

A Citizen's Guide to Biological Assessment of Wetlands

The Macroinvertebrate Index of Biological Integrity (IBI)

*Field and Laboratory Protocols,
Pictorial Keys to Wetland Invertebrates*



**Minnesota Pollution Control Agency
Saint Paul, Minnesota 2002
data sheets revised 2021**

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The Macroinvertebrate Index of Biological Integrity (IBI)

By Dr. Judy Helgen

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revised 2021

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This guide is dedicated to all those who care enough about the fragility, diversity and beauty of healthy wetlands to give their time, energy and spirit to understanding their condition and to trying to protect them for the future benefits of all of life.

A Citizen's Guide to Biological Assessment of Wetlands: The Macroinvertebrate Index of Biological Integrity (IBI)

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A Citizen's Guide to Biological Assessment of Wetlands:

The Macroinvertebrate Index of Biological Integrity (IBI)

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Summary

This Guide provides the framework and protocols for citizens to do biological monitoring and assessment of wetlands. It is the basis for the training sessions held in June before citizens go with team leaders to sample wetlands in their local area. The Guide provides details for the field and laboratory protocols including data sheets and metric scoring sheets for scoring the IBI. Six metrics are rated for the IBI total score: the Leech Taxa Metric, the Corixidae Proportion Metric, the Dragonfly-Damselfly Taxa Metric, the ETSD Taxa Metric, the Snail Taxa Metric and the Total Taxa Metric. Background for the identifications of typical wetland invertebrates is given, including tips for identifications, an illustrated glossary, a list of taxonomic names, and eighteen pages with pictorial keys to the wetland invertebrates.

Acknowledgements

This Guide has been produced with funding assistance from US EPA to the Minnesota Pollution Control Agency. The Guide has evolved over many years of experience with training citizens and team leaders in Dakota County, Minnesota, and more recently Hennepin County. The input and commitment of Mary Kay Lynch and Margot Monson were very important for the final revision of this Guide. Joel Chirhart and Mark Gernes of MPCA were very helpful in the development of the citizen monitoring protocols. Dan Huff and Charlotte Shover of Dakota County, and Tim Reese of Hennepin County provided the organizational skills and passion to draw in many interested citizens and team leaders. Lastly I want to thank the many citizens and team leaders who have given so much of their time, energy and commitment to learn about and assess the quality of wetlands. Their feedback and suggestions on ways to make the protocols, the training and the materials in the Guide more understandable have been critically important in shaping this Guide.

The figures in the Guide are redrawn from figures from several publications. The publishers who have graciously given permission for use of specific figures are the Canadian Museum of Nature, Ottawa, Ontario Canada; the Lyons Press, Guilford CT; Roy Sawyer and the University of Illinois Press; John Wiley and Sons, Inc., NY; Jones and Bartlett Publishers, Sudbury, MA; the Royal Ontario Museum of Canada, Toronto, Canada; and Matthew Burne, Massachusetts Division of Fisheries and Wildlife. Details about the publications and the figures used are given in the Appendix 1 at the end of the Guide.

A Citizen's Guide to Biological Assessment of Wetlands: The Macroinvertebrate Index of Biological Integrity (IBI)

INTRODUCTION

The purpose of this Guide is to provide the background information for citizens to do biological assessments of depressional wetlands by sampling the invertebrates, identifying them, scoring the metrics for the Index of Biological Integrity (IBI), and making an assessment of the condition of the wetland. This Guide includes protocols and data sheets for field sampling, protocols and data sheets for processing samples in the laboratory, metric scoring sheets for scoring the IBI, and a pictorial guide to the common invertebrates in wetlands. This Guide is used during an all day training session on the protocols, identifications and data handling for scoring the IBIs. The training is held in early June. Following the training each team of volunteers with their team leader proceed to sample a few wetlands in their local area. The teams are brought together after the field season to share experiences and data for their wetlands. Often, teams take the information about the wetlands they sampled to their local governments.

A technical invertebrate IBI for wetlands has been developed by MPCA and other states. The IBI scores show strong responses to measures of human disturbance, or pollution, in wetlands. In Figure 1, the IBI scores for 44 large depressional wetlands are plotted against the gradient of human disturbance as measured from water and sediment chemistry and degree of physical alteration in and around the wetland. The technical IBI uses 10 different measures, called metrics, of the invertebrate community. The citizen IBI uses six metrics and is derived from the more technical IBI. Further information on the technical IBI is available in reports by MPCA (Gernes and Helgen 2002, Helgen and Gernes 2001) and on the web (US EPA 2002). Information and reports about the efforts of citizens using the citizen IBI are available on the web at the following address: www.mnwhep.org.

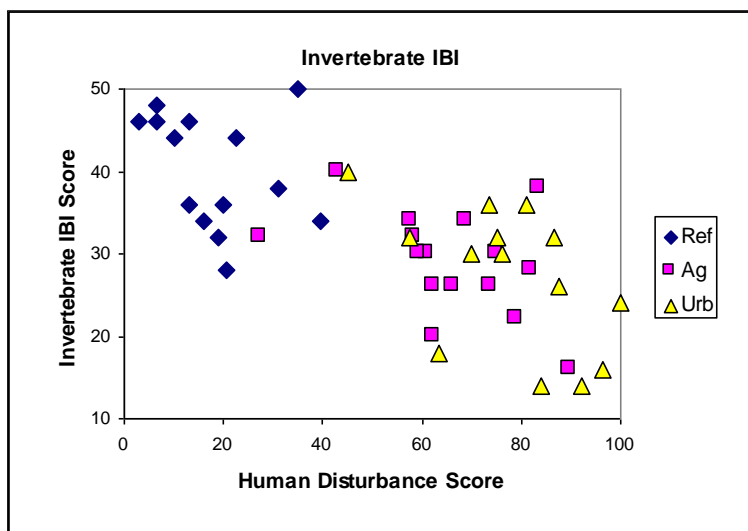


Figure 1. Invertebrate technical IBI scores totaled from ten invertebrate metrics from 44 large depressional wetlands in Minnesota. Human Disturbance Score is the sum score of factors of human disturbances in the landscape, buffer, hydrology, and water and sediment chemistry.

Macroinvertebrates are useful indicators of the health or condition of wetlands and other water bodies. They respond to many kinds of pollution, including chemical pollution and physical disturbance to the landscape around the site, wetland structure, and hydrology. There are several advantages of using macroinvertebrates:

- Invertebrates are commonly and widely distributed in many types of wetlands
- Invertebrates respond with a range of sensitivities to many kinds of pollution, for this reason they are commonly used in toxicity testing to develop water quality standards
- Many aquatic invertebrates complete their life cycles in wetlands, so they are exposed directly to the physical, chemical and biological conditions within the wetland
- Aquatic invertebrates are important in wetland food webs for wildlife

Having the life cycle of reproduction, development and maturation occur within the wetland exposes the invertebrates to all the conditions of the wetland. Usually, having more kinds (or taxa) of invertebrates is a good sign of health in a wetland. An important metric is the total taxa richness, the total number of kinds found in the sample.

Invertebrates with longer life cycles, such as dragonflies, may signal that conditions remained healthy for the duration of their development. In addition, predatory invertebrates such as leeches, beetles, dragonflies, damselflies and most true bugs require the presence of other invertebrates as their food (or prey). Having a rich array of predators means there are many prey available. Prey species of invertebrates include mosquitoes, midges, crustaceans and worms. The greater the number of taxa present, the more complex the community structure is.

Some invertebrates are more sensitive to pollution. Most kinds of mayflies and caddisflies tend to drop out of polluted wetlands; they can't tolerate polluted conditions. Likewise, most of the dragonfly and damselflies are sensitive to pollution. The midges (chironomids) are sometimes called indicators of pollution, but this is not true for wetlands. There are many kinds of midges that are lost in polluted situations, and other kinds that are pollution tolerant. The midges that are "pollution indicators" are the midges that can tolerate low oxygen conditions in streams. But many wetlands naturally have low oxygen conditions, and most of the invertebrates inhabiting them are adapted to low oxygen in the water by trapping air bubbles (some beetles and bugs), developing red blood (some midges make hemoglobin to store oxygen), or breathing air at the water's surface (mosquitoes).

Some kinds of invertebrates are tolerant and do tend to increase in relative numbers of individuals in more disturbed wetlands. The proportion of the corixid bugs (family Corixidae) increases relative to the count of all beetles and bugs in bottletrap samples. Many Corixidae bugs feed on algae and detritus that tend to increase in polluted wetlands. They increase greatly in waste stabilization ponds. In the technical IBI, the proportion of the dominant three taxa is greatest in the most disturbed wetlands. The proportion of certain taxa designated as tolerant taxa also tends to increase with disturbance.

For the citizen IBI, six invertebrate metrics are used. Five of these are based on counting the number of different kinds, or taxa, of invertebrates in the samples. The word taxon (plural is taxa) refers to uniquely different kinds of organisms. A taxon could be at the order, family, genus or species level. The approach used in the training and in the Guide is to try to identify how many members of a group such as snails, for example, appear to be different kinds or taxa. The volunteers may not be able to ascribe a precise name to each kind, but they may be able to determine there are distinctly different kinds of snails present in the sample. This can be judged by grouping all the kinds of snails from one wetland together and looking for distinctly different features, e.g., the direction of the coils and differences in shapes.

Note that for the taxa metrics, we are counting the taxon as one, we are not using the total count of individuals within that taxon.

The six metrics for the citizen invertebrate IBI are:

- *The Leech Taxa Metric.* The number of kinds of leeches found in dipnet and bottletrap samples is greater in healthier wetlands. There is one kind of leech that tends to increase in relative numbers in more polluted wetlands, but overall, more leech taxa indicates less disturbance. Leeches feed on a variety of different kinds of prey, both invertebrate and vertebrate. Very few kinds of leeches suck blood from mammals.
- *The Corixidae Proportion Metric.* All aquatic beetles and most true bugs are predators, mostly feeding on other invertebrates. Many of the corixid bugs feed on algae and detritus that tends to increase in polluted wetlands. The corixid bugs tend to increase in proportion to the total count of individuals of beetles and bugs found in the bottletrap samples. This is the only metric that relies only on data from bottletrap samples, and the only one that counts the number of individuals.
- *The Dragonfly-Damselfly Taxa (Odonata) Metric.* The number of kinds of dragonfly and damselfly larvae found in dipnet and bottletrap samples tends to be higher in healthier wetlands. These insects are predators at all stages, and have somewhat longer life cycles than other invertebrates. Dragonflies pump water in and out of their posterior end, which could expose them to pollutants. Some odonates lay their eggs on stems of aquatic plants, so if the plants are lost, they lose their egg-laying sites.
- *The ETSD Taxa Metric.* This metric adds the total number of taxa of mayfly larvae (Ephemeroptera) and caddisfly larvae (Trichoptera) and to this is added a one for the presence of dragonfly larvae (D) and a one for the presence of fingernail clams (S, for Sphaeriidae) from bottletrap and dipnet samples. Mayflies, caddisflies and fingernail clams are sensitive to pollution. Mayflies and caddisflies are gill breathers, allowing them to take in pollutants directly from the water. Fingernail clams filter small particles from the water, allowing direct intake of pollutants, but also making them more vulnerable to siltation in the water.
- *The Snail Taxa Metric.* Most snails in wetlands are lunged (pulmonate), meaning they are air breathers. Sometimes you will see snails hanging upside down under the surface film. They

are breathing and may be feeding on the film. Snails are herbivores and feed on plants and the algae coating surfaces of plants, sticks and substrates. The number of taxa of snails is greater in higher quality wetlands than in disturbed wetlands. Algae and plants can accumulate contaminants, so snails could be exposed to pollutants through their feeding. Also if the vegetation is lost, there will be less food for snails.

- *The Total Taxa Metric.* The total number of invertebrate taxa is usually one of the strongest indicators of the health of wetlands. The total taxa metric sums the total number of leech taxa, dragonfly and damselfly taxa, mayfly and caddisfly taxa, snail taxa, and presence of fingernail clams. In addition, the number of macrocrustacean taxa is added to the total taxa. These are crustaceans that are visible to the eye. Smaller crustaceans like water fleas (*Daphnia*), ostracods and other zooplankters (copepods) are not counted. The Dipteran or true fly taxa are also included in the total taxa metric. Mosquito larvae, *Chaoborus* (the phantom midge), the midges (*Chironomidae*), the biting midges (*Ceratopogonidae*) and soldier flies are some examples of some of the Dipteran taxa that might occur in wetlands.

