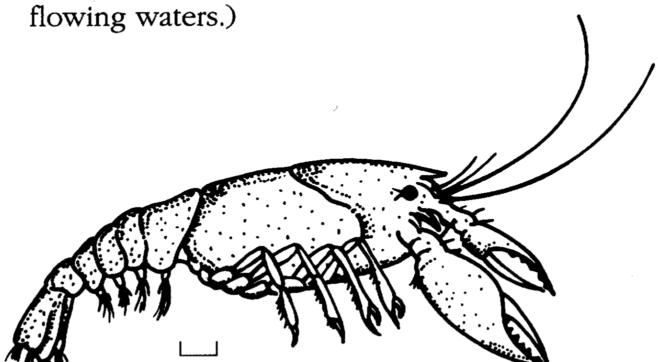
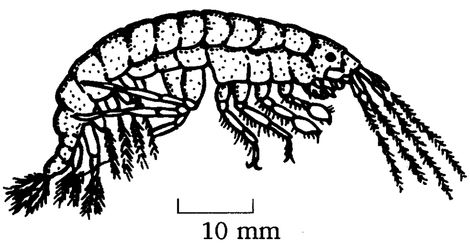
Yabbies (Class Crustacea, Order Decapoda, Family Parastacidge)
Yabbies are large (up to about 20 cm), robust crustaceans with strong grasping forelegs ('pincers'). They are smooth-shelled and generally light brown or blue-black in colour. Yabbies feed mainly on dead plant material, but may also eat invertebrates, algae and living plants. They can tolerate a wide range of water temperatures and oxygen levels. (Murray crayfish look similar to yabbies, but have ornately spined bodies and large white claws. They prefer cool, well oxygenated, flowing waters.)



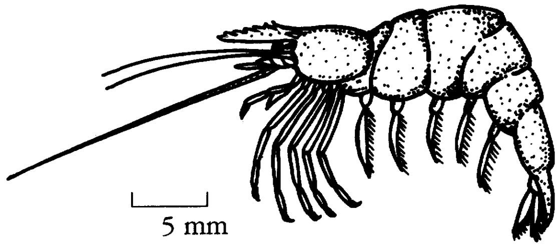
Yabby

Amphipods, scuds or side-swimmers (Class Crustacea, Order Amphipoda)
These are small crustaceans (up to about 10 mm long) have laterally compressed bodies (that is, flattened from side to side) and seven pairs of walking legs. They feed mostly on organic detritus, aquatic vegetation or by scavenging dead animals.



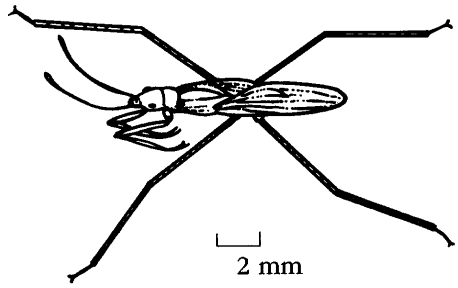
Scud or side-swimmer

Shrimps (Class Crustacea, Order Decapoda, Family Atyidae)
Shrimps are small (up to 2-3 cm long), transparent, fast-moving crustaceans, with long slender legs. They commonly live among aquatic plants or loose stones especially in slow flowing areas, and scavenge for their food - comprising of dead animals and aquatic vegetation.

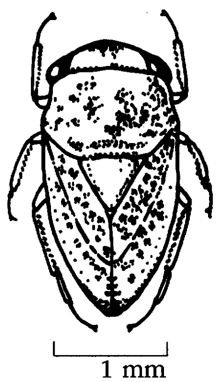


Shrimp

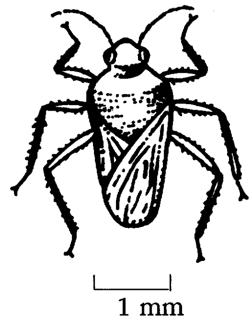
Water bugs (Class Insecta, Order Hemiptera)
You can identify water bugs by their beak-like mouthparts, which they use for piercing their prey and extracting body juices. Immature and adult water bugs look similar except that the adults have wings, which are leathery near the base and membranous (film-like) towards the tip. They can be found among aquatic plants on the water surface or swimming through slowly flowing or still water. All water bugs are carnivorous, feeding on animals. Many common pond and river insects - such as water boatman, backswimmers, water scorpions and pond skaters - belong to this Order.



