs beat their gills from side-to-side to draw water across their bodies. This allows them not only to take in oxygen from the moving water, but also to collect food from the water being pulled through their tunnels.

Polymitarcyid nymphs possess two rows of fan-like gills on the both sides of abdominal segments 2–7.

Polymitarcyid nymphs can grow to 30 mm in length making these the largest mayflies found in Singapore.

Polymitarcyid nymphs possess large tusks on their head *(bottom right)* and two rows of fan-like gills *(top right)* on both sides of the abdomen.

## Phylum Arthropoda

Class Insecta

Order Hemiptera

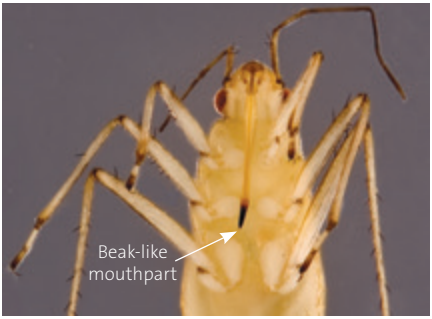
Suborder Heteroptera

True Bugs

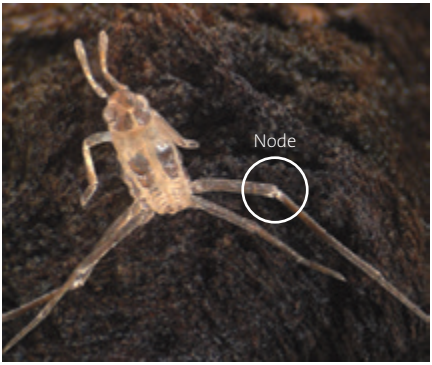
Hemipterans are predators or scavengers that feed on an assortment of living and dead prey, such as zooplankton, aquatic insects, 'drowning' terrestrial insects, and small fishes. Hemipterans use a specialised beak-like mouthpart used for piercing and sucking.

Hemipterans undergo a three-stage life cycle: eggs, nymphs, and adults. The nymphs closely resemble the adults in structure, but are smaller, paler, and soft-bodied.

Hemipterans can be either semi-aquatic bugs (Infraorder Gerromorpha) or aquatic bugs (Infraorder Nepomorpha). Semi-aquatic bugs live on the water surface and possess legs that do not break the surface tension of the water. This enables them to tread, skate, or stride atop the water. Aquatic bugs live in the water but are also air-breathers. They use different strategies to retrieve and retain air to maximise the time they can remain under water.




The specialised beak-like mouthpart of a hemipteran allows it to feed on living or dead prey.




Semi-aquatic bugs *(left)* possess modified legs that allow them to 'walk' on water.

## Phylum Arthropoda

Class Insecta

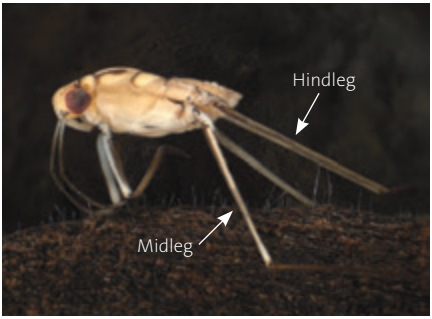
Order Hemiptera

Infraorder Gerromorpha

Family Gerridae

Pond Skaters

As their common name suggests, pond skaters are found 'skating' on the surface of the water, usually under shelter among floating plants or underneath large shoreline plants. They appear as a small animal walking on four-stilts atop the water. They have extremely long mid- and hind-legs that are much longer than their short and broad body. The body of the gerrids measures up to 20 mm long while the legs may span up to 40 mm. The long legs of gerrids are covered with hydrophobic hairs that allow the insects to make use of water surface tension to walk or 'skate' on the surface. The forelegs are short and are used to assist in feeding.




Gerrids have legs mid- and hind-legs that allow them to move on the surface of water.


The forelegs of gerrids are short and are used for feeding.

**Phylum Arthropoda**
Class Insecta
Order Hemiptera
Infraorder Gerromorpha
Family Hebridae
Velvet Water Bugs

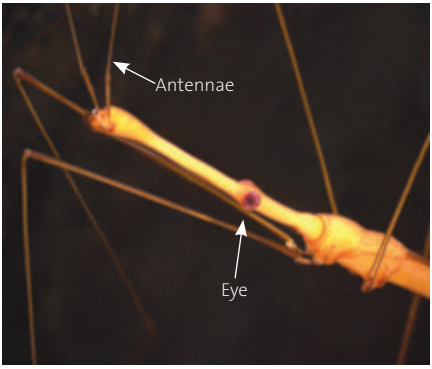
Hebrid Velvet Water Bugs have a 'velvet' layer of dense and minute hairs covering their entire body.

Hebrid bugs are semi-aquatic and are found at edge of the ponds, amongst plants and mosses or under the shelter or rocks. They have a layer of dense and minute hairs over the body, resembling the appearance of a velvet fabric. This gives rise to their common name, Velvet Water Bugs. Hebrid bugs are small; typically less than 4 mm in length.

Hebrids are predators that feed on small invertebrates found around the edge of the pond, such as springtails.

**Phylum Arthropoda**
Class Insecta
Order Hemiptera
Infraorder Gerromorpha
Family Hydrometridae
Water Measurers

Hydrometrids are semi-aquatic bugs that reside at the edge of the ponds, hidden amongst plants. They have a very long and slender body that resembles a stick when they are not moving. The heads of hydrometrids are extremely long (up to a third of their body length), bearing a pair of long antennae attached at the front of the head, and a pair of eyes in the middle of the head. Hydrometrid legs are long and threadlike, allowing them to tread quickly across the water surface.




Hydrometrids are characterised by a long head bearing long antennae at the tip and eyes in the middle.

When motionless, the semi-aquatic hydrometrid (with its long and slender body and almost invisible threadlike legs) appears like a stick. This allows them to remain camouflaged amongst plants at the edge of the pond.

## Phylum Arthropoda

Class Insecta

Order Hemiptera

Infraorder Gerromorpha

Family Mesoveliidae

Water Treaders

Mesovelid bugs are semi-aquatic bugs that are found at the edge of the pond, hiding amongst plants. The head of mesovelid bugs is elongated, with the eyes located closer to the thorax than the front of the head. A pair of long 4-segmented antennae extend from the tip of the head. The legs of mesovelid bugs are long and slender, enabling them to run extremely fast across floating vegetation and the surface of the water. Mesovelid bugs are small, typically not more than 4 mm in length.

Mesovelid bugs have long and slender legs that allow them to run quickly across the surface of the water.

The eyes of mesovelid bugs are located closer to the thorax than the tip of the head. A pair of long antennae are attached at the tip of the head.