Each metric is given a score of five, three or one points. The scores for all six metrics are summed to give the IBI score. The best possible IBI score is 30 (6 metrics x 5 points), the lowest possible score is 6 (6 metrics x 1 point). Then the condition of the wetland is assessed using the suggested criteria given: 23 – 30 is excellent condition, 15 – 22 is moderate condition, 6 – 14 is poor condition. These criteria are based on dividing the possible range of IBI scores (6 to 30, a range of 24 points) by three.

Citations and web sites

Minnesota Wetland Health Evaluation Project. www.mnwhep.org

Gernes, Mark C. and Judy C. Helgen. 2002. Indexes of Biological Integrity (IBI) for Large Depressional Wetlands in Minnesota. Minnesota Pollution Control Agency, St. Paul, MN. Final Report to US EPA. May, 2002. <http://www.pca.state.mn.us/index.php/view-document.html?gid=6100>

Helgen, Judy C. and Mark C. Gernes. 2001. Monitoring the Condition of Wetlands: Indexes of Biological Integrity Using Invertebrates and Vegetation. In Rader, R.B., D.P. Batzer and S.A. Wissinger (eds), Bioassessment and Management of North American Freshwater Wetlands. John Wiley and Sons, Inc. New York.

US EPA. 2002. Judy C. Helgen, Principal Contributor. Methods for Evaluating Wetland Condition #9. Developing an Invertebrate Index of Biological Integrity for Wetlands. US EPA Office of Water. EPA-822-R-02-019. March 2002. Available on web: http://water.epa.gov/type/wetlands/upload/2008_12_23_criteria_wetlands_9Invertebrate.pdf

FIELD SAMPLING FLOW CHART: WETLAND INVERTEBRATES

You will have training in the field methods, and then training in the invertebrate identifications. See protocol sheet on sampling and see the diagram on where to sample.

STEP 1: Select wetlands and plan sampling dates; Assemble equipment

Dipnet, trays with $\frac{1}{2}$ " screen, sieve, sample jars, squirt bottles for tap water and alcohol, alcohol, waders, bottletraps with dowels, etc.

STEP 2: Go to your wetlands to sample invertebrates in the month of June. Do Steps 3 and 4 in the same week.

STEP 3: Set out 6 bottletrap samplers (BT) for two overnights

STEP 4: Do two dipnetting (DN) efforts (each 3-5 sweeps) for **one DN sample** within the emergent vegetation and near shore zone, in same area as bottletraps.

STEP 3: After **bottletraps** are out for 2 nights, pour the contents of all the bottletraps into your sieve, backflush with alcohol into sample jar, add more alcohol to sample jar, place label (pencil on index card) inside jar. Tighten lid.

NOTE FOR BT AND DN SAMPLES: if sample occupies more than $\frac{1}{4}$ of the jar volume, put the sample into more than one jar (otherwise it might rot!). Label each jar "jar 1 of 2, jar 2 of 2".

STEP 4: Place contents of a **dipnet effort** onto $\frac{1}{2}$ " hardware cloth screen over trays of water. Encourage invertebrates to go into the water for 10'. Then remove the vegetation and do the **second dipnet effort** the same way. Then pour tray contents through your sieve, backflush with alcohol into a sample jar. Add label and more alcohol to sample jar. Final % alcohol should be 80%. **This is one dipnet sample.**

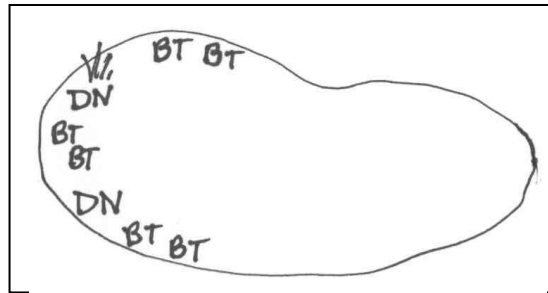
STEP 5. Check your samples to be sure the lids are tight. Change the alcohol if sample is rich in organic material, or it seems to be decomposing. Keep samples in a cool place away from heat sources or sparks.

Analyze your samples in a laboratory with microscopes. Record your data on the data sheets as guided by the training provided by MPCA. See laboratory protocols in this guide.

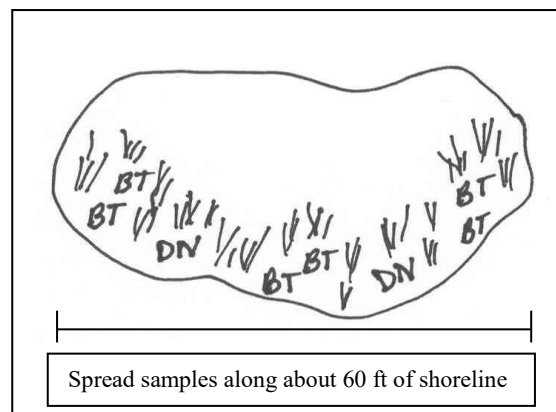
Sampling diagram for wetland invertebrate sampling

Below are three schematic diagrams of emergent vegetation in a wetland. Place your 6 bottletraps in the emergent/submerged vegetation zone, spread evenly along 45-60 feet of shoreline. Place in water less than three feet deep, but vary the depth at which the bottle traps are placed, i.e., don't place them all at 3 ft, place some at one foot, some at two feet, some at three feet. For the one dipnet sample, you will make two sampling efforts, each consisting of 3-5 sweeps of the net. Do the two dipnet efforts in areas near where you place your bottletraps. Cover about 45 – 60 ft of shoreline.

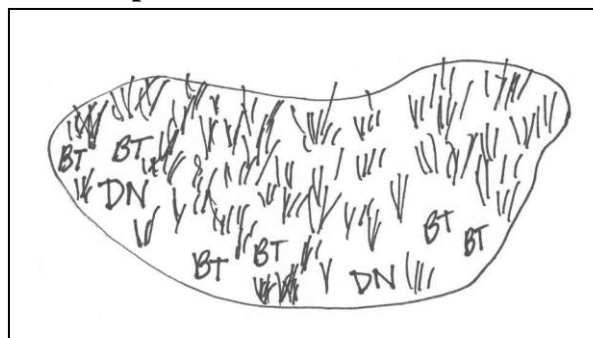
1. If there is very little vegetation, place the traps close to shore and any vegetation that might be present.



2. If there is a vegetated border around the wetland, place the traps and do the dipnetting in water from near the shore to up to one meter deep. Sweep net right into the vegetation.



3. If the wetland has very dense vegetation throughout, try to find open pockets in which to do the dipnetting and place the bottletraps. Dipnet with a choppy motion if there is dense submersed vegetation and little open water.



Field Sampling Protocol: Sampling Invertebrates

Goal: to collect **one complete dipnet (DN)** sample and **one complete set of bottletrap (BT)** sample from each wetland site. We do the dipnetting to get the widest number of species and the bottletrapping to get the actively swimming predators.

1. When to sample

Sample for the invertebrates in June, or at the latest, early July.

2. Where to sample

Sample for the invertebrates in the shallow, near-shore area not deeper than 3 feet (1 meter). Use the same general area where the bottletraps were set. Be sure to sample very close to the shore or in the vegetation fringe at shore.

If there is a cattail fringe (or other emergent vegetation), sample in the area between the cattails and the shore. If there is no water between the emergent vegetation and the shore, then sample within the cattails and to the outer edge of the cattails towards the open water. If there is no emergent vegetation, sample very near shore in water up to 3 feet deep.

3. Bottletrap samples --setting them out

- a. Use 6 bottletraps per site.
Spread the six bottle traps along the shore, covering 45-60 feet of shoreline.
You will combine the data from all 6 traps for metrics.
- b. Put at least two of the traps in very shallow water near shore, the others in shallow water not deeper than about 2 –3 ft.
- c. Set out the bottletraps 2 nights before collecting them.
- d. Fill traps with water with no air bubbles (tip trap under water so bubbles escape).
- e. Press funnel into trap opening so it snaps in tightly. Again, remove air bubbles.
- f. Lower bottle on dowel, orient bottle horizontally in water.
- g. Put bottletraps about one hand length under the water.

4. Bottletrap samples -- collecting them

- a. **Collect all of the bottletraps each into a single jar if possible.**
If the sample occupies more than $\frac{1}{4}$ of the volume of the jar, use a second or third jar as necessary. Be sure to label the jars appropriately.
- b. Raise trap up the dowel, remove the funnel, pour the trap contents through your sieve.
- c. Dislodge any critters stuck to the inside walls of the bottle. What's on the outside of the bottle **is not** part of the sample.
- d. Collect the remaining bottle traps, and pour contents into sieve.
- e. Backflush the contents of the sieve into your sample jar with 95% alcohol.
- f. **NOTE:** if you have a lot of leeches or other organisms in your traps, you may need to use more jars to preserve the sample.
- g. **NOTE:** if you have fish, tadpoles or salamanders you should note these on your field data sheet and leave them at the site. Note approximate numbers.

- h. **Label properly.** Put pencil or India ink label inside the jars. Label outside for convenience. See # 6 below on labeling samples.

5. Dipnet (DN) samples

You collect **one dipnet sample** per site. Each DN sample **consists of two dipnetting efforts**. Dipnet in the near-shore shallow areas in water up to one meter deep. "Sample close to edge and into veg." Use a 12 x 16" wood framed ½" hardware cloth screen over a tray (or two Coleman cooler trays) of water. The tray(s) of water should sit within a larger kitty litter pan or dishpan. This can float on the wetland.

FIRST DIPNETTING EFFORT.

- a. Put water in your collecting pans that sit underneath your hardware cloth screen.
- b. Place the framed ½" hardware cloth screen over the water so its edges don't hang over the edge of the pans. This way the critters go down into the water in the pans.
- c. Sample in the shallow emergent vegetation zone in water not deeper than 3 feet.
- d. **Hold the long-handled dip net vertically**, one hand near net, one hand up handle.
- e. Using strong strokes, sweep the net through the water towards you about 3-5 times.
- f. **BE SURE TO SAMPLE RIGHT INTO THE VEGETATION NEAR SHORE.**
- g. Evert all of the net contents onto the hardware cloth screen. Get everything out of the net.
- h. Spread the vegetation, loosen it. Do this periodically for up to 10 minutes.
This allows the critters to get down into the water in the pans.
- i. After 10 minutes, remove the vegetation and do the second dipnetting effort.

SECOND DIPNETTING EFFORT

- a. Move to a different shallow area.
- b. Repeat the process described in a. - g. above.
- c. After spreading out the vegetation for 10 minutes, remove it, and pour the water from the collecting pans through your sieve. Be sure to dislodge the leeches and snails which might attach to the pan.
- d. Backflush the sieve contents into your sample jar with 95% alcohol. Be sure to get any critters which attach to the sieve walls. Use two jars if critters and debris occupy more than ¼ of the jar volume.
- e. **Label properly.**
- f. **If your sample from the two efforts will occupy more than ¼ the sample jar divide the sample into two jars and label accordingly.**

6. Sample labeling

- a. **Record sample code on field data sheet**, especially if different from site name.
- b. Use **pencil** or truly permanent India ink on 100% cotton cardstock or index card.
- c. Indicate Site Name, Sample Code, Date, County, Collector's name, if DN or BT sample. Indicate if there is more than one jar -- jar #1 of 2, jar #2 of 2.
- d. Place label **INSIDE** jar. This is the only label you trust.
- e. For convenience, label also on the outside of the jar.
- f. Remember alcohol is flammable. Keep lids tight. Store away from flame or heat.