Water strider or pond skater



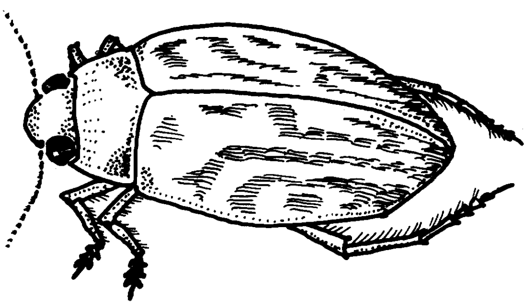
Pigmy backswimmer



Water cricket

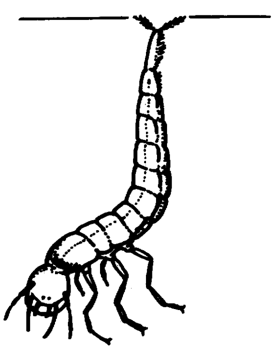
Other beetles (Class Insecta, Order Coleptera)
Various beetle adults and larvae can, as a general rule, be found in water of poorer quality than that inhabited by elmids. Some common ones are listed here.

Diving beetles (Family Dytiscidae)
The adults are hard, oval and smooth, with flat, hair-covered hind legs that act as oars or paddles. They range from about 5 to 25 mm long and, although generally dark, some may be brightly coloured. Air carried in a chamber beneath their wings allows diving beetles to stay submerged for long periods. Like their larvae, which are sometimes called water tigers, they are voracious predators. The larvae are mostly elongated slender animals, with two long, curved piercing jaws through which they suck the body juices of their prey.



1 mm

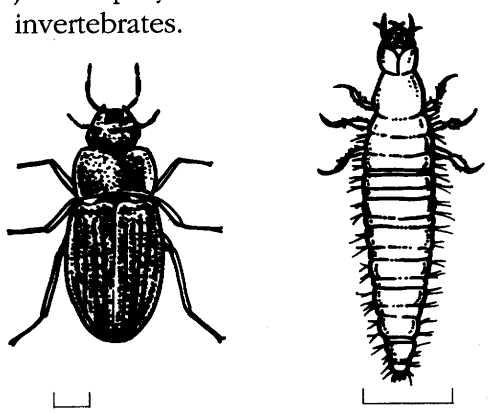
Diving beetle (adult)



1 mm

Diving beetle (larva)

Water-scavenger beetles (Family Hydrophilidae).
The adults range in length from 1 mm to more than 40 mm. They are dark, smooth and oval-shaped - somewhat like diving beetles - but can be distinguished by their short club-like antennae and their habit of hanging, head-uppermost, from the water surface. Also, when these beetles dive they carry a silvery layer of air across the under (or ventral) surface of the body. The mainly herbivorous adults feed on living and dead plant materials; however, most of the generally slender and flattened crawling larvae use their large crushing jaws to prey on other macro-invertebrates.

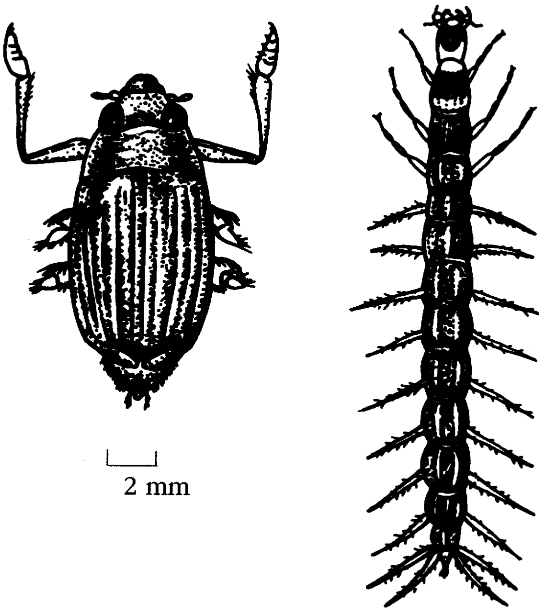


1 mm 2 mm

Water scavenger

(adult) (larva)