## Phylum Arthropoda

Class Insecta

Order Hemiptera

Infraorder Nepomorpha

Family Belostomatidae

Giant Water Bugs

Belostomatids are free-swimming in ponds, found hidden among aquatic plants. They have a flat, oval body. The Giant Water Bugs are the largest of the Hemipterans and can measure up to 60 mm in length.

Giant Water Bugs possess a pair of strong and bent front legs that allow them to grasp onto prey, including small fish and tadpoles. The air-breathing belostomatids hold an air-bubble underneath their leather-like 'wings' so they can breathe through spiracles on their abdomen whilst they are underwater. They swim towards the water surface periodically to replenish this air supply by using a pair of long and retractable respiratory appendages that extend from the end of their abdomen to pump air back under their wings.

Belostomatids are oval in shape and are larger than most aquatic insects.

Belostomatids possess a pair of strong and bent forelegs that are used for hunting.


Hidden at the end of the abdomen is a pair of retractable respiratory appendages that can extend out of the water to re-supply the belostomatid with air held in a bubble under their wings.

## Phylum Arthropoda

Class Insecta

Order Hemiptera

Infraorder Nepomorpha

Family Corixidae

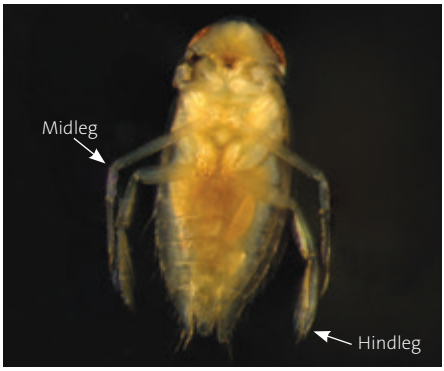
Water Boatmen

Corixids are fast swimming aquatic bugs with oblong bodies that are curved on the back and flat in front. The mid- and hind-legs are long and slender, bearing swimming hairs that allow them to swim quickly in the water. The hairs on corixid legs make them appear like oars that they use to paddle through the water. This gives rise to the common name Water Boatmen.

While not swimming, corixids are hidden amongst floating and aquatic plants. They use claws on the mid- and hind-legs to hang on to plants while hiding from other predators during rest.

Corixids have a triangular mouthpart that is used to feed on different types of food, such as algae, mosquito and midge larvae and other pond debris. The forelegs are short and are used to for feeding.

The body of a corixid is oblong in shape.




Corixids have swimming hairs on their oar-like mid- and hind-legs which allow them to swim quickly in the water.

## Phylum Arthropoda

Class Insecta

Order Hemiptera

Infraorder Nepomorpha

Families Helotrephidae

Hemispherical Backswimmers

Helotrephids are small aquatic bugs, typically up to 4 mm in length. They are characterised by the fusion of the head with the first section of the thorax.

Helotrephids have a body that appears like a hemisphere, with a round back and a flat underside. Helotrephids swim on their back as they hunt for small invertebrates such as midge or mosquito larvae for food. Their appearance and their movement in water gives rise to their common name Hemispherical Backswimmers.

When not hunting, helotrephids are found at the bottom of the pond, covered with pebbles, gravel, and sand.

Helotrephids have a rounded back and flat underside, resembling a hemisphere.

## Phylum Arthropoda

Class Insecta

Order Hemiptera

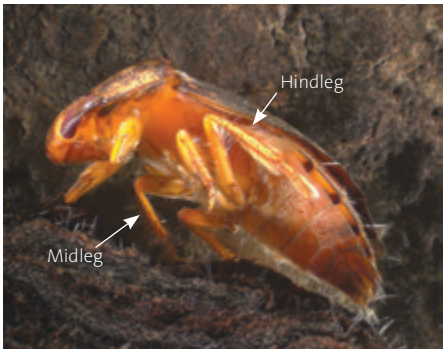
Infraorder Nepomorpha

Family Naucoridae

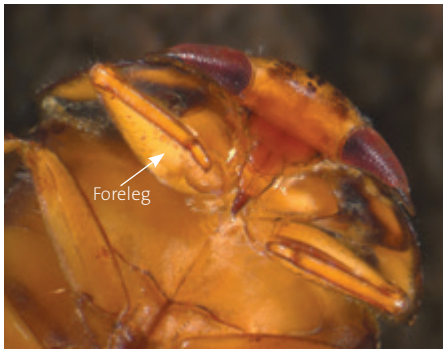
Creeping Water Bugs

Naucorids are aquatic bugs that are found near to the water's edge, hidden among pond debris, gravel, or plants, where they ambush their prey. The relatively large Naucorids, typically 20 mm in length, are able to take other small invertebrates such as midge larvae with ease. They use a pair of strong sickle-shaped fore-legs to grasp and hold onto their prey while they feed with strong mouthparts. Their long mid- and hind-legs bear swimming hairs that allow them to move quickly in the shallow water as they hunt.

The air-breathing naurcorids need to surface from time-to-time to replenish their air-supply, which is stored underneath their leather-like wings.




The oval shaped naucorid is flat with long mid- and hind-legs bearing swimming hairs that allow it to move quickly underwater.




Naucorids possess strong, sickle-like forelegs that grasp prey.

## Phylum Arthropoda

Class Insecta

Order Hemiptera

Infraorder Nepomorpha

Family Nepidae

Water Stick-Insects; Water Scorpions

Nepids have a long and slender body, which makes them appear stick-like while not moving. This give rise to their common name Water Stick Insect. They have a pair of strong and bent forelegs that allow them to grasp onto prey. Nepids are large aquatic bugs, up to 50 mm long.

They can feed on tadpoles, frogs, or small fish even bigger than themselves.

Nepids are ambush predators that are well-camouflaged, looking like twigs amongst aquatic plants. During the ambush, Nepids stay near to the water surface with their head pointing downwards and the end of the abdomen sticking out of the water so they can breathe air through a respiratory appendage at the end of the abdomen.


Nepids have a long and slender body, appearing 'stick-like' when motionless. They possess a pair of strong and bent forelegs that allow them to grasp their prey.

A pair of respiratory appendages at the end of the abdomen enable Nepids to breathe while the rest of their body is underwater.

**Phylum Arthropoda**
Class Insecta
Order Hemiptera
Infraorder Nepomorpha
Family Notonectidae
Backswimmers

Notonectids are aquatic bugs that swim on their backs, giving rise to their common name Backswimmers. While swimming on their backs, their flat underside and slightly curved back appears like a boat on the water. Notonectids are characterised by a pair of long hindlegs that bear swimming hairs. They use their hindlegs as oars to paddle themselves forward.