Field Data Sheet Wetland Invertebrate Sampling. Site data and site sketch.			
Site Name	Town	County	
Sample name (if coded differently from site name)			
Location description: DO SKETCH OF SITE ON BACK OF PAGE, show roads, compass directions. Write out road names/#'s, directions, name of park, private owner name, whatever is necessary to tell a stranger how to get to your wetland.			
Date dipnet samples were collected:		Water temperature:	
Samples collected by: Collector's name/Phone # Team Name:			
Near shore area: describe vegetation (or lack of it) where you sampled (e.g. little or no veg, choked with cattails, lots of submerged vegetation, lots of duckweed).			
Slope into wetland in the water near edge: gentle or steep?			
Describe bottom of wetland: (e.g. solid or very mucky?)			
BOTTLETRAPS (BT). You will collect 6 total bottletraps (see protocol sheet).			
1 Sample codes if different from site name:			
2 Date/Time BTs were set out:			
3 Number of BTs deployed:			
4 BTs set out by (name, phone #)			
5 Locations where BTs set out (indicate on site sketch on back)			
6 Date/Time BTs were collected			
7 Number of BTs collected successfully			
8 Number of jars which contain the BT samples:			
9 Indicate if the following were present in bottletraps:			
	Tadpoles	Salamander adults	Fish
	Frog adults	Salamander larvae	Other
DIPNETTING (DN). One sample consists of two dipnetting efforts (see protocol sheet).			
1 Sample code if different from site name:			
2 Date/Time DN sample was taken:			
3 Locations where the 2 DN efforts were done (indicate on site sketch on back)			
4 Were 2 dipnetting efforts done? (see protocol)			
5 Describe approximate water depths where you sampled:			
NOTES:			

LAB PROCESSING OF BOTTLETRAP and DIPNET

You need to compare and count the taxa within each group from **both your BT and DN samples**. If you have the same taxon in both DN and BT samples, you count it as one taxon.

FROM BT SAMPLES ONLY

Pick out to a petri dish from the BT samples all adult beetles, beetle larvae, and all bugs, including corixid bugs

Count the number of corixid bugs, non-corixid bugs, beetle larvae and beetle adults and record on the **Invertebrate Lab Data Sheet** under Corixid Proportion Metric. It is OK to pool your BT samples and then do the counts for the ratio if you prefer.

Transfer the data for the corixid metric to the **Metric Scoring Sheet** and score the corixid metric.

Transfer the data for the number of taxa for categories # 1 –7 to the appropriate **Metric Scoring Sheet** and score the metric for Leech Taxa, Snail Taxa, ETSD, Dragonfly and Damselfly taxa, and Total Taxa.

FROM BOTH BT AND DN SAMPLES

Pick out the invertebrates from BT and from DN samples into separate **petri dishes labeled by group name and BT or DN** for the groups listed below. You will have 14 petri dishes, one set for the 7 groups listed from BT samples and one set for the 7 groups listed for the DN samples.

1. All leeches
2. All dragonfly and damselfly larvae
3. All caddisfly and mayfly larvae (some may be tiny!)
4. All snails (unless one type is very abundant)
5. All macro-crustaceans (see Invertebrate Lab Data Sheet)
6. Dipterans (see Dipteran sheet in Guide).
7. Fingernail clams (don't need to pick them all, presence only)

- **Look at one category of organisms, e.g., dragonflies, from both the DIPNET and the BOTTLETRAP** samples from your wetland. Get all the kinds in front of you. Then determine if they are the same kind, or are different kinds. If you have immature and more mature stages of one taxon, it counts only as one taxon.
- Use the **Identifications Sheets** provided to assist you in deciding how many kinds you have in each group of invertebrates.
- Record the number of kinds on the **Invertebrate Lab Data Sheet**.

- **On the Metric Scoring Sheet add up the scores for the six invertebrate metrics to get the IBI total score** for your wetland: Corixid Proportion, Dragonfly-Damselfly (Odonata) Taxa, ETSD, Leech Taxa, Snail Taxa, Total Taxa.
- **Rate the wetland as having excellent, moderate or poor condition** using the suggested guidelines on the Metric Scoring Sheets Page 5. Transfer the metric scores and the IBI total score to the **IBI Scoring Table**, the table to show all the wetlands you have studied.

Invertebrate Lab Datasheet (Revised May 2019)

Site ID:	Site Name:	Team Name:
Date Sampled:		Analyzed by:
Date Analyzed:		

LEECHES

Erpobdella

DN

BT

TAXON PRESENCE

(Put 1 for each taxon)

Erpobdella punctata

Nephelopsis

Other:

Glossiphonids

Glossiphonia complanata

Helobdella

Stagnalis

Fusca

Other:

Placobdella

Papillifera

Ornata

Other:

Batracobdella

Other:

Hirudinidae

Haemopsis grande (large mottled)

Macrobdella decora

Other:

Other:

TOTAL LEECH TAXA

BUGS & BEETLES (counts in BT only)

BT

a. Corixid bugs (juveniles & adults)

b. Non-corixid bugs

c. Beetles (larvae)

d. Beetles (adult)

e. Sum of a+b+c+d=e

CORIXID RATIO (a/e)

Invertebrate Lab Datasheet (Revised May 2019)

Site ID:	Site Name:	Team Name:
Date Sampled:		Analyzed by:
Date Analyzed:		

ODONATA		DN	BT	TAXON PRESENCE (Put 1 for each taxon)
<u>Dragonflies</u>	Aeshnidae			
	Corduliidae			
	Gomphidae			
	Libellulidae			
	Other:			
	Other:			
	SUBTOTAL DRAGONFLIES			
<u>Damselflies</u>	Coenagrionidae			
	Lestidae			
	Other:			
	Other:			
	SUBTOTAL DAMSELFLIES			
TOTAL ODONATA TAXA				

MAYFLY-CADDISFLY		DN	BT	TAXON PRESENCE (Put 1 for each taxon)
<u>Mayflies</u>	Baetidae			
	Baetis			
	Callibaetis			
	Caenidae			
	Siphonuridae			
	Trichorythidae			
	Other:			
	Other:			
<u>Caddisflies</u>	Leptoceridae			
	Ceraclea			
	Leptocerus			
	Oecetis			
	Triaenodes			
	Limnephilidae			
	Anabolia			
	Limnephilus			
	Phryganeidae			
	Banksiola			
	Phryganea			
	Other:			
	Other:			
TOTAL MAYFLY-CADDISFLY TAXA				

Invertebrate Lab Datasheet (Revised May 2019)

Site ID:	Site Name:	Team Name:
Date Sampled:		Analyzed by:
Date Analyzed:		

SNAILS

Planar

Left-Coiled

DN

BT

TAXON PRESENCE

(Put 1 for each taxon)

Helisoma campanulata

Helisoma trivolvis

Other:

Right-Coiled

Helisoma anceps

Promenetus

Planorbula

Gyraulus

Armiger

Other:

Spired

Left-Coiled

Physa

Aplexa

Other:

Right-Coiled

Fossaria

Acella

Stagnicola elodes

Stagnicola reflexa

Lymnaea stagnalis

Other:

TOTAL SNAIL TAXA

DN

BT

RECORD 0 OR 1

FINGERNAIL CLAMS

(None: 0; Present: 1)

Dipteran

DN

BT

TAXON PRESENCE

(Put 1 for each taxon)

Culicidae (Mosquitoes)

Ceratopogonidae (Biting Midge)

Chironomidae (Non-biting Midge)

Chaoboridae (Phantom Midge)

Stratiomyidae (Soldierfly)

Tipulidae (Crane Fly)

Tabanidae (Horse Fly)

Sciomyzidae (Marsh Fly)

Empididae (Dance Fly)

Dolichopodidae (Longlegged Fly)

Other:

Other:

TOTAL DIPTERAN TAXA

Invertebrate Lab Datasheet (Revised May 2019)

Site ID:	Site Name:	Team Name:
Date Sampled:		Analyzed by:
Date Analyzed:		

<u>Crustacea</u>	DN	BT	TAXON PRESENCE (Put 1 for each taxon)	
Amphipods (scuds, etc)				
Clam shrimp				
Crayfish				
Fairy Shrimp				
Isopods				
Other:				
TOTAL CRUSTACEA TAXA				

<u>Other</u>	DN	BT
Tadpoles & Adult Frogs		
Fish		
Water Mites		
Exotic Snails		
Daphnia		
Seed Shrimp		
Other:		
Other:		

Total Wetland IBI Scoring Sheet (2 pages)

Site Name:	Site Number:
Team Name:	Team Leader:
Date Sampled:	Date sample analyzed:

Instructions:

1. There are 6 invertebrate metrics used to calculate the total wetland health score.
2. Transfer the data from the lab sheets to calculate each individual metric score.
3. Calculate the Total Wetland Health Score of the wetland (the sum of the 6 metric scores).

Metric 1: Leech Taxa Metric - The number of taxa of leeches from dipnet (DN) and bottletrap (BT).

A.	Total number of kinds (taxa) of leeches	
B.	Metric 1: Leech Taxa Metric Score	

Metric Scoring for Leeches	
Total # taxa of leeches	Metric Score
4-5	5
2-3	3
0-1	1

Metric 2: *Corixidae* Proportion Metric - The proportion of *Corixidae* to the total beetles and bugs (including *Corixidae*) in all BT samples (do not count bugs & beetles from DN samples).

A.	Total number of <i>Corixidae</i> :	
B.	Total number of bugs and beetles (including <i>Corixidae</i>)	
C.	<i>Corixidae</i> Ratio (A/B)	
D.	Metric 2: <i>Corixidae</i> Proportion Metric Score	

Metric Scoring for <i>Corixidae</i> Proportion	
% Ratio	Metric Score
Ratio A/B < 33%	5
Ratio A/B 33% - 67%	3
Ratio A/B > 67%	1

Metric 3: Odonata Metric - The number of taxa of dragonfly and damselfly nymphs from DN and BT.

A.	Total number of kinds of damselfly larva	
B.	Total Number of kinds of dragonfly nymphs	
C.	Sum of A + B	
D.	Metric 3: Odonata Metric Score	

Metric Scoring for Odonata	
Total # taxa of Odonata	Metric Score
4+	5
3	3
0-2	1

Metric 4: ETSD Metric - The number of taxa of mayflies and caddisflies + the presence of fingernail clams + presence of dragonfly nymphs from DN and BT.

A.	Total number of kinds of mayflies and caddisflies	
B.	Fingernail clams present (score 1 if present, 0 if none)	
C.	Dragonfly nymphs present (score 1 if present, 0 if none)	
D.	Sum of A + B + C + D	
E.	Metric 4: ETSD Metric Score	

Metric Scoring for ETSD	
Total # of taxa	Metric Score
4 +	5
2-3	3
0-1	1

Metric 5: Snail Metric - The total number of kinds of snails from DN and BT.

A.	Total number of planar snails	
B.	Total number of spiral snails	
C.	Sum of A + B	
D.	Metric 5: Snail Metric Score	

Metric Scoring for Snails	
Total # of taxa	Metric Score
4+	5
3	3
0-2	1

Metric 6: Total Invertebrate Taxa Metric - The total sum of taxa

A.	Total number of taxa of leeches	
B.	Total number of taxa of Odonata	
C.	Total number of taxa of mayflies and caddisflies	
D.	Total number of taxa of snails	
E.	Total number of taxa of macrocrustaceans	
F.	Total number of taxa of Dipteran	
G.	Sum A + B + C + D + E + F	
H.	Metric 6: Total Invertebrate Taxa Metric Score	

Metric Scoring for Total Taxa Metric	
Total # of taxa	Metric Score
11-16	5
6-10	3
0-5	1

TOTAL IBI SCORE (Wetland Heath Score): Sum of all 6 metric scores

A.	Total IBI Score: Wetland Heath Score	
B.	Wetland Health Assessment	

Total IBI Score	Wetland Health Assessment
23-30	Excellent
15-22	Moderate
6-14	Poor

Site Name:
Site Number:
Team Name:
Date:

IBI SCORE TABLE FOR INVERTEBRATE IBI FOR WETLANDS

Interpretation of Wetland IBI Scores: Suggested scoring criteria below are given as an example. The range of the total possible IBI points (6 - 30) was trisected.

CITIZEN MONITORING OF WETLANDS	<u>Total IBI Score For a Wetland Site</u>	<u>Assessment</u>	STEPS FOR COMPUTING THE IBI SCORE
	23 - 30 points	Excellent condition	1. Enter your data in the Invertebrate Lab Data Sheets pages 1 - 4.
	15 - 22 points	Moderate condition	2. Fill out the Metric Scoring Sheets Pages 1 - 2 to score metrics.
	6 - 14 points	Poor condition	3. Transfer Metric Scores to the IBI Scoring Table and sum IBI score.