Whirligig beetles (Family Gyrinidae)
The common name comes from the adults' habit of swimming rapidly in irregular curves on the water surface. These too are dark, smooth and oval in shape, up to 2cm long or less, with long slender front legs and flat middle and hind legs. The division of their eyes into top and bottom portions enables them to see both above and below the surface, which helps them to locate their prey - mainly insects that have fallen onto the water. The larvae have three pairs of legs, plus ten pairs of feathery gills on the sides of the abdomen, and are also predators, eating aquatic animals.



2 mm

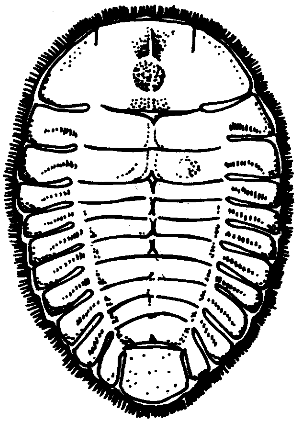
10 mm

Whirligig beetle

(adult) (larva)

Water pennies (Family Psephenidae)

In this case the name comes from the brown, flattened, oval larvae, up to 12 mm long, because they looked rather like the coins in our former currency. These larvae stay pressed flat against stones in fast-flowing sections of stream, where they graze on the algae growing on the stones. Adult water pennies live only a short time (from a few days to 3 weeks) and are rarely collected.



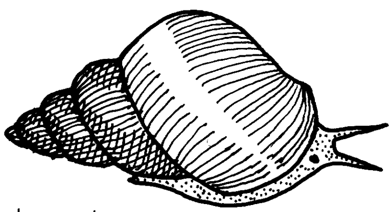
1 mm

Water penny (larva)

4. Tolerant

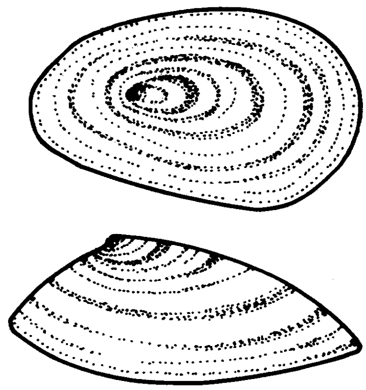
Snails and limpets (Phylum Mollusca, Class Gastropoda)

Both snails and limpets are soft-bodied animals with hard, resistant shells, which are coiled in the former case but flattened and cap-like in limpets. Limpets - usually small (less than 6 mm diameter) - commonly occur on the leaves of submerged plants. Both animals are mainly herbivorous, grazing on the algae that coat most submerged surfaces.



1 mm

Snail

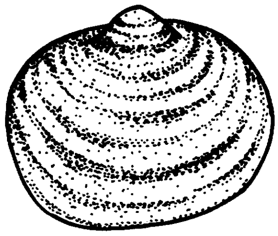


1 mm

Limpets

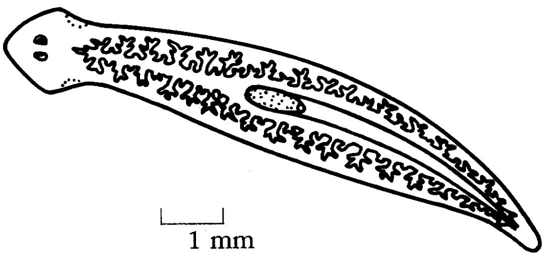
Bivalves or mussels (Phylum Mollusca, Class Bivalvia)