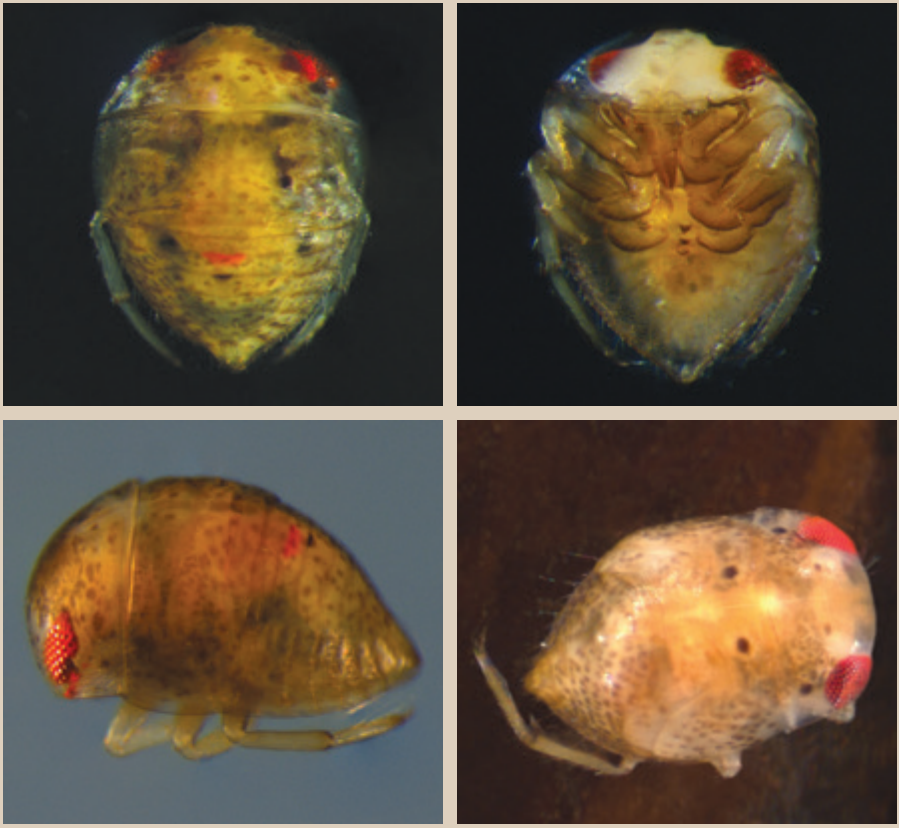
Notonectids hide among floating or aquatic plants near the water surface. They are active predators, using their bent fore- and mid-legs to grasp and hold onto prey that fall into water. They also feed on aquatic invertebrates, such as mosquito and midge larvae.

Notonectids swim on their backs, using their oar-like hindlegs to paddle themselves forward.

**Phylum Arthropoda**
Class Insecta
Order Hemiptera
Infraorder Nepomorpha
Families Pleidae
Pygmy Backswimmers

Pleids are small aquatic bugs, typically up to 4 mm in length. They possess a brownish body that is curved on the back and flat underneath. Pleids possess a pair of 3-segmented antennae on their heads.

Pleids swim on their backs. They swim quickly in the water to hunt for small invertebrates, such as midges and mosquito larvae. While not swimming, Pleids hide among floating plants or other aquatic plants in the shallow parts of a pond.



Pleids are small backswimmers that hide among aquatic plants in ponds.

## Phylum Arthropoda

Class Insecta

Order Odonata

Damselflies and Dragonflies

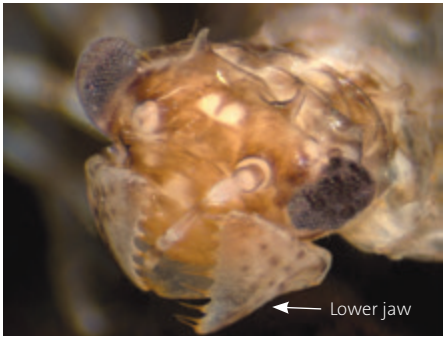
Odonate nymphs reside at the pond bottom amongst aquatic plants or other plant debris. Damselflies and Dragonflies are voracious predators. They have an enlarged lower jaw that can rapidly extend out to capture their prey such as other odonates, fly larvae, bugs, beetles, mayflies, aquatic worms, snails, and small crustaceans. Larger dragonfly nymphs also hunt tadpoles, crayfish, and even small fishes. While not hunting, the lower jaw sits in front of the head like a mask.

Odonates have a three-stage life-cycle: eggs, nymphs, and adults. During emergence from the aquatic nymph to a terrestrial adult stage, odonate nymphs crawl upwards on plant stems, rocks, or other structures. Once they climb out of the water, they moult and emerge as a flying, winged adults, leaving behind the emptied exoskeleton clinging to the surface from which the adult emerged.

Odonates include damselflies (suborder Zygoptera) and dragonflies (suborder Anisoptera).

Damselfly nymphs are long and slender, bearing three long leaf-like gills at the end of their abdomen. These gills, which allow the damselfly nymphs to breathe underwater, also act like tails, assisting the damselfly nymphs to swim quickly in water.

Dragonfly nymphs are broad and stout. They also possess three gills at the end of the abdomen that allow them to breathe underwater. However, the dragonfly nymphs' gills are much reduced, appearing as short, triangular lobes. Instead of using these gills to swim, dragonfly nymphs are able to propel themselves forward by quickly expelling water from the end of the abdomen.




The lower jaw of an odonate nymph sits in front of its head like a mask at rest.



Damselfly nymphs *(top right)* possess long abdominal gills that look superficially like tails. Dragonfly nymphs *(right)* have much reduced gills that appear like small spikes on the last abdominal segment.

## Phylum Arthropoda

Class Insecta

Order Odonata

Infraorder Zygoptera

Family Coenagrionidae

Pond Damsels

Coenagrionid nymphs have long and slender bodies, with leaf-like gills extending from the last abdominal segment. They are characterised by a triangular-shaped lower jaw with movable spines that opens up to grasp onto prey.

Coenagrionids reside at the bottom of ponds, hidden amongst aquatic plants where they hunt for prey. They are territorial and defend the area where they reside.

The long and slender body, together and leaf-like gills of coenagrionids, assist them to swim quickly to hunt and defend their hunting grounds.

The triangular lower jaw of coenagrionid nymphs have movable spines at the tips to catch prey.