Team Leader

Phone #

Community of team

County

SCORING TABLE

Metric Scores (5, 3 or 1) From Metric Scoring Sheets Pages 1-4

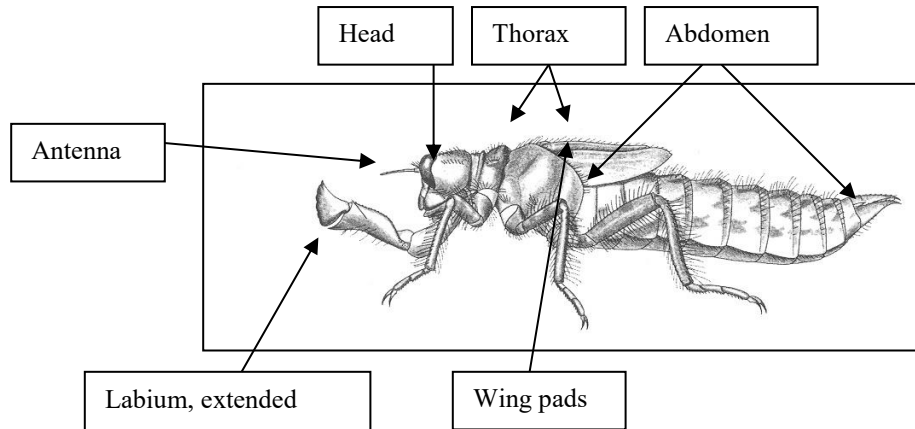
Site Name	Site #	Date Sampled	Date Processed	Leech	Corixid	Odonata	ETSD	Snail	Total Taxa	Total IBI Score	Assessment

TIPS FOR DOING INVERTEBRATE IDENTIFICATIONS

- 1. Dragonfly and damselfly mouth parts:** use two pairs of forceps, one to hold the body, the other to spread out the mouthpart (labium) away from the head under the microscope.
- 2. Leech eyes:** press the anterior end down with forceps so you can view the anterior end flattened out under the microscope. Look carefully, eyes get trapped within the segments in the leeches body and can be hard to see, especially in dark specimens.
- 3. Leech anterior vs. posterior end:** the posterior sucker of leeches is usually much larger than the sucker-like mouth on the anterior (front) end.
- 4. Planorbid snails, how to tell top (anterior) from bottom:** examine the snail to see which of the coiled sides has the deepest indentation. The top of a planorbid snail is less indented than the bottom (posterior end). In some snails you have to look carefully to make this distinction.
- 5. To tell the coiling direction of snails.** Hold the snail with its top (anterior end) facing up and its opening facing towards you. If the opening is on the right side, it is a right-coiled snail. If the opening is on the left side, it is a left-coiled snail.
- 6. To see differences among some planorbid snails,** look at the shape of the coil. In *Gyraulus* the coils are almost like a round tube of clay, in *Planorbula*, it is as if a flat plate was pressed on top of the coils to flatten them.
- 7. Mayflies:** tails may be broken, gills may be broken off. Sometimes there's only a gill or two left on the mayfly. Look for other specimens in your samples to see if they are more intact. Also, the antennae may be broken.
- 8. Caddisflies:** look to see if the larva has a hump on its back. You'll need to take it out of the case to do this. To confirm it is a caddisfly, see the pair of tiny hooks on the fleshy end of the caddisfly. Look for differences in the pattern on the top of the head. Look for the antennae on the head. They are always small, but some are longer than others.
- 9. Bugs:** immature bugs may have incomplete wing pads. Long skinny adult bugs like *Ranatra* and *Hydrometra* have very skinny wings lying against the body.
- 10. Diptera: the fleshy prolegs** in midges and other Diptera (true flies) are not true legs, they are not jointed hard legs.
- 11. You may have different ages** of the same taxon in your sample. Do your best to see if they are the same taxon or not.
- 12. Work on one group of invertebrates at a time,** e.g., leeches or dragonflies. Have all the specimens picked out from your bottletrap and dipnet samples and examine similar ones together. If necessary, line up all the different kinds (taxa) together to assure yourself they are different taxa. In training we have seen people taking out one specimen at a time and examining it by itself. It is better to examine them together.
- 13. Lighting and viewing:** be sure that both the top and bottom lights of your microscopes work, and use them. Use a pen light to give additional lighting, especially on darker specimens.

Glossary for wetland macroinvertebrates with illustrations

Insect Body Structure: 3 Body Divisions, head, thorax and abdomen. Legs and wings are attached to the thorax.



Abdomen. The abdomen is the posterior or rear-most section of the three sections of the insect body (head, thorax, abdomen). In mayflies and some caddisflies, there are gills attached to segments of the abdomen.

Antenna (singular), antennae (plural). A pair of segmented appendages located on the head above the mouthparts and usually sensory in function. Crustaceans have two pairs of antennae, insects have one pair.

Anterior. Anterior refers to the front, or head end of the organism. Posterior refers to the rear or tail end.

Arachnids are a group within the Phylum Arthropoda that includes the mites, scorpions and spiders. The adults have four pairs of jointed legs. In water mites, the immature stage has only 3 pairs of legs, but the adult mites have 4 pairs of legs. We don't count them in the wetlands IBI.

Arthropoda. Arthropoda is a major Phylum of invertebrates. It includes the Class Crustacea, Class Arachnida, and Class Insecta (or Hexapoda, referring to the 6 legs).

Bugs. Are the Order Hemiptera, a kind of insect with piercing mouthparts (except Corixidae, see Key). **NOTE:** do not refer to all insects as "bugs." There are many orders of insects, not just bugs.

Carapace. The carapace is the outer covering of crustaceans as in crayfish, clam shrimp and amphipods. The exception is the fairy shrimp, which lack a carapace.

Dipteran (singular), Diptera (plural). An order of insects called the true flies. Adults have two wings rather than four found in most other adult insects. Diptera are a very diverse group.

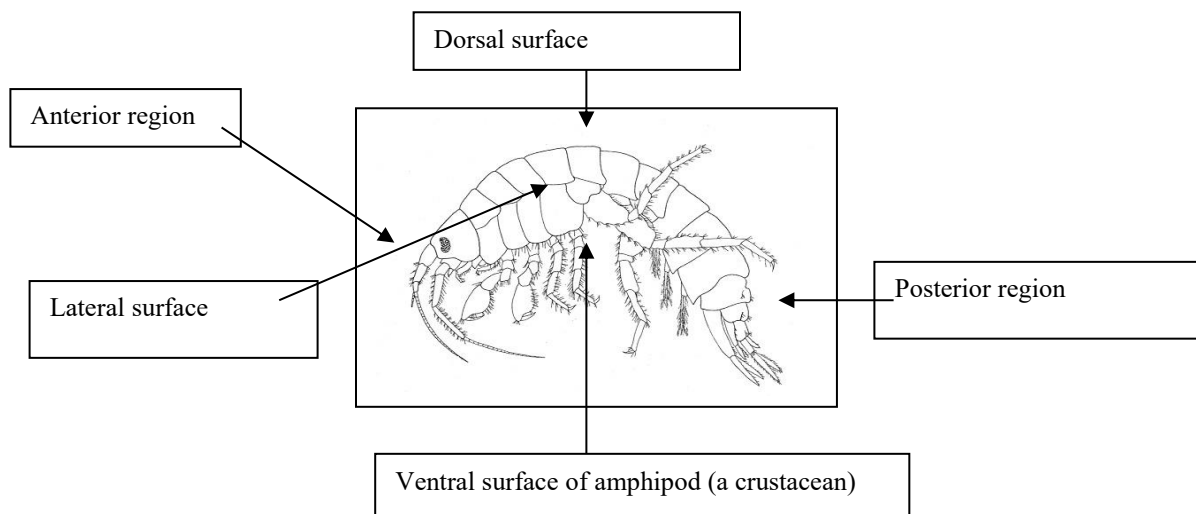
Aquatic dipteran larvae lack wing pads and do not have 3 pairs of jointed legs attached at the thorax. Some larvae (like the Chironomidae midges) have fleshy prolegs that aren't jointed legs.

Dorsal. Dorsal refers to the back surface of the organism. Ventral refers to the underside, or "belly" surface of the organism. See illustration on next page

Family. Family is a category in the classification of organisms. A family is comprised of one or usually more than one genus. The genera have a common evolutionary origin, and are often clearly separated by body characteristics (morphology) from the genera of other families. Family is between the categories of order and genus (or tribe).

Genus (singular), genera (plural). Genus is a category in the classification of organisms. A genus is comprised of one, or usually more than one species that are related to each other in body characteristics (morphology) and evolutionarily. Genus is the principal category between family and species.

Head capsule. A hardened capsule over the head of most insect larvae. See illustration located by prolegs in this glossary.



Labium. The labium is part of the structure of the mouthparts of an insect. It is essentially the lower "lip." In dragonfly and damselfly larvae, the labium is highly modified into a hinged structure that can be projected rapidly outwards to grab invertebrate prey and bring them to the mouth. See illustration at the beginning of the glossary.

Larva (singular), larvae (plural). The larva is an immature stage that develops from the eggs and precedes the pupal stage.

Lateral. Lateral refers to the left and right sides of the organism.

Lateral filaments. These would be filaments projecting from the sides of the organism.

Macroinvertebrates. These are larger invertebrates that are visible to the eye. It usually does not include the smaller invertebrates like Daphnia (water fleas) or copepods and ostracods.

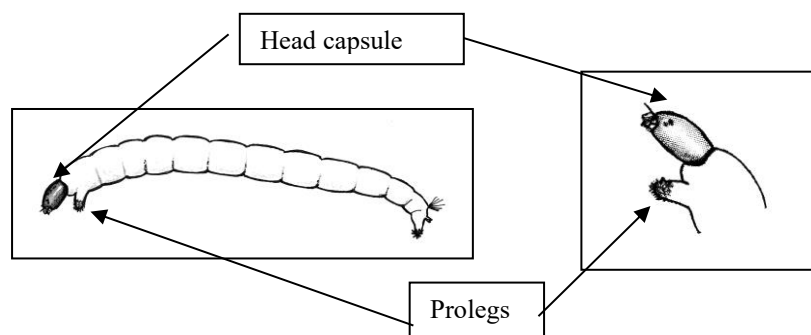
Operculum. In snails, the operculum is a flat, disk-shaped hard covering that fits into the opening of the snail. It looks like a small pick for a guitar. When the snail retreats into the shell, the operculum covers it up. This is found only in the gilled snails, not in the lunged snails. If empty shells are collected, the operculum will not be present because it is attached to the body of the snail.

Operculum. In the mayfly families of Caenidae and Trichorythodidae, the operculum refers to the plate that lies over the stack of gills on the abdomen.

Order. Order is a category in the classification of organisms. An order is comprised of one or more families that are related to each other evolutionarily and in body characteristics (morphology). Order is a category between family and class.

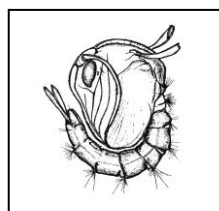
Planorbid snail. Planorbidae is a family of snails that have a disc-shape or a very low spire. The width of the shell is greater than the height of the shell.

Posterior refers to the rear or tail end of the organism. **Anterior** refers to the front or head end.



Prolegs. Prolegs are fleshy, non jointed legs found in some insect larvae. They can be located at the anterior or posterior end.

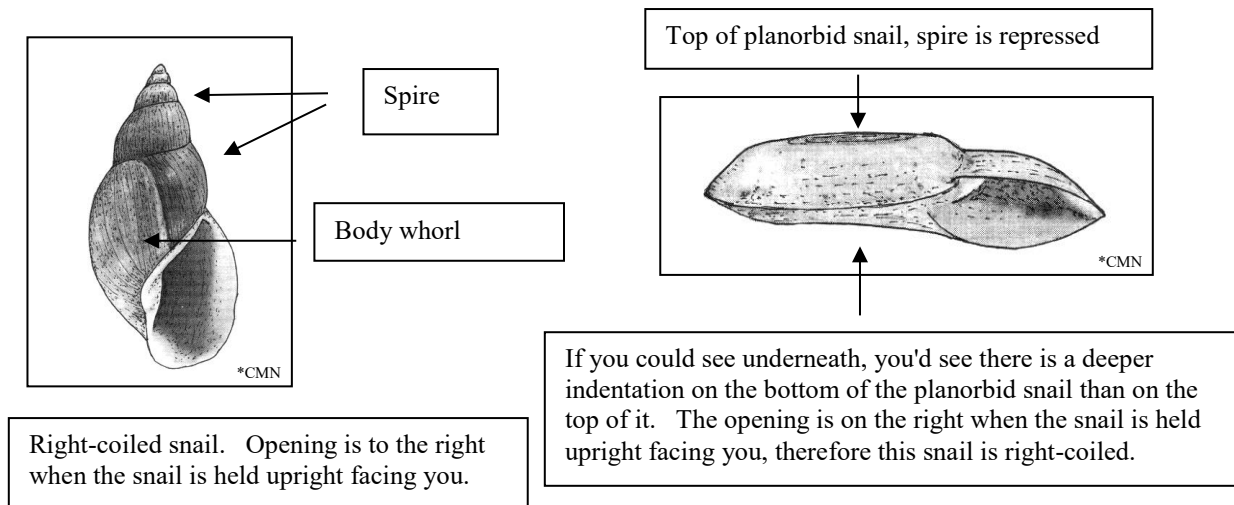
Pupa (singular), pupae (plural). In developing insects, the pupa is the stage between the larvae and the adult. Usually the pupal stage does not feed. The larval body is metamorphosing into the adult insect.