These molluscs have two shells joined by a hinge. They feed by filtering food particles (plankton and fine organic matter) through their gills. Orb-shell mussels (Family Corbiculidae) have solid, strong sculptured shells 15-25 mm long and live in fairly swift-flowing shallow rivers or creeks. Pea-shell mussels (Family Sphaeriidae) have thin, weakly sculptured shells 2-10 mm long and live in mud in streams and ponds. Freshwater mussels (Family Hyriidae) are much larger than the other bivalves and can grow up to 150 mm. Some species occur only in rivers and others only in lakes and billabongs. Rivers mussels rarely survive in water with low oxygen levels.



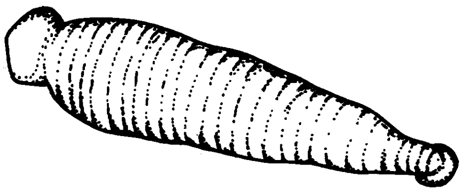
5 mm
Orb-shell mussel

Flatworms (Phylum Platyhelminthes, Class Turbellaria)
These small (usually less than about 15 mm long), soft-bodied, flattened animals glide over the surface of plants and stones. They are mostly scavengers, feeding on soft or decomposing animal matter.



1 mm
Flatworm

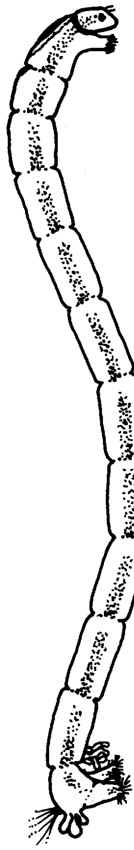
Leeches (Phylum Annelida, Class Hirudinea)
Suckers at each end of the body distinguish these worm-like animals, which can be brightly coloured or dark. Some leeches take blood from animals such as frogs, fish and turtles, while others do not feed on blood but prey on other invertebrates or scavenge for their food.



1 mm
Leech

5. Very tolerant

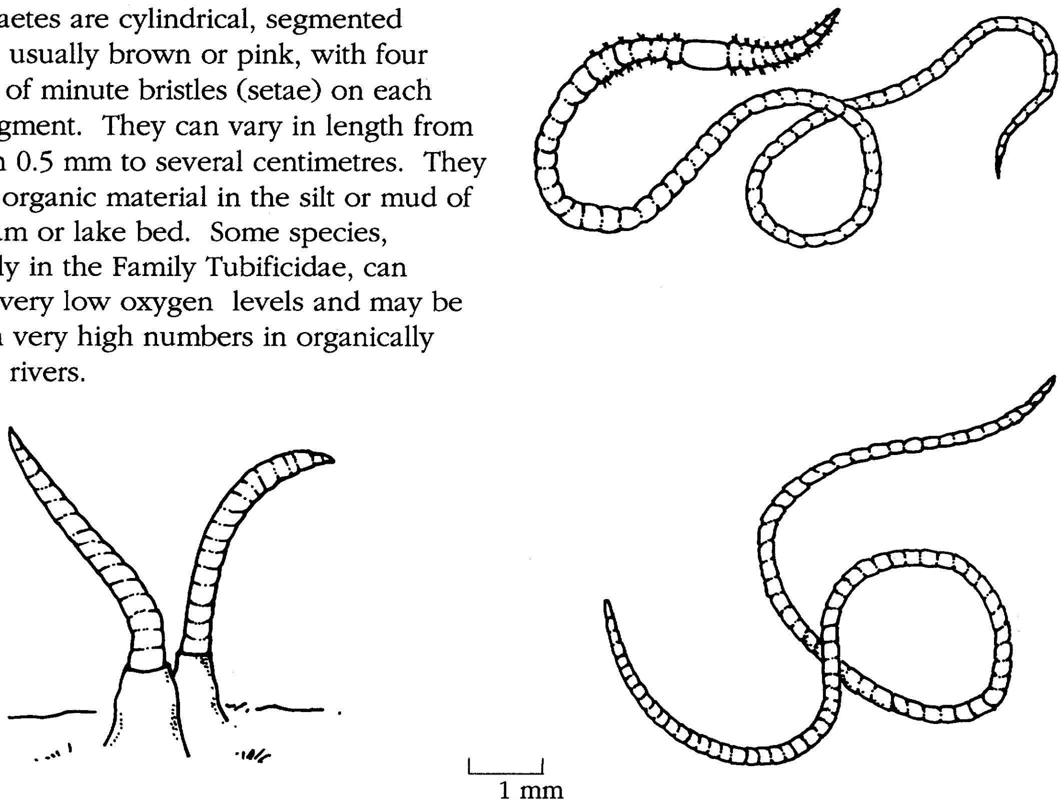
Chironomids or midge larvae (Phylum Arthropoda, Class Insecta, Order Diptera, Family Chironomidae)
The slender, worm-like larvae may grow in to 15 mm long, with one pair of short fleshy legs below the head and another pair at the tail end. They may be white, green or red. Red chironomids, called 'bloodworms', are often found in water with very low oxygen levels. Some species, however, occur only in cool. well-oxygenated mountain streams. Chironomids vary in their feeding habits: some eat algae, others live on detritus (fine organic matter) and some are predators.