**Phylum Arthropoda**

Class Insecta

Order Odonata

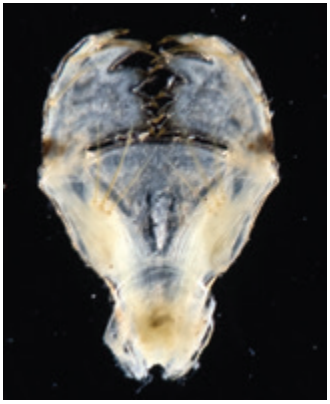
Infraorder Anisoptera

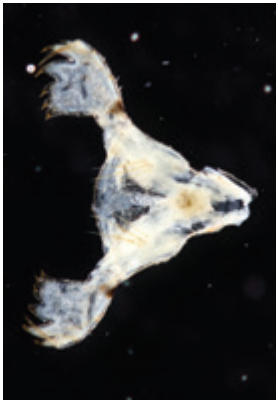
Family Corduliidae

Cordulid nymphs have a short and stout body. Their modified lower jaw looks spoon-shaped at rest. During hunting, the lower jaw opens in the middle, revealing large irregular teeth that are used to grasp prey. Cordulid nymphs hunt different types of animals, depending on their size. Small cordulid nymphs feed on zooplankton, while larger cordulid nymphs feed on small aquatic insects and crustaceans.

Cordulid nymphs are found at the bottom of the pond close to the water's edge. They are hidden amongst roots, leaf litter and other plant debris during the day and move into deeper water to hunt at night.

Cordulid nymphs are short and stout.





The lower jaw of cordulid nymphs is spoon-shaped at rest, but opens up to show irregular teeth while hunting.

## Phylum Arthropoda

Class Insecta

Order Odonata

Infraorder Anisoptera

Family Gomphidae

Clubtails

Gomphid nymphs reside at the pond bottom, hiding in mud, coarse sand, and gravel or below the cover of leaf litter. They are stout and flattened. They use their flattened body to burrow into the pond debris to hide from predators and ambush their prey. They are predators that feed on other small dragonfly nymphs, water mites, mayfly nymphs, and midge larvae.

Gomphid nymphs are characterised by a pair of short 4-segmented antennae. The third segment of the antennae is longer than the rest of the segments and appears to be flattened.


Gomphid nymphs are characterised by a pair of short 4-segmented antennae, with the third enlarged segment longer than the others.

**Phylum Arthropoda**

Class Insecta

Order Odonata

Infraorder Anisoptera

Family Libellulidae

Skimmers; Darters; Perchers

Libellulid nymphs reside at bottom of the ponds, hiding amongst roots, aquatic plants, leaf litter, and other pond debris. They are active during the night. Libellulid nymphs are ferocious predators, hunting on insects and tadpoles that are sometimes larger than themselves. Some libellulids nymphs hunt odonate nymphs, including their own family. Nymphs are characterised by their spoon-shaped lower jaw, which opens up to reveal short and regular teeth.

The spoon-shaped lower jaw opens up to reveal short and regular teeth on its margin.

## Phylum Arthropoda

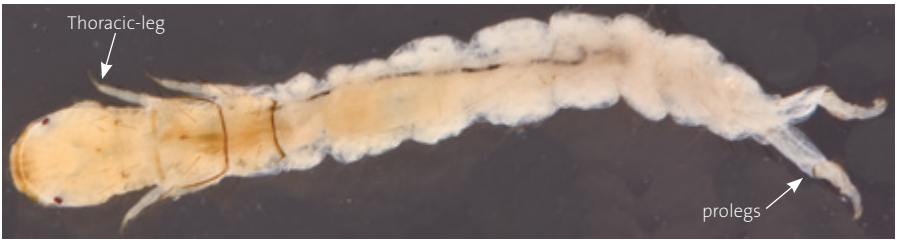
### Class Insecta

### Order Trichoptera

### Caddisflies

Trichopteran larvae live at the bottom of the ponds, either burrowing into loose sandy and silty substrata or hidden amongst vegetation. They have a hardened head that points downwards. At least the first thoracic segment of these larvae is also hardened with a plate; some groups have plates on two or all three thoracic segments. Their 9-segmented abdomen is fleshy and pale. Caddis larvae have three pairs of jointed legs attached to the thorax and a pair of prolegs on the last abdominal segment.

Trichopterans undergo a four-stage life cycle: eggs, larvae, pupae, and adults. Some trichopteran larvae form cases that protect themselves against predation, as retreats for ambushing prey and to increase the circulation of aerated water over their bodies. During the pupal stage, case-making trichopterans seal the ends of the cases to protect the non-feeding pupae.




Trichopteran larvae have three-pairs of thoracic legs and one pair of prolegs on the last abdominal segment. Each proleg may be segmented and bears a single claw.

Some trichopteran larvae make cases made by glueing together silt, sand, plant material or other pond debris using a kind of silk they produce.

## Phylum Arthropoda

Class Insecta

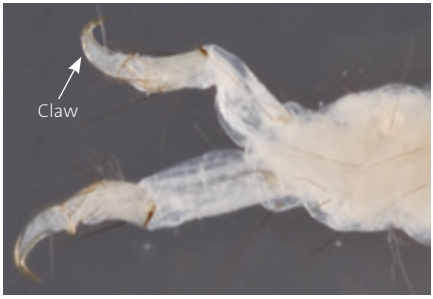
Order Trichoptera

Family Ecnomidae

Ecnomid larvae are free-living at the bottom of the pond, hidden within pond debris. They do not construct a case. All three thoracic segments of ecnomid larvae are hardened. Their abdominal prolegs are long; each bearing a large, curved claw.

Ecnomid larvae feed on a variety of food. Young larvae are detrivores that feed on fine organic particles, while older larvae are predators that feed on other invertebrates, such as midge larvae, other trichopteran larvae, and zooplankton.


An Ecnomid larva with three hardened thoracic segments.




The long prolegs attached to the last abdominal segment of an ecnomid larva each bear a large and curved claw.

**Phylum Arthropoda**

Class Insecta

Order Trichoptera

Family Hydroptilidae

Microcaddis

Hydroptilid larvae live at the bottom of the pond, on the surfaces of rocks and boulders or hidden amongst algae or plants. They possess a greatly enlarged abdomen that may appear swollen in comparison to the rest of the body. All three thoracic segments of hydroptilid larvae are hardened. A pair of reduced prolegs is present on the last-abdominal segment, each proleg bears a small claw. Hydroptilid larvae are small, typically between 4 and 6 mm in length.

Hydroptilid larvae feed on filamentous algae, micro-algae growing on rock surfaces, epilithic microalgae and periphyton. They form cases before developing into pupae. These cases are translucent and purse-like, formed by a glue-like substance the hydroptilid larvae produce.

Hydroptilid larva with a translucent, purse-like case that encloses its 'swollen' abdomen.

**Phylum Arthropoda**

Class Insecta

Order Trichoptera

Family Leptoceridae

Leptocerid larvae reside at the bottom of the pond hidden amongst debris or aquatic plants. They are detrivores or herbivores, feeding on the pond debris. These larvae build cases around themselves using small pieces of plants, sand grains or other debris. Leptocerid larvae have long hind-legs that are longer than their fore- and mid-legs. Only the first segment of the thorax is hardened; the second and third thoracic segments are not. Leptocerid larvae have reduced prolegs on the last abdominal segment.