Mosquito pupa or "wiggler"

Raptorial. An insect with raptorial legs has legs that are adapted for grasping live prey. The front legs of the giant water bug are raptorial.

Spire. In snails, the spire is the main portion of the shell that extends above the opening of the shell. In flattened, disk-shaped snails (planorbid snails), the spire is completely flat at the top of the snail. To tell top from bottom in a planorbid snail, you need to find which side is LEAST indented. This would be the top.



Taxa (plural), taxon (singular). A taxon is a group of organisms that is distinct from other groups of organisms. A taxon can be at any taxonomic level (order, family, genus, species). If you count a genus as a taxon, then you would not count its family as a taxon, because that family is already represented by the genus. Total taxa refers to the total number kinds of unique organisms you have. You may have some taxa identified at the genus level (e.g. *Caenis* mayfly) and some identified only at the family level (e.g., fingernail clams, family Sphaeriidae).

Thorax. The thorax is the body region of an insect that is between the head region and the abdominal region. It carries the wings and the legs. See illustration with "abdomen."

Ventral. Ventral refers to the underside, or "belly" surface of the organism. Dorsal refers to the back side or surface of the organism.

Whorls. The whorl of a snail refers to the coils in the shell. One whorl is one complete turn of the coil. Mature snails will have 4 or more whorls. The largest whorl, called the body whorl, is at the opening to the snail. It is the first whorl produced as the snail grows.

Wing pads. Wing pads are the developing wings in the immature insect larvae. They do not cover the abdomen. These can be seen in the illustrations of mayfly larvae, dragonfly larvae and damselfly larvae. Adult wings are seen in the illustration sheets on adult aquatic beetles and bugs. They cover the abdomen almost completely.

Taxonomic names of typical wetland invertebrate groups. Phylum, Class, Order, Family.

Phylum Annelida: worms

Class Hirudinea: Leeches



- Family Glossiphoniidae
- Family Erpobdellidae
- Family Hirudinidae (includes bloodsucking leeches)

Phylum Mollusca: molluscs (the taxonomy has been revised, these names are what we have in the pictorial key in the Guide)

Class Pelecypoda: Bivalve molluscs, clams



- Family Unionidae (freshwater mussels, not usually in depressional wetlands)
- Family Sphaeriidae (fingernail clams)

Class Gastropoda: Snails



- Family Lymnaeidae pond snails, lunged snails
- Family Physidae tadpole snails, lunged snails
- Family Planorbidae ramshorn snails, lunged snails
- Family Valvatidae gilled snails, less likely in depressional wetlands

Phylum Arthropoda (arthropods)

Class Crustacea



- Order Amphipoda amphipods, also called scuds or sideswimmers
- Order Anostraca fairy shrimp
- Order Conchostraca clam shrimp
- Order Decapoda crayfish
- Order Isopoda sow bugs

Class Insecta



- Order Coleoptera Beetles
 - Family Dytiscidae predaceous diving beetles
 - Family Gyrinidae whirligig beetles
 - Family Haliplidae crawling water beetles
 - Family Hydrophilidae water scavenger beetles



Order Diptera



- Family Ceratopogonidae biting midges
- Family Chaoboridae phantom midges
- Family Chironomidae chironomid midges; many kinds, some are sensitive, some are tolerant
- Family Culicidae mosquitoes
- Family Stratiomyidae soldier flies



- Order Ephemeroptera Mayflies
 - Family Baetidae
 - Family Caenidae
 - Family Siphonuridae



- Order Hemiptera True bugs
 - Family Belostomatidae giant water bugs
 - Family Corixidae water boatmen
 - Family Gerridae water striders
 - Family Hydrometridae marsh treaders, marsh measurers
 - Family Nepidae water scorpions
 - Family Notonectidae backswimmers
 - Family Pleidae pigmy back swimmer



- Order Odonata Dragonflies and Damselflies
 - Suborder Anisoptera (dragonflies)
 - Family Aeshnidae
 - Family Corduliidae
 - Family Gomphidae
 - Family Libellulidae



- Suborder Zygoptera (damselflies)
 - Family Coenagrionidae
 - Family Lestidae



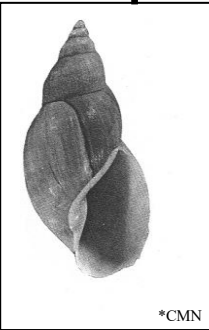
- Order Trichoptera Caddisflies
 - Family Hydroptilidae
 - Family Leptoceridae
 - Family Limnephilidae
 - Family Phryganeidae
 - Family Polycentropodidae



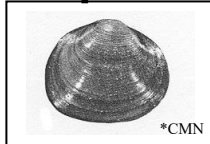
General Key to Wetland Macroinvertebrates: Begin Here! Pages given in keys are to Key Pages

KEY PAGE 1

Hard (lime) shells
MOLLUSCS: SNAILS and CLAMS, see PAGES 14 - 15



*CMN

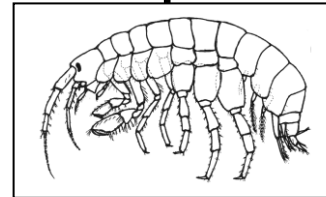


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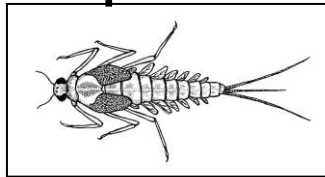
Fingernail clam
3 - 10 mm

Has obvious external legs that are jointed and in pairs; has three body divisions

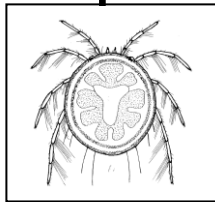
5 or more pairs jointed legs, 2 pairs antennae, no wings, no wing pads **CRUSTACEANS PAGE 12 - 13**



3 pairs jointed legs, 1 pair of antennae **INSECTS PAGE 2**

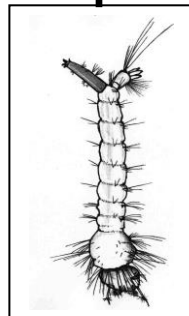
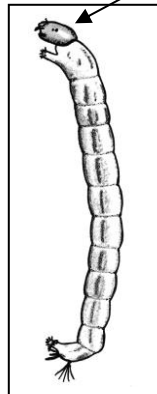


4 pairs jointed legs in adults, no antennae, no wings. Spiders and mites. **ARACHNIDS**

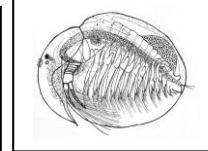
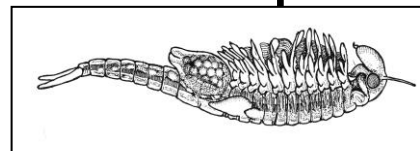


Water mites (Hydracarina) are small, aquatic arachnids only .5 - 3 mm diameter. They are active swimmers, very round, opaquely colored black, brown or red.

Has distinct, brownish head capsule, and/or tail brushes or tails. **DIPTERANS PAGE 11**

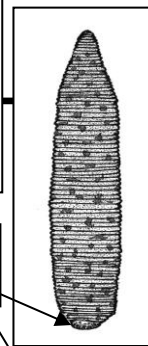


Has 5 or more pairs of legs mostly concealed under carapace, or has 10 or more leafy appendages **CRUSTACEANS PAGE 12 - 13**

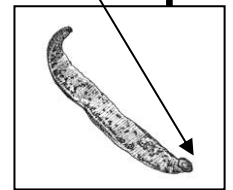


Lacks obvious external jointed legs; may have fleshy prolegs

Worm-like, no obvious hard head capsule, sucker at rear end larger than front sucker **LEECHES, PAGE 16 - 18**