1 mm
Chironomid

Freshwater worms (Phylum Annelida, Class Oligochaeta)

Oligochaetes are cylindrical, segmented animals, usually brown or pink, with four bundles of minute bristles (setae) on each body segment. They can vary in length from less than 0.5 mm to several centimetres. They feed on organic material in the silt or mud of the stream or lake bed. Some species, especially in the Family Tubificidae, can tolerate very low oxygen levels and may be found in very high numbers in organically polluted rivers.



Freshwater worms

Recording your findings for tolerance ranking method

Follow these steps to get a broad indication of stream health using tolerance ranking.

1. Look at the numbers of animals in each group that you have recorded on your record sheet. Identify the two groups with the most animals.
2. Fill in the names of these two groups in the dominant-species section of the Macro-invertebrate Record Sheet.
3. Look up the ranking of each of your two dominant groups. Referring to the water quality table below and the example, given, rank your water quality based on the dominant groups you have recorded.

The two dominant groups in this example were worms and snails. Worms are 'Very tolerant' and snails are 'tolerant'. Circle the appropriate ranking across the top and the left-hand side of the table, ('very tolerant' across the top and 'tolerant' down the left-hand side). Read into the centre of the table to where the column and row intersect. This gives you an indicator of the water quality based on your two dominant groups of macro-invertebrates; the example below gives the rating 'degraded - poor'.

Water quality indicator table using tolerance ranking of macro-invertebrates

Dominant group 1 e.g., worms — **Dominant group 2 e.g., snails**

	Very tolerant	Tolerant	Medium	Sensitive	Very sensitive
Very tolerant	Degraded	Degraded - poor	Poor	Medium	Good - medium
Tolerant	Degraded - poor	Poor	Poor	Medium - good	Good
Medium	Poor	Poor	Medium	Medium - good	Good
Sensitive	Medium	Medium	Good	Good	Excellent

Macro-invertebrate count and water quality

If you find	it suggests
Little variety of organisms, with great abundance of each kind.	Water overly enriched with a selective pollutant such as organic matter.
Only one or two kinds of organisms, in great abundance.	Severe organic pollution.
A variety of organisms, but only a few of each kind or no organisms, but the stream appears clean.	Stream has undergone flooding or scouring.
No animals.	Toxic pollution.

Method two - surveying macro-invertebrate variety

You can determine whether or not a site is polluted by comparing a monitoring site with a reference site. This method was developed by an aquatic biologist, Charles Hocutt, and its technical name is the Hocutt's Ordination Technique.