Leptocerid larvae reside in constructed cases from which two long hindlegs protrude that stretch out further than the fore- and midlegs.

Reduced prolegs on the last abdominal segment of leptocerid larva.

## Phylum Arthropoda

Class Insecta

Order Trichoptera

Family Polycentropodidae

Polycentropodid larvae live amongst gravels and pebbles or plant material at the bottom of the edge of the pond. They are free-living (caseless) larvae with only the first thoracic segment hardened. The second and third thoracic segments remain fleshy, appearing similar to the abdominal segments. Polycentropodid larvae have long prolegs on their last abdominal segment, each bearing a large and hook-shaped claw.

The feeding strategies of polycentropodid larvae are varied. Some are predators, feeding on other invertebrates, in particular midge larvae, while others are filter-feeders, feeding on small food particles in the water.

Only the first thoracic segment of polycentropodid larvae is hardened, the second and third thoracic segments appear fleshy, similar to the abdominal segments.


The long prolegs on the last abdominal segment of polycentropodid larva bear a large hook-shaped claw.

## Class Chondrichthyes

Order Myliobatiformes

Family Potamotrygonidae

*Potamotrygon motoro* (Müller & Henle, 1841)

Motoro Ray

This is a cartilaginous fish that in native to Argentina, Brazil, and Paraguay, where it inhabits calm or slow-flowing waters on the sandy edges of lagoons, creeks, and streams. It is a popular aquarium fish and has been introduced into Singapore at least since 2006. Abandoned pets have established in some of the reservoirs.

The Motoro Ray has a circular disc covered dorsally with attractive black ocelli, and a short, thorny tail armed with one or two long venomous spines. It can attain a disc width of up to 60 cm disc width; sometimes larger. As with all rays and sharks, the male has a pair of sexual appendages (claspers) on each pelvic fin.

It feeds on molluscs, crustaceans, larva of aquatic insects, and other fishes.

Motoro Rays reach sexual maturity during their third year. They are ovoviviparous; the young develop inside the mother and are born live and fully formed. The litter size ranges from 3 to 21. They can live for more than 20 years.

Motoro Rays are dangerous due to the venomous spine located on top of the caudal fin. The sting can cause immense pain and rapid tissue degeneration (necrosis) due to the venom; also expect headaches, nausea, and diarrhoea. Motoro rays are not aggressive and only use the sting in defence.

## Class Actinopterygii

Order Osteoglossiformes (Bony-tongues and relatives)

Family Osteoglossidae (Bony-tongued fishes)

*Scleropages formosus* (Müller & Schlegel, 1840)

Asian Arowana; Golden Dragonfish

This fish is introduced to Singapore. It is characterised by a bony tongue and a bony head. Its body is relatively deep with large scales. It has a pair of short barbels on the tip of the lower jaw.

The Asian Arowana is a surface-feeding predator and feeds on insects, shrimps, frogs, and other fishes. It is a popular aquarium fish. It is prized by many businessmen as it is symbolic of good luck and prosperity; it is also called Golden Dragonfish due to its superficial resemblance to dragons. It can grow to 90 cm long.

This species is an oral brooder. The male broods the eggs and young fry in his mouth. Water moving through the fish's gills keeps the eggs and fry well aerated. During brooding, the male parent does not feed.

The Arowana is a highly territorial fish.

## Order Cypriniformes (Carps and relatives)

Family Cyprinidae (Carps and relatives)

*Cyprinus carpio* (Linnaeus, 1758)

Common Carp; Koi

The Common Carp belongs to the largest family of freshwater bony fish. This family of fish is distinguished by toothless jaws. Instead, they have pharyngeal teeth set in one to three rows. These 'teeth' help to masticate food such as vegetable matter and invertebrates. Cyprinids usually have a terminal or inferior mouth, with none or two pairs of barbels.

The Common Carp is a heavy-bodied fish with large and rounded scales. Like all carps, it has only a single dorsal fin. It has a pair of fleshy barbels on its relatively small and protrusible mouth (unlike Goldfish, which have no barbels). It is omnivorous, feeding on both plants and invertebrates.

The Common Carp is native to Europe and was introduced into Singapore as food fish. It is a rather hardy fish and can survive better than most fishes in polluted water, thus it can out-compete native species easily. It can grow to 1 m or more.

*[photo: many koi in ponds] and [photo: close-up of koi]*

The colour of Common Carp may range from grey to brassy green. Colourful varieties are commonly known as 'Koi', and are prized as ornamental fish and can be commonly found in landscaped ponds.

## Order Siluriformes (Catfishes)

Family Clariidae (Walking Catfishes)

*Clarias batrachus* (Linnaeus, 1758)

Common Walking Catfish

The Walking Catfishes are air-breathers and can survive out of water for considerable periods as long as they are kept moist. Their head are broad, bony, and flattened. Many have smooth bodies and lack scales. They have long dorsal and anal fins which are without spines. They also have strong pectoral fin spines, which enable the fish to 'walk' from one water body to another, aided by a wriggling movement of the body. They have four pairs of long barbels around the mouth which serve a sensory function.

Walking Catfishes inhabit freshwater ponds, streams, swamps, and even ditches and canals. They are very tolerant of stagnant, polluted, muddy waters. They are nocturnal predators of small fish and invertebrates. During the day, they hide under debris or burrow into the mud. They have an accessory respiratory organ above their gills which allow them to use atmospheric oxygen. They can also breathe through their skin and can live out of water for quite some time. They can grow to 80 cm long.

The strong spine on the pectoral fins of a Walking Catfish (*Clarias batrachus*) can inflict a very nasty, painful wound if mishandled.

## Order Siluriformes (Catfishes)

### Family Loricariidae (Armoured sucking catfishes)

*Pterygoplichthys pardalis* (Castelnau, 1855)

Spotted-belly Armoured Sucker Catfish

The Sucker Catfishes, native to South America, were introduced into Singapore as a popular aquarium fish. They are very hardy and can survive in very polluted water. They can be found in a variety of freshwater habitats, including ponds, drains, reservoirs, and rural streams.

This fish is well-adapted to live at the bottom of ponds with its flattened ventral surface. The lips around its mouth are expanded to form a sucker disc which allows the fish to adhere to surfaces in fast flowing water. They feed mainly by scraping algae off submerged surfaces. They can also feed on small benthic organisms as well as feeding off detritus and scavenging on dead animal and plant matter. They can grow to around 60 cm.