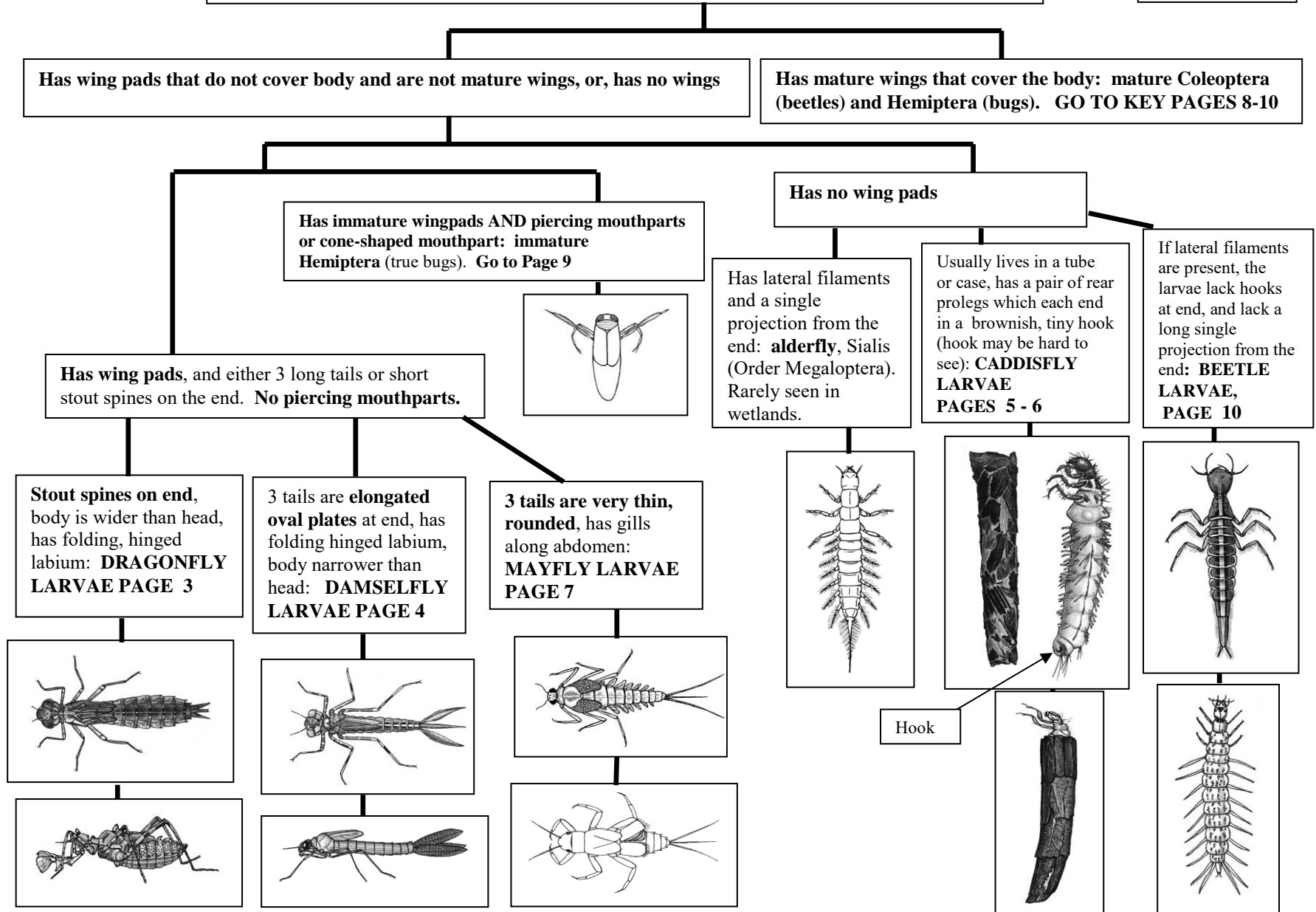


Sucker at rear end



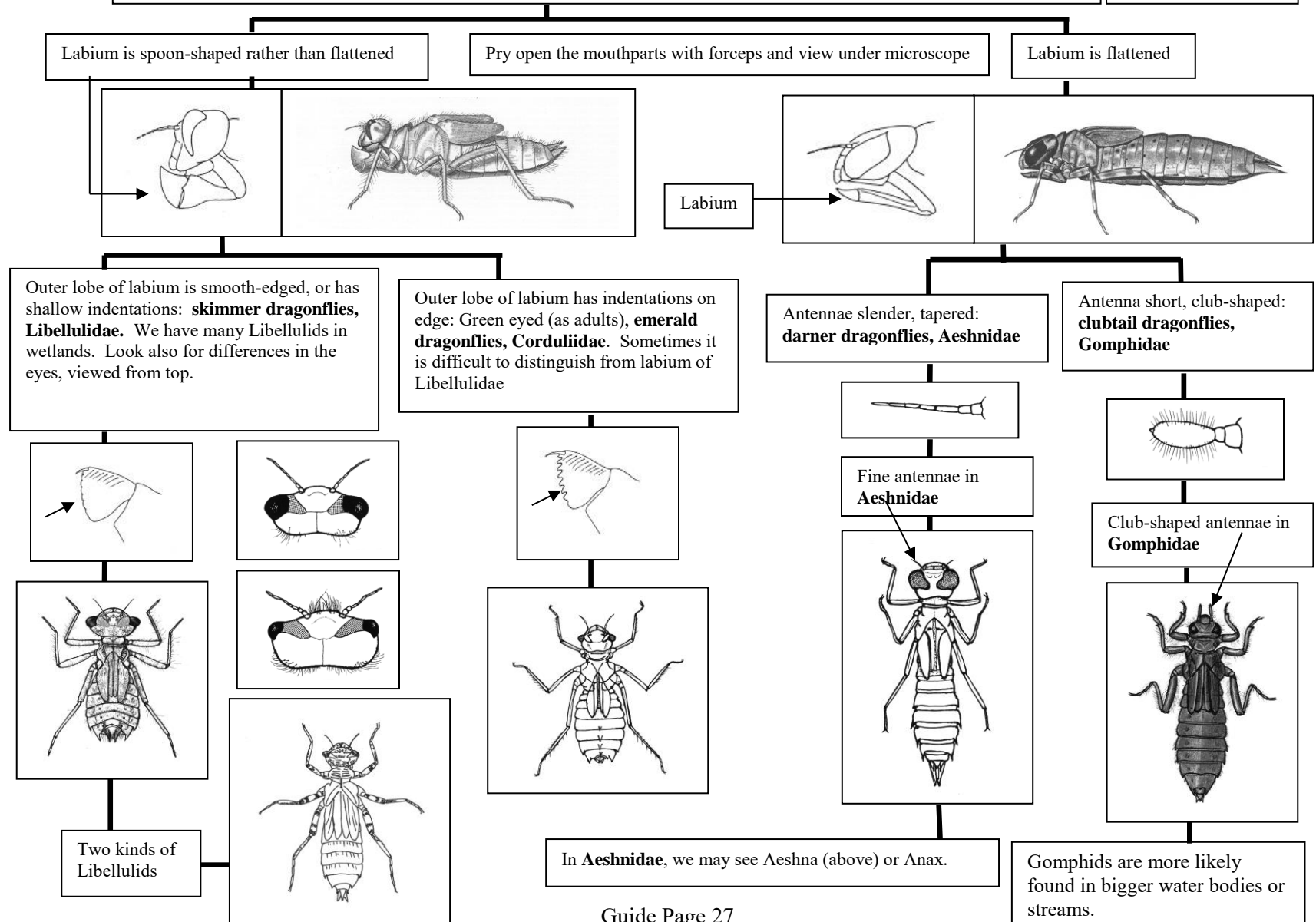
Insects (Class Insecta): 3 obvious pairs of jointed legs, 1 pair of antennae

KEY PAGE 2



Dragonfly larvae, Order Odonata, Suborder Anisoptera. How to identify the families of dragonflies in wetlands

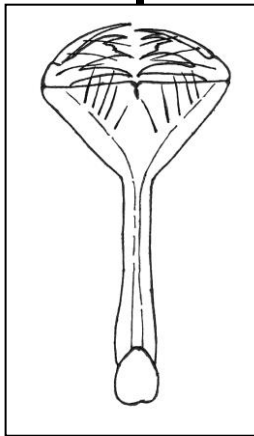
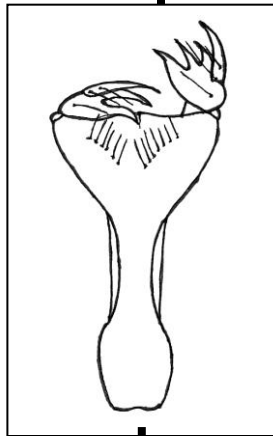
KEY PAGE 3



To tell apart the two major families of damselflies, you need to look at the special hinged labium that lies beneath the mouth. You need to tease it away from the mouth to see its shape. It is used to capture invertebrates and bring them to the mouth. Use two pair of forceps.

Damselfly family: Lestidae

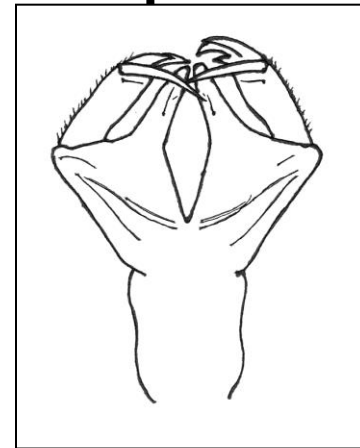
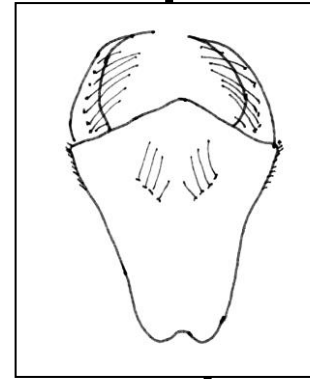
Lestidae has a labium that has an elongated, narrow base and a distinct "Y" shape



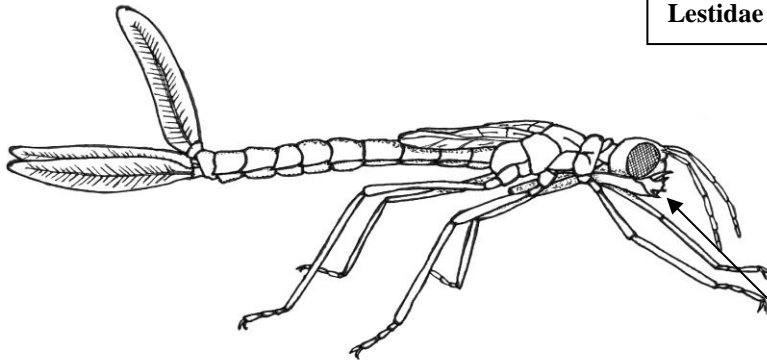
Labium, isolated from Lestidae (on left) and from Coenagrionidae (on right). Viewed top down.

Damselfly family: Coenagrionidae

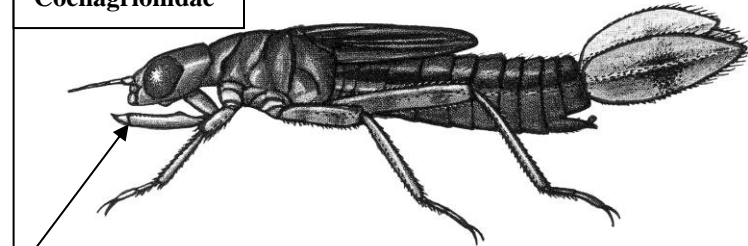
Coenagrionidae has a labium with a wider base and not as elongated



Lestidae



Coenagrionidae

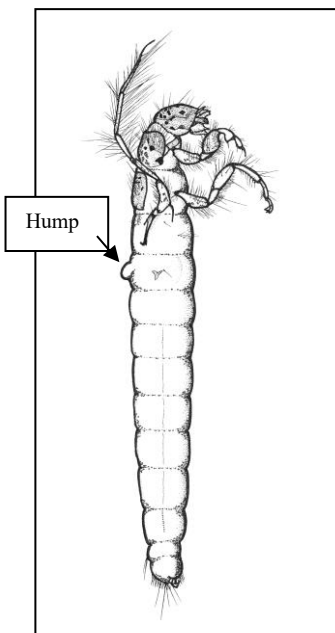
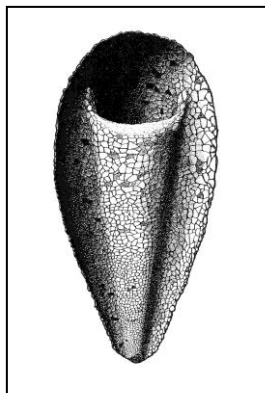
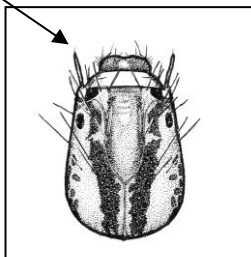


Labium (side view) folds up under the mouth. It is used to capture other invertebrates to eat. Damselflies are predators.

Caddisfly larvae (Order Trichoptera) in wetlands and their cases

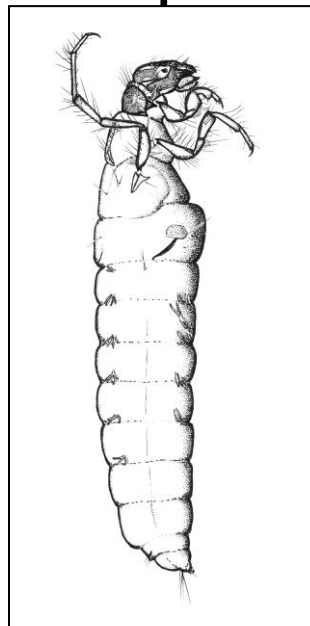
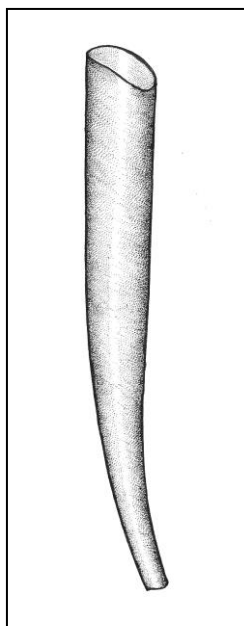
KEY PAGE 5

This page: Family Leptoceridae, antennae are relatively long, but look carefully. They are thicker than hairs, have only one segment. Head of Leptocerus shown below.

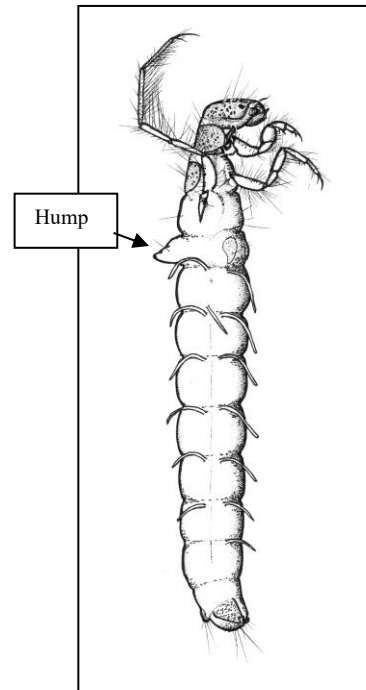


Hump

Genus Leptocerus and case of silk, to 9.5 mm

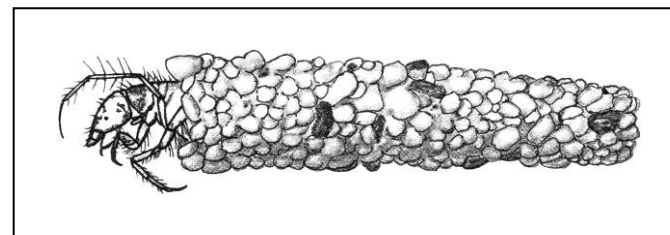
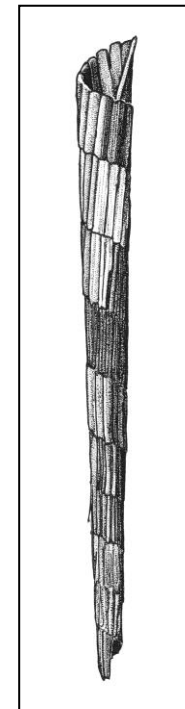


Genus Ceraclea and case (above) to 13 mm. No hump on back.