It involves assessing the 'healthiness' of a stream by comparing the kinds (variety) of macro-invertebrates and numbers (abundance) found at your monitoring site compared to the reference site. Generally, a 'healthy' water body would have greater variety and numbers of macro-invertebrates than an 'unhealthy' one. This 'healthiness' assessment is a relative one, which will depend on the stream, the sampling season and the collecting method. It is a good method to use to monitor one site or a section of stream over time, but not suitable for comparing sites in different streams or sections of catchment, or sites where the samples have been collected using different sampling techniques - say, sweep nets at one site and kick nets at another.

The purpose of the **reference site** is to provide a gauge against which to measure numbers of macro-invertebrates at your monitoring site. Your macro-invertebrate reference site should therefore:

- be located upstream but still in the same section of catchment as your monitoring site (for example, both in the middle catchment section of the stream)
- be located away from known or expected sources of pollution
- have a similar stream-bed to your monitoring site so that you can use the same sampling procedure - say, sweep net sampling - at both sites
- be sampled at the same time as your monitoring site, so as to provide a direct comparison in time.

Collecting the sample

Select the macro-invertebrate sampling method suitable for the stream-beds at both your reference and monitoring sites - that is, sweep net, kick net, or artificial substrate sampler (see instructions on sampling procedure earlier in this section of the manual).

Conduct the following sampling procedure at both sites.

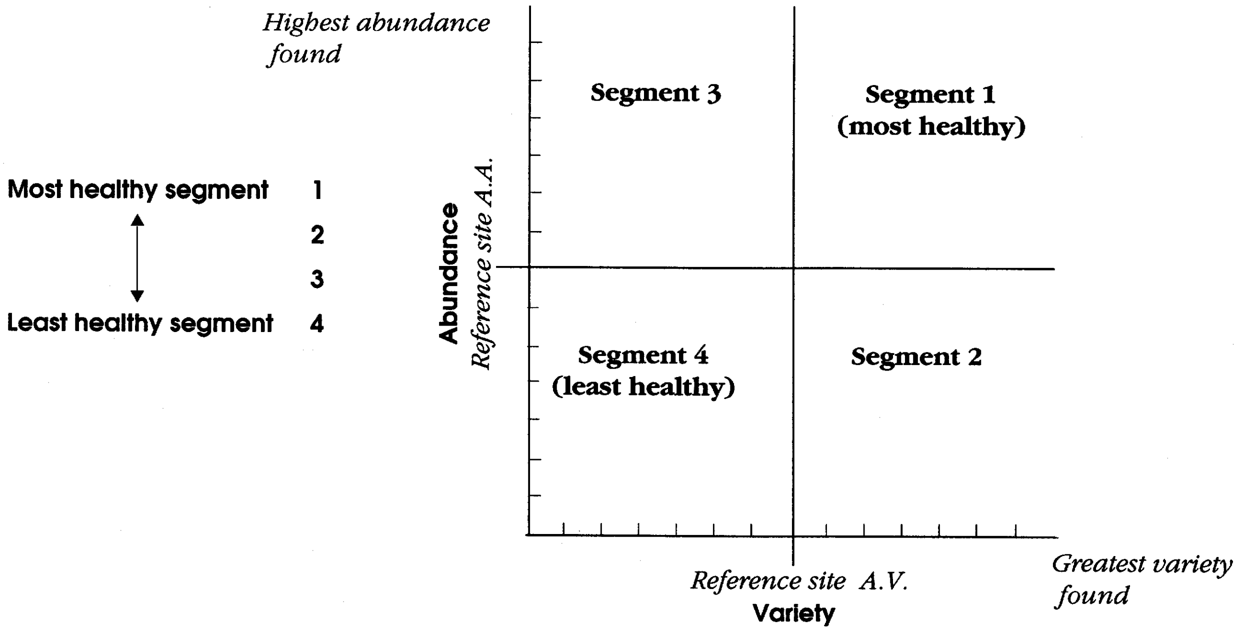
1. Collect a sample and empty it into a tray. Count the total number of individual macro-invertebrates in your sample, and record this number (the abundance figure) on the Macro-invertebrate Record Sheet.
2. Next, group together all the specimens of the same kind (that is, the same taxa or whatever classification level you can identify them to) and put each group into a separate container. Count the number of different groups of macro-invertebrates in your sample and record this number (the variety figure) on your Macro-invertebrate Record Sheet.
3. Repeat this procedure for two more samples at your monitoring site, making sure to sample upstream from your last sample so as to avoid site disturbance affecting your results.