The Spotted-belly Armoured Sucker Catfish (*Pterygoplichthys pardalis*) has rows of bony plates covering its body, like armour *(left)*. The expanded lips around the mouth allow the fish to cling to surfaces *(right)*.

## Order Cyprinodontiformes (Toothcarps)

### Family Poeciliidae (Live-bearing toothcarps)

The live-bearing toothcarps are fishes with small, upturned mouths. They have a single dorsal fin. They are sexually dimorphic (i.e. sexes differ in appearance). Males are smaller and tend to be colourful. Their anal fin is modified into an elongated tube called the gonopodium and is used to impregnate females. The fertilised eggs develop and hatch inside the females and the young are born alive and expelled through the urogenital opening. These omnivorous fish are native to tropical America.

## Order Cyprinodontiformes (Toothcarps)

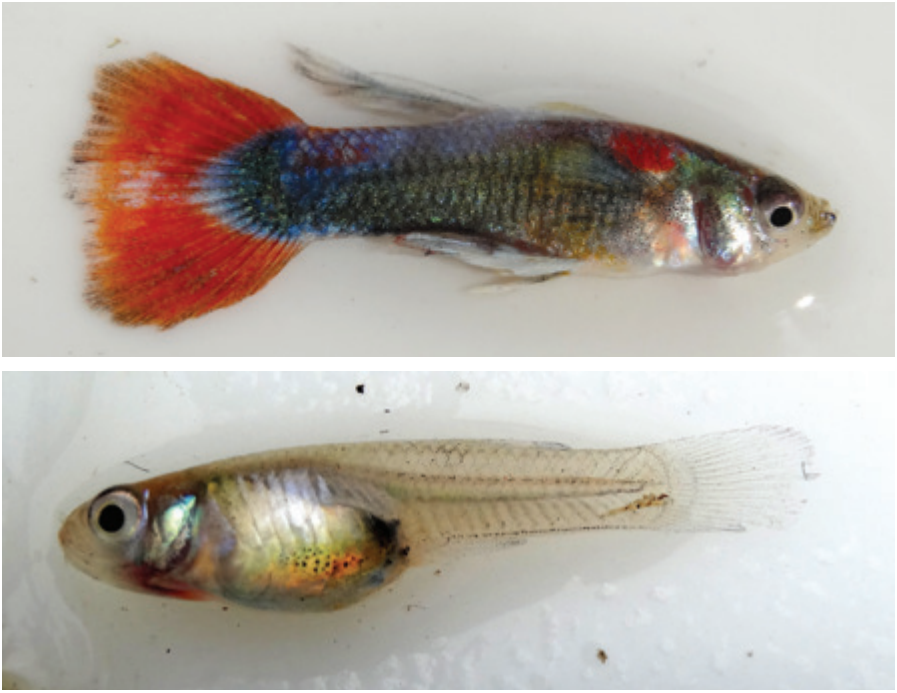
Family Poeciliidae (Live-bearing toothcarps)

*Poecilia reticulata* (Peters, 1859)

Guppy

The Guppy is a a very hardy, introduced species and can live in a variety of water bodies, including brackish water, polluted canals, and even sewage tanks. They are absent from forest streams. They are very common and usually found in small schools of three or more individuals. The species is sexually dimorphic. The males are more colourful and have longer and fuller fins. The females are larger than and not as attractive as the males.

As with other members of the family, the Guppy gives birth to live young. Guppies breed profusely, giving birth to 30 fry at a time (another common name is 'Millions Fish'. Males grow up to 3 cm and females up to 5 cm.



The guppy (*Poecilia reticulata*) was intentionally introduced into Singapore (in the early 1900s) to control mosquito breeding. Breeders develop a wide variety of colours in males, ranging from brilliant blue and red to silvery white. Some also have elaborate patterns and various fin styles (ranging from round, square to sword shapes). The male *(top)* is much more colourful than the female *(bottom)*.

## Order Perciformes (Perches and relatives)

### Family Cichlidae (Cichlids)

The cichlids are medium-sized fishes, the largest species of which can grow to about 70 cm. They are all exotic to Singapore and originate from Africa, South America and India. They are the most common fishes in our freshwater habitats. Cichlids are characterised by a single nostril on each side of the head (a feature shared only with damselfishes (family Pomacentridae). They have a single dorsal fin with 13–19 spines. The caudal fin is typically rounded, truncated, or slight emarginated. Their body is laterally compressed. The lateral line is interrupted, with 26–40 scales. Cichlids are territorial and aggressive; some are even predatory.

## Order Perciformes (Perches and relatives)

### Family Cichlidae (Cichlids)

### *Oreochromis mossambicus* (Peters, 1852)

Mozambique Tilapia; Common Tilapia

Introduced by the Japanese during World War II and known by many locals as 'Japanese Fish', the Common Tilapia is very widespread in ponds, drains, canals, and reservoirs. It is a sexually dimorphic species. The mature male is black with a white throat and red fin edges, while the female is drab brown or grey. It grows up to 40 cm.

This species can tolerate water with very low dissolved oxygen levels as it can breathe atmospheric oxygen. Young fish are carnivorous or omnivorous while adults tend to feed on plants or detritus. Some large individuals are said to feed on small fishes, including their own kind. It is aggressive towards other species of fish.

Tilapia is a substrate spawner. The male can dig a large circular pit (approximately 1 m in diameter). The female broods her eggs and young fry in her mouth. She continues to look after them when the fry are free swimming. The young fry swim close to their mother for protection and swim into her mouth when they sense approaching danger.

A male Mozambique Tilapia (*Oreochromis mossambicus*).

## Order Perciformes (Perches and relatives)

Family Cichlidae (Cichlids)

*Geophagus altifrons* (Heckel, 1840)

Long-finned Eartheater

Introduced from South America, the Long-finned Eartheater can be found in slow-moving streams, ponds, and reservoirs. This fish is greyish in colour, with faint, vertical bands and bluish-green iridescent scales on their flanks. It has a habit of plunging its mouth deep into the substratum in search of food. It can grow to 25 cm long.

The Long-finned Eartheater (*Geophagus altifrons*) is well sought after by aquarists for their brilliant colours and large size.

## Order Perciformes (Perches and relatives)

Family Cichlidae (Cichlids)

*Tilapia buttikoferi* (Hubrecht, 1881)

Hornet Tilapia; Zebra Tilapia

The Hornet Tilapia (*Tilapia buttikoferi*) is a large, aggressive, and robust cichlid.

*Tilapia buttikoferi* was introduced to Singapore from Africa. This is a very hardy species that feeds on almost anything in the water. It has a white or yellow body with black bars. Size 40 cm.

## Order Perciformes (Perches and relatives)

Family Cichlidae (Cichlids)

Louhan

As Louhan gets bigger and are voracious and aggressive, many pet owners release the fish into ponds and reservoirs in Singapore.