Hump

Genus Trienodes and case, to 33 mm, has hump on back

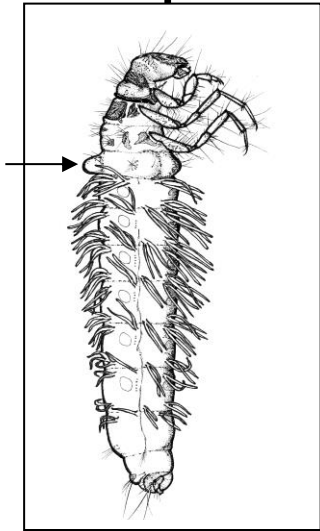


Genus Oecetis, to 15 mm. Has hump on back. In its case of sand grains.

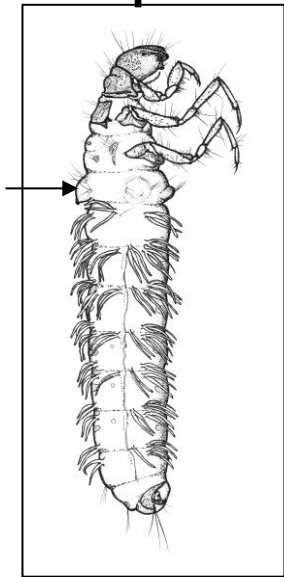
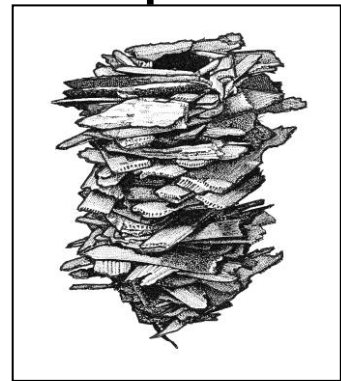
Caddisfly larvae (Order Trichoptera) in wetlands and their cases

KEY PAGE 6

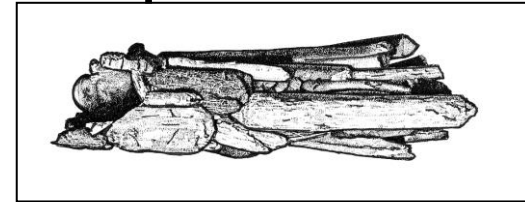
Family Limnephilidae, has very short antennae very hard to see; many kinds of cases in this family



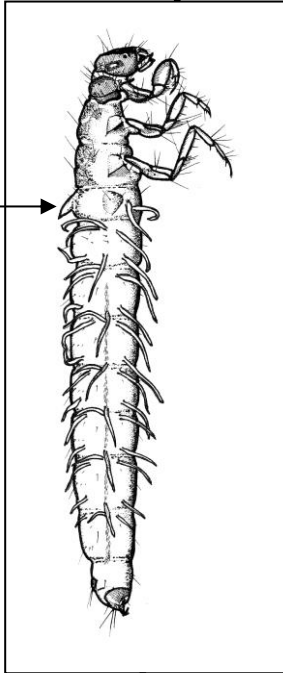
Genus Limnephilus and case to 29 mm



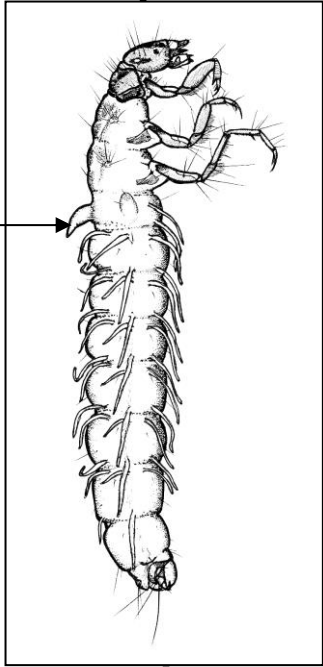
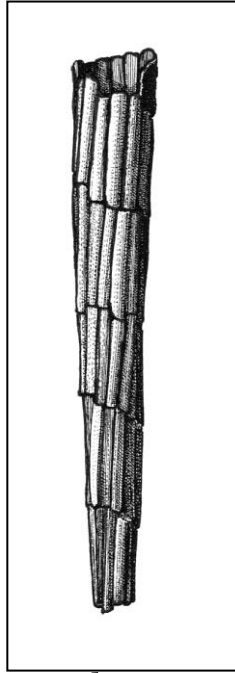
Anabolia and case, to 29 mm



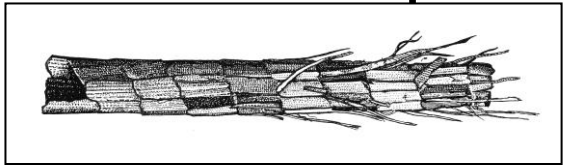
Family Phryganeidae, large larvae, to 40 mm or more when mature



Phryganea and case, to 60 mm; has dark stripes on top of head



Banksiola and case, to 45 mm



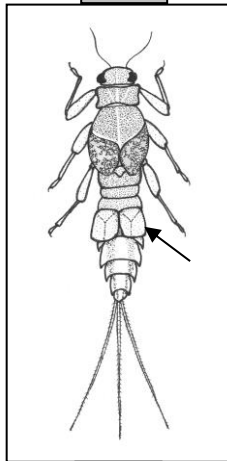
Mayflies (Order Ephemeroptera) in wetlands

KEY PAGE 7

Mayfly larvae have 3 pairs of obvious external jointed legs, they have wing pads and usually 3 thin tails at the end. Some members of the family Baetidae have only two tails, or the center tail is shorter. Many mayfly larvae have gill plates along the abdomen with which they collect oxygen from the water and through which they exchange ions from their blood. The families Caenidae and Trichorythidae have their gills located underneath a pair of gill coverings (operculum) located on the upper abdomen. Both of these families are found on the substrate and are less likely to be actively swimming in the water. **NOTE: gills are fragile, and may be lost from abdomen.**

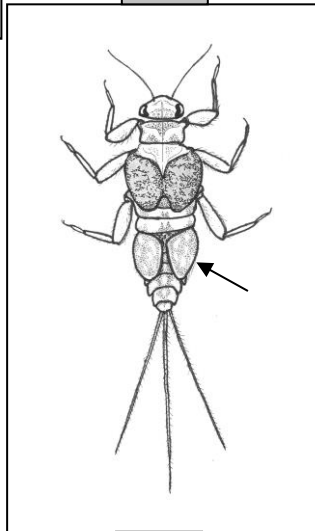
You may see other kinds of mayflies than those pictured here. Look at the antennae length. Look at the shape of the gills along the abdomen. Some mayflies will have divided gills, some will have gills that appear almost feathery. Look for irregular vs regular "veins" in the gill plates (tracheation)

Family Caenidae. Common, gills are tucked under two rectangular plates (arrow); silt accumulates on body hairs and acts as camouflage in silty water; very small, only 2.5 – 4 mm long.



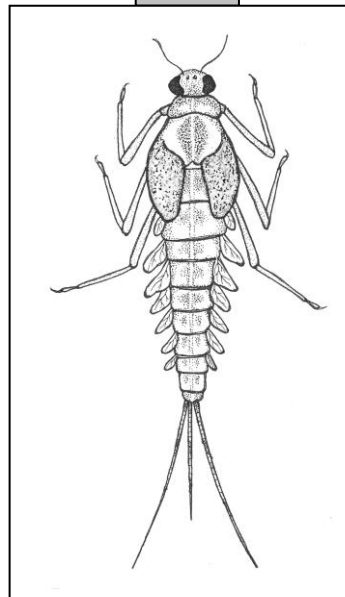
Genus Caenis

Family Trichorythidae. Gills are tucked under two triangular plates (arrow); are crawlers; body 3 – 7 mm long.



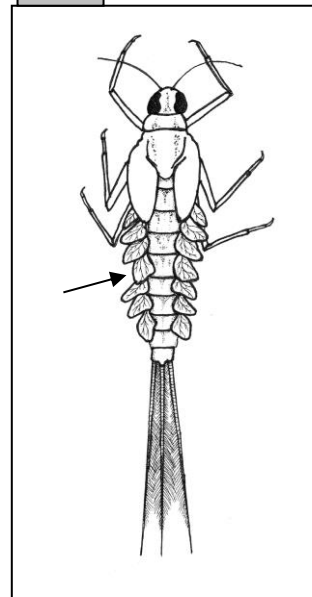
Genus Trichorythodes

Family Baetidae. Gills are oval plates along the sides of the segments of the abdomen, but some are irregular and more veined (arrow, right image); relatively long antennae; swimmers; body 4 – 9 mm long.

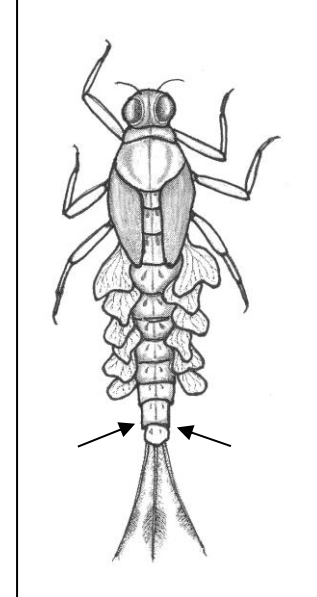


Genus Baetis

Family Siphonuridae. Antennae are relatively short. In some species the gills are irregular-shaped plates along the sides of the abdomen, but in other species the gills are regular shapes; fast swimmers, body 9-16 mm. May have sharp points on last body segment (not shown, at arrows).



Genus Callibaetis



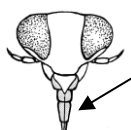
Genus Siphonurus

Adult True Bugs (Hemiptera) and adult beetles (Coleoptera): obvious external legs AND mature adult wings

KEY PAGE 8

Wings are leathery, compressible, not rigid, **has piercing mouthparts** (except Corixidae, see separate sheet **PAGE 9**): **aquatic bugs, order Hemiptera**. In immatures, the wings are not complete over the body.

Wings are hard, not compressible has chewing mouthparts: **adult water beetles, order Coleoptera**. Many adult beetles have long hairs on legs for swimming. **BETTER GO TO PAGE 10**

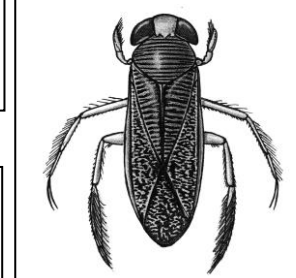
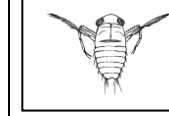


Mouth forms a **narrow pointed, piercing beak**

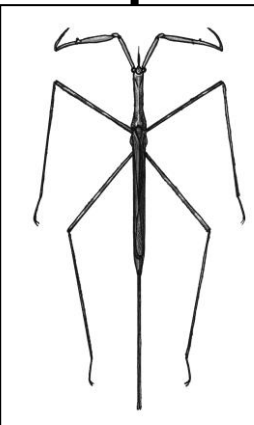
Mouth forms a **wider, cone-shaped beak**, swims right side up, front legs short, scooplike, adults 5 – 7 mm: **water boatmen, family Corixidae** (juvenile and adult *Sigara* below). **GO TO PAGE 9**

Does not live on surface of water

Corixid beak

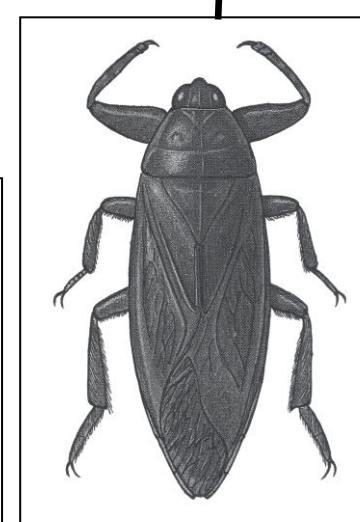


29-32 mm long, has long stout breathing tube projecting from end: **water scorpion, family Nepidae** (*Ranatra*)

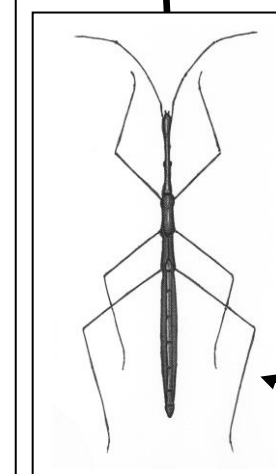


Does not have a long tube projecting from the end

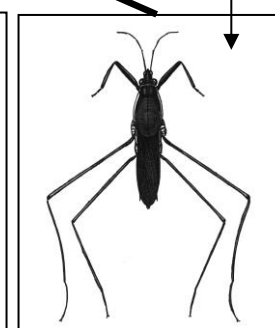
20-65 mm, body flattened and oval, front legs are raptorial: **giant water bugs, family Belostomatidae** (*Lethocerus*).