   For example, walk two steps upstream from your earlier site.
4. Calculate the averages of these three samples and record these as the **average variety figure (A.V.)** and the **average abundance figure (A.A.)** on the Macro-invertebrate Record Sheet.

Plotting the results from your survey of macro-invertebrate variety

These figures **(A.V. and A.A.)** need to be plotted onto a 'graph' so that you can compare and interpret the figures from the monitoring and reference sites.

1. To make up your 'graph', mark both axes so that each includes the highest and lowest numbers found in your reference and monitoring site samples.
2. Plot the reference site's **A.A.** figure on the vertical axis and it's **A.V.** figure on the horizontal axis.
3. Divide the graph into four segments by drawing a line from the A.A. figure parallel to the horizontal axis, and a vertical line from the A.V. figure parallel to the vertical axis. You have now drawn up the 'graph' for your reference site onto which you can now plot your monitoring site figures and interpret the differences (see the example below).
4. Plot the A.A. and A.V. figures from your monitoring site onto your referenced 'graph' and determine which segment (1, 2, 3 or 4) it falls within.
5. Repeat sampling at your monitoring site over time and plot its A.A. and A.V. figures on your 'graph' to plot your results over weeks or months.



The four segments of the 'graph' are determined by the A.A. and A.V. counts from your reference site. (N.B. These segments may not always be squares.) Each of the four segments of the 'graph' represents a different combination of variety and abundance.

A 'healthy' community would be expected to have high abundance of individuals (A.A.) and high variety (A.V.) and so would lie in Segment 1. Segment 4, with low abundance and low variety, is the least 'healthy'. 'Healthiness' will increase from segment 4 towards any of the other segments.

Interpreting the results from your survey of macro-invertebrate variety

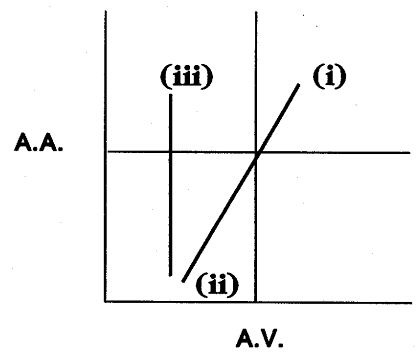
To interpret your results from this variety and abundance counting method, compare the position of your monitoring site with respect to your reference site by noting which segment of the 'graph' the monitoring site falls in. You can then interpret your results to see whether a stress (such as a pollution impact) has occurred between sampling times at your monitoring site. You can plot how variety changes over time to monitor the healthiness of your site.

Example

(i) monitoring site before effluent discharged into stream **(high variety and abundance - healthy)**

(ii) monitoring site immediately after effluent discharge into stream **(low variety and abundance - unhealthy)**

(iii)monitoring site after sustained effluent discharge **(increased abundance of organisms tolerant of effluent)**



Other examples

If the point lies in:

- **segment 1**, then the monitoring site has a higher variety and higher abundance than the reference site and therefore is 'healthier' than the reference site
- **segment 2**, then the monitoring site has a higher variety, but lower abundance than the reference site: this suggests a non-selective stress like a flood or scouring effect which may be a natural rather than a human-caused event
- **segment 3**, then the monitoring site has a lower variety and higher abundance than the reference site, and may be subjected to a selective stress (such as organic pollution) in which some species tolerant to that stress can survive and reproduce effectively
- **segment 4**, then the monitoring site has a lower variety and lower abundance than the reference site: this suggests a toxic stress (for example, pesticides, heavy metals) that affects both species and abundance

Note: If the co-ordinates for the monitoring site are very close to the reference lines on the 'graph' then its placement in any segment of the 'graph' is suspect, and careful comparison between the types of animals should be made.