The Louhan is actually an artificial hybrid between several South American cichlid species. It was produced by fish farms in Singapore and Malaysia in early 2000s. It is very popular aquarium fish and was a fad at one time—lucky numbers can apparently be perceived from the black markings on its body. This fish is able to breed and survive in the wild in Singapore. It can grow to about 40 cm long.

## Order Perciformes (Perches and relatives)

Family Eleotridae (Gudgeons/Sleepers)

*Oxyeleotris marmorata* (Bleeker, 1852)

Soon Hock; Marbled Gudgeon


The Marbled Gudgeon or Soon Hock (*Oxyeleotris marmorata*) is a native species which is commercially valuable food fish in Singapore and is cultured in cages.

The gudgeons are characterised by having no lateral lines (a feature shared with their relatives, the gobies (family Gobiidae)); instead, they have a system of sensory canals and pores and cutaneous papillae on their head. Unlike gobies, their pelvic fins are not fused to form a sucker. Gudgeons are also known as 'sleepers' as many species are ambush predators, lurking under cover to snatch small fish and crustaceans that venture too near. They are voracious predators, even preying on their own species.

The Marbled Gudgeon is native and found in streams, ponds, canals, and reservoirs. It is a sluggish fish and is found at the bottom of the substratum, where it ambushes its prey. In the field, this species is easily recognised by its short and broad head, stout body, blunt snout, symmetrical patterns on the dorsal surface and rounded, outstretched pectoral fins. The sensory papillae on the head are arranged in transverse pattern. The teeth are arranged in several rows in the jaws; they are usually small, sharp, and conical. They have two separate dorsal fins. They grow to a length of 50 cm.

## Order Perciformes (Perches and relatives)

### Family Osphronemidae (Gouramies and fighting-fishes)

*Osphronemus goramy* (La Cepède, 1801)

Common Giant Gouramy; Kalui

The Giant Gouramy (*Osphronemus goramy*) is considered an excellent food fish and is cultivated in fish ponds.

The young Giant Gouramy (*Osphronemus goramy*) looks rather different from the adult; it is very dark in colour and has transverse bars.

This family of gouramies is distinguished by its bulky appearance, a short spine in each pelvic fin, and a long, filamentous second pelvic fin ray that functions as a tactile organ. The dorsal fin is located nearer the tail.

The Giant Gouramy is introduced to Singapore. It is uncommon but is found in ponds and reservoirs. It has thick lips, giving it an almost smiling expression. It is mostly herbivorous and can grow to over 60 cm. The males is a nest builder and constructs a large, floating nest of vegetation along the banks.

## Order Perciformes (Perches and relatives)

### Family Channidae (Snakeheads)

Snakeheads have large depressed heads, large mouths, torpedo-shaped bodies, and long-based dorsal and anal fins. They have an accessory breathing organ located on the upper part of the gill chamber and are able to breather atmospheric oxygen. They will drown if denied access to the water surface. Snakeheads have sharp teeth and are sit-and-wait predators of small fish, crustaceans, insects, and frogs, sucking unsuspecting prey into their mouth when they venture too close. They are egg-layers and usually both parents will guard their brood until the young disperse. They would even challenge large animals, including man, when their young are threatened.

## Order Perciformes (Perches and relatives)

### Family Channidae (Snakeheads)

#### *Channa micropeltes* (Cuvier, 1831)

#### Toman

This is the largest snakehead in Singapore, growing up to 1 m in length. It is non-native and commonly found in disturbed forest streams, ponds, and reservoirs. It is cultured as a game fish, for it is a good fighter when hooked. Eggs are laid in a nest of sunken vegetation near the shore and fiercely protected by the parents. Juvenile fish gather in large shoals for safety.

The jaws of the Toman are lined with sharp teeth.

## Order Perciformes (Perches and relatives)

### Family Channidae (Snakeheads)

*Channa striata* (Bloch, 1793)

Aruan

This native fish is the most common snakehead locally. It can grow to over 90 cm. It is a very hardy and versatile fish, and can be found in forest streams as well as ponds and reservoirs. It is largely solitary and lurks near the bottom, hiding among aquatic plants to ambush small fish and shrimps. When nesting, both the males and females construct a nest of vegetation in shallow water. The eggs are fiercely guarded by the male.

The Aruan is commonly sold in local wet markets. They are valued by local Chinese, as soup with Aruan is said to be highly effective for healing bodily wounds, and is traditionally recommended for post-operation patients.

## ADDITIONAL READINGS

There are numerous other texts for those want to find out more about freshwater life in Singapore. Here are some recommended readings:


**Freshwater Life**

Bhathal, R. S. and Foo, T. K. 1981. *A Guide to Pond Life*. Singapore Science Centre, Singapore.

Ng, P. K. L. 1992. *Freshwater Life in Singapore,* Revised Edition. Singapore Science Centre, Singapore.

Ng, P. K. L., Corlett, R., Tan, H. T. W. (Eds.). 2011. *Singapore Biodiversity: An Encyclopaedia of the Natural Environment and Sustainable Development*. Editions Didier Millet, Singapore.

Yeo, D.C.J., Wang, L. K. and Lim, K. K. P. 2010. *Private Lives: An Exposé of Singapore's Freshwaters*. The Raffles Museum of Biodiversity Research, Singapore.

**Aquatic plants**

Yong, J.W.H., Tan, P. Y., Hassan, N.H. and Tan, S. N. 2010. *Selection of Plants for Greening of Waterways and Water bodies in the Tropics*. National Parks Board, Singapore.

**Macroinvertebrates**

Blakely, T.J., Harding, J.S., Clews, E. and Winterbourn, M.J. 2010. *An Illustrated Guide To The Freshwater Macroinvertebrates Of Singapore*. University of Canterbury, Christchurch, New Zealand.

Tang, H.B., Wang, L. K. and Hamalainen, M. 2010. *A Photographic Guide to the Dragonflies of Singapore*. The Raffles Museum of Biodiversity Research, Singapore.

Yule, C.M. and Yong, H.S. 2004. *Freshwater Invertebrates of the Malaysian Region*. Academy of Sciences Malaysia, Kuala Lumpur, Malaysia.

**Fish**

Larsen, H. K. and Lim, K. P. P. 2005. *A Guide to Gobies of Singapore*. Singapore Science Centre, Singapore.

Lim, K. P. P. and Ng, P. K. L. 1990. *A Guide to the Freshwater Fishes of Singapore*. Singapore Science Centre, Singapore.

**Alien Species**

Baker, N. and Lim, K. K. P. 2012. *Wild Animals of Singapore: A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes*. Draco Publishing and Nature Society (Singapore), Singapore.