Lives on surface of water, antennae are much longer than head: families Hydrometridae (*Hydrometra*) and **Gerridae** (*Gerris*, right figure)

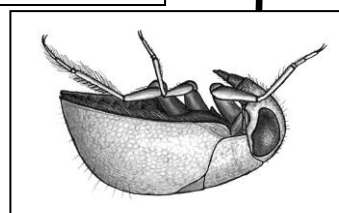


Robust, dark colored

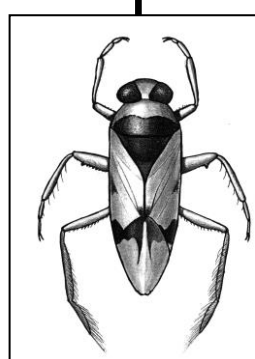


Delicate, lighter colored, wings hard to see

Less than 3 mm, dark brown hard convex body, swims on back: **pigmy backswimmer, family Pleidae** (*Neopleia*)



Hind legs elongate, flattened and hairy, swims on back, body softer, often partly white with red eyes: **backswimmer, family Notonectidae** (*Notonecta*)



Corixid bug, water boatman, ventral view. Note the rounded beak; note the short brushy front legs.

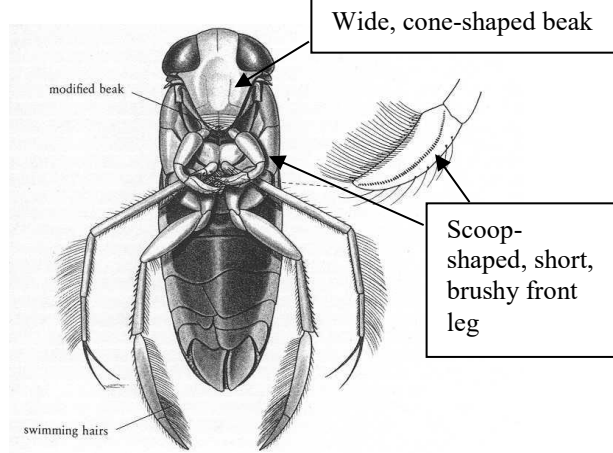
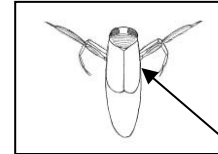
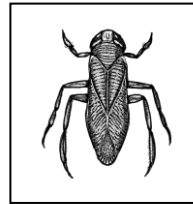


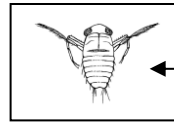
Figure 10.14. *Sigara* adult, ventral (fore tarsus enlarged)

Corixid bugs (family Corixidae) have a modified beak. It is more rounded and wide than other aquatic bugs, which have an elongated, pointed beak with which they pierce into their prey to suck up the prey's juices.

Adults wing pads cover body, adults are about 5-7 mm, juveniles are smaller. Dorsal views.

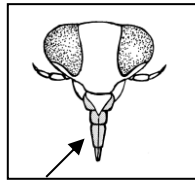
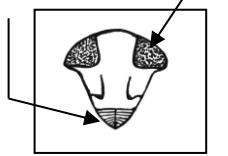


Immature corixid with immature wing pads



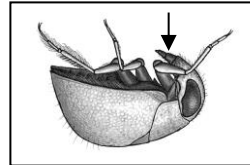
Juvenile corixid

Corixid head with wide beak



Pointed beak of **non-corixid** bug

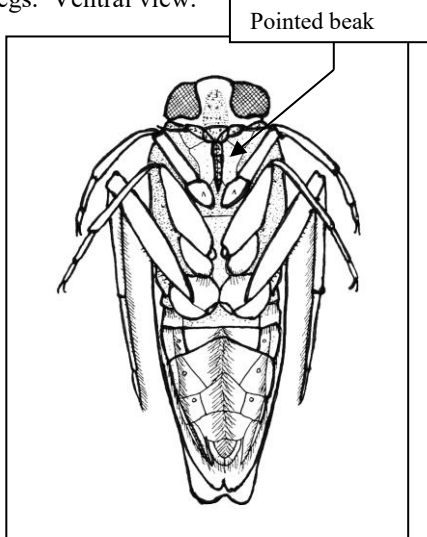
Non-corixid bug, has a pointed beak
Pigmy back swimmer has pointed beak, swims on back



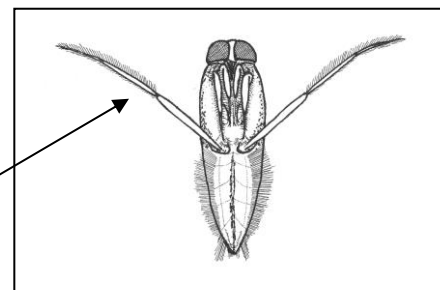
Life size, approximate, is less than 3 mm



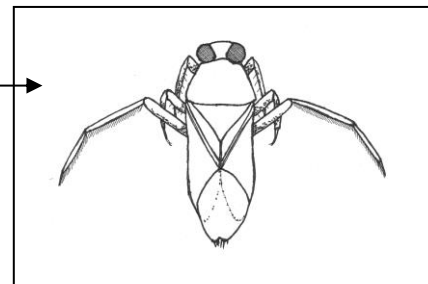
Non-corixid bug, a backswimmer, or Family Notonectidae, 4-16 mm. Note the pointed beak; the long thin front legs. Ventral view.



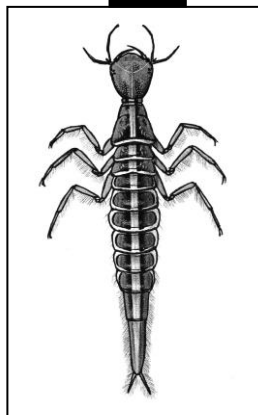
Backswimmer, on its back (ventral view). A non-corixid bug. Note elongated rear legs used to swim.



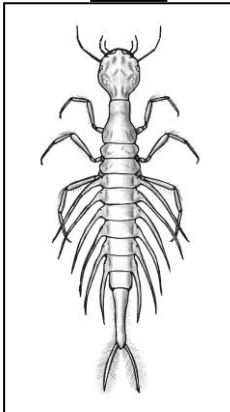
Backswimmer, dorsal view



Dytiscidae: predaceous diving beetles, mandibles sickle-like



Dytiscus larva to 4.8 cm

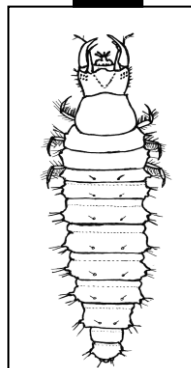


Coptotomus larva

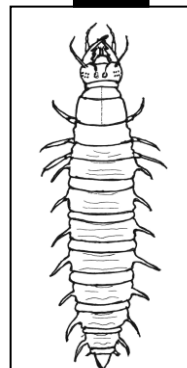
Beetle larvae have **no wing pads**, lack hooks at end, lack long single projection from end

Beetle adults have mature, hard wings and chewing mouthparts

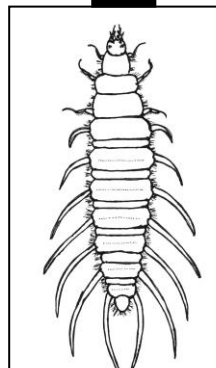
Hydrophilidae: water scavenger beetles; mandibles thick



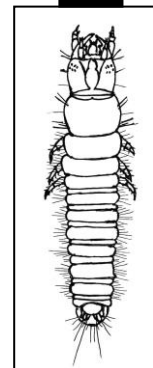
Tropisternus larva to 1.5 cm



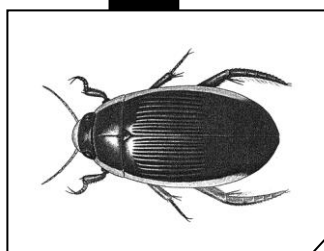
Hydrochara



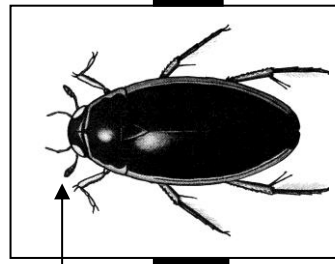
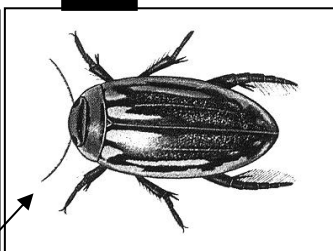
Berosus, adult below



Enochrus

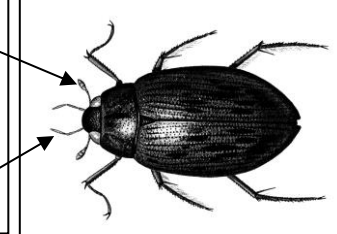


Adult Dytiscidae 2.5 – 2.8 cm, **antennae are threadlike**, not club-shaped. Predaceous diving beetles.

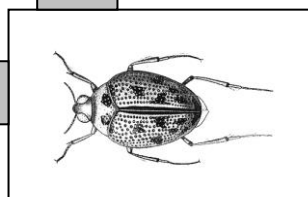
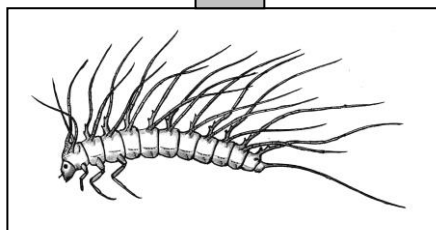


Adult 8 – 10 mm. The fine projections are not the antennae. The **club-shaped antennae** point sideways, often lie against the head.

Antennae club-shaped, usually lie flat on head, may be tucked under (**Hydrophilidae**)
Fine projections are **not** the antennae

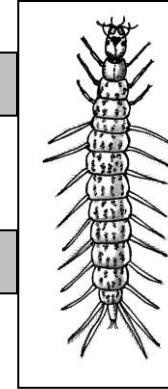
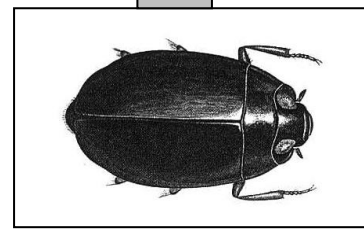


Haliplidae: crawling water beetles, Peltodytes



Peltodytes 2-6 mm, usually spotted, has large plates overlapping base of rear legs on ventral surface.

Gyrinidae, whirligig beetles, Dineutus larva and adult, 3-15 mm, swims on surface, look for 4 separate eyes, 2 up, 2 down

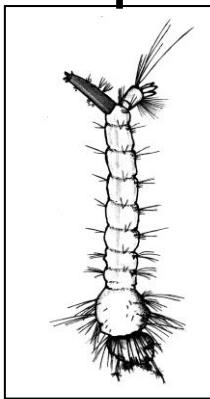


ORDER DIPTERA, TRUE FLIES

Dipteran larvae have **no obvious external jointed legs**. They have a **head capsule** and/or tail brushes or tails (but see the pupae). This page shows some Dipterans (true flies) in wetlands.

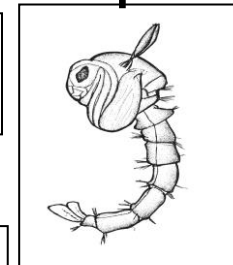
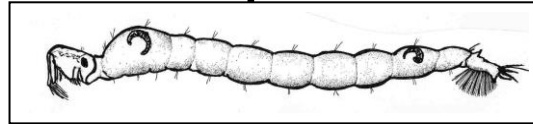
KEY PAGE 11

Family Culicidae: mosquitoes. Larva has a breathing tube at the rear, either hangs at surface or the cattail mosquito larva punctures the stems of cattails to get air. Feeds on microorganisms coating surfaces of plants and bottom. Sensitive to pesticides but develop resistances. Larvae 3-15 mm. Some species (but not all) carry