Macro-invertebrate Record - Sheet 1

Complete a Site Description Sheet each time you conduct a biological survey.

Name of monitoring group:	
Person(s) conducting the Survey/Test:	

		Site grid reference
Date of Survey or Test: / /	Easting (4-digit no.)	
Time of Survey or Test: a.m./p.m.	Northing (5-digit no.)	

Type of net(s) used and net mesh size:

Tolerance ranking method

Record, in the correct column for your sampling method (kick or sweep net, or A.S.S.), the number of each of the following macro-intertebrates you collected in the sample. Duplicate this Record Sheet if you sample on more than two occasions.

Tolerance Ranking	Sampling Date	1 Kick	Sweep	A.S.S.	2 Sweep	Kick	A.S.S.
Very sensitive	stonefly nymphs						
Sensitive	mayfly nymphs						
	caddis-fly larvae						
	elmid beetles						
Medium	dragon-fly & damsel-fly nymphs						
	mites						
	yabbies						
	amphipods						
	shrimps						
	water bugs						
	Other beetles e.g. diving beetles, water pennies etc.						
Tolerant	snails & limpets						
	bivalves or mussels						
	flatworms						
	leeches						
Very tolerant	chironomids						
	worms						
Other							
Dominant groups		Dominant group 1 ____ Tolerance rating ____ Dominant group 2 ____ Tolerance rating ____			Dominant group 1 ____ Tolerance rating ____ Dominant group 2 ____ Tolerance rating ____		
Broad water-quality ranking							

Macro-invertebrate Record - Sheet 2

Method One - Tolerance ranking technique

Referring to your completed table on sheet 1:

1. Identify the two dominant groups (the ones with the most animals) in your sample and record these names on the dominant groups section of the table.
2. Below their name, fill in the tolerance ranking of your dominant groups (referring to the table or biological descriptions).
3. Referring to the water quality indicator table below, rank your water quality based on the dominant groups you have recorded. To do this, circle the appropriate ranking across the top and the left-hand side of the table for the dominant groups you recorded - say, 'very tolerant' across the top and 'tolerant' down the left-hand side. By starting at these rankings, read into the centre of the table to where they intersect. This gives you an indicator of the overall water quality based on your two main groups.
4. Write in your broad water-quality ranking in the table on the previous page.
5. See the example earlier in this section of the manual.

Water quality indicator table

	Very tolerant	Tolerant	Medium	Sensitive	Very sensitive
Very tolerant	Degraded	Degraded - poor	Poor	Medium	Good - medium
Tolerant	Degraded - poor	Poor	Poor	Medium - good	Good
Medium	Poor	Poor	Medium	Medium - good	Good
Sensitive	Medium	Medium	Good	Good	Excellent

Macro-invertebrate Record - Sheet 3

Method Two - Surveying macro-invertebrate variety and abundance

Sampling method:	☐ **kick net**	☐ **sweep net**	☐ **artificial substrate sampler**		
Size of mesh in net:			**Length of time A.S.S. left submerged**		

		Reference Site	**Monitoring Site**	**Monitoring Site**	**Monitoring Site**
Date sampled:					
Total no. of individuals in sample: (Abundance)	**sample 1**				
	sample 2				
	sample 3				
Average (A.A.)					
Total no. taxa in sample: (Variety)	**sample 1**				
	sample 2				
	sample 3				
Average (A.V.)					

1. Draw the axes for your 'graph' and mark each axis so that it covers the highest and lowest abundance and variety figures.
2. Plot the reference site's A.A. figure on the vertical axis and its A.V. figure on the horizontal axis and divide the graph into four segments by drawing a line from the A.A. figure parallel to the horizontal axis, and a vertical line from the A.V. figure parallel to the vertical axis.
3. Plot your monitoring site co-ordinates onto this 'graph'.
4. Repeat macro-invertebrate sampling at this site over time and plot these monitoring site co-ordinates.

Interpretation of your 'graph' results and background.