NParks, 2009. International Day for Biological Diversity 2009: Invasive Alien Species. < http://www.nparks.gov.sg/cms/index.php?option=com_content&view=article&id=64&Itemid=159 > NParks, Singapore.

Yeo, C.J. and Chia C.S.W. (2010) Introduced species in Singapore: an overview. *Cosmos,* 06, No. (1).

**Water Quality**

Burger, D.B., Clews, E., Quek, R.F., Wang, J. 2012. *Guidelines on Water Quality Monitoring for Tropical Ponds*. CUGE Standards, CS C01: 2013. Centre for Urban Greenery & Ecology, NParks, Singapore.

## GLOSSARY

| | |
|---|---|
| **Abdomen** | The most posterior body part of an arthropod. It houses the reproductive organs and is responsible for a variety of functions (e.g. reproduction, digestion, respiration, locomotion) depending on the organism and the life stage |
| **Anal fin** | The unpaired fin on the ventral side, between the anus and the tail fin |
| **Antenna** (plural – antennae) | Elongate sensory appendage on the head |
| **Barbel** | An elongate fleshy tentacle-like projection, usually near mouth |
| **Caudal fin** | The tail fin |
| **Cephalothorax** | Fused head and thorax body parts as seen in shrimps, crayfish and arachnids |
| **Chitin cuticle** | The outer, non-cellular layer of the arthropod exoskelton, composed of a mixture of chitin and protein |
| **Compound eyes** | Eyes consisting of numerous separate light-sensitive elements. Present in most insects and some crustaceans |
| **Dorsal fin** | The fin on the fish's back |
| **Detrivores** | Animals that feed on decomposing organic matter |
| **Exoskeleton** | External skeleton or outer covering (body wall) of arthropods |
| **Filter feeders** | Animals that feed by filtering food particles such as algae, zooplankton, decomposing plant and animal material from the water |
| **Gonopodium** | Modified anal fin of some male fish, that is used as an organ of copulation |
| **Gills** | Respiratory organs generally consisting of a thin walled structure that enables aquatic animals to take oxygen from water and to excrete carbon dioxide |
| **Haemoglobin** | A red protein that is responsible for carrying oxygen around the body |
| **Herbivores** | Animals that feed on plant tissue |
| **Inferior mouth** | A mouth that points downward, with the upper jaw longer than the lower jaw |

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|---|---|
| **Larva** (plural – larvae) | The immature stage of insects. Specifically, the larva is the life stage that follows the egg stage; before the pupal stage of insects with a complete life-cycle and before the adult stage of insects with an incomplete life cycle |
| **Metamorphosis** | The process of transformation from an immature form to an adult form in two or more distinct stages |
| **Moulting** | The periodic shedding of the exoskeleton in arthropods |
| **Nymph** | Insect larvae are also called nymphs |
| **Omnivores** | Animals that feed on both plant and animal tissue |
| **Operculum (in gill-bearing snails)** | A lid-like covering capable of closing the opening of a calcareous shell |
| **Parasites** | Animals living in or on another organism to obtain nutrition |
| **Pectoral fins** | A pair of fins usually situated behind the head, one on each side |
| **Pelvic fins** | A pair of fins situated behind or below the pectoral fins |
| **Pharyngeal teeth** | Teeth within the pharynx (back part of the throat) |
| **Pincers** | Jointed grasping appendages present in some crustaceans (e.g. shrimps and crayfish) |
| **Predators** | Animals that capture prey and consume live animals |
| **Proleg** | A fleshy false leg. Prolegs can found on the thorax or abdomen of some insect larvae |
| **Pupa** (plural – pupae) | A transitional stage between larval and adult stages, where larval characters are lost and adult characters are gained. Seen only in insects with complete life-cycles |
| **Sucker** | A structure adapted for sucking for nourishment or for clinging to objects by suction |
| **Terminal mouth** | Mouth located at the front end of the head |
| **Thoracic legs** | Jointed legs that are attached to the thoracic segments of insects. The three pairs of legs are known as fore-legs, mid-legs and hind-legs (from head to abdomen) |
| **Thorax** | The second or middle body part of insects that bears the true segmented legs and wings when these structures are present. In crustaceans and arachnids, the thorax and head are fused to form a single segment, the cephalothorax |

# INDEX

## About the Book

*A Guide to Freshwater Fauna of Ponds in Singapore* is an introductory naturalists' resource for the collection/survey and identification of macroinvertebrates and fish residing in local ponds. Brief ecological notes are also provided to enhance the reader's appreciation of the roles these ecosystems and their inhabitants fulfil in the environment.

## About the Authors

**Adam Quek** is a research associate in TMSI, NUS. Through his involvement in biomonitoring and research projects on ponds, streams, waterways and reservoirs in Singapore, he has acquired local expertise in characterising freshwater environments, identification of aquatic fauna and evaluation of water quality. His current research focus is on the investigation and evaluation of ecological concepts applicable to tropical habitats.

**Tan Li Yun** is a research assistant in TMSI, NUS. A recent graduate from NUS, she is familiar with research protocol and biotic assessment biodiversity from her participation in the Undergraduate Research Opportunities Programme in Science (UROPS) and Student Summer Exchange Programme to University of Costa Rica. Currently, she is involved in the development of ecological guidelines for ponds and other freshwater systems in Singapore.

**Wang Luan Keng** founded The Nature Workshop, which specialises in nature education. As part of her objectives to reach out to the schools and public, she has produced a series of educational publications on Singapore's biodiversity. She is also a field ornithologist and works on birds in Southeast Asia. Her research focuses on life-history tradeoffs in tropical birds. She works with many organisations and government agencies on various topics related to bird population management, bird dispersal, and introduced species.

**Esther Clews** leads the Inland Waters cluster of the Ecological Monitoring, Informatics and Dynamics (EMID) Group at TMSI, National University of Singapore. Her research over the last 12 years has centred on characterising freshwater environments and identifying interactions between landscapes, habitats, water quality and biota. She works closely with governmental agencies and researchers from a range of disciplines (engineering, geology, geography as well as biosciences) applying monitoring data and standard survey techniques to develop systems understanding and inform and evaluate management.

## About TMSI and EMID

The Tropical Marine Science Institute (TMSI) is a centre of excellence for research and development in tropical marine science, regionally and internationally. TMSI is a national resource centre in tropical marine science which embraces multi-disciplinary research across aquatic and environmental sciences. The Institute plays a leading role in research and development, as well as education, both at national and international levels.

Ecological Monitoring, Informatics and Dynamics (EMID) research revolves around a cross-disciplinary, quantitative approach with a strong focus on operations and management, towards the overarching goal of sustainable resource management. The Inland Waters Cluster of the EMID research group applies freshwater research through the development of assessment tools and environmetrics to ecological appraisal and prediction.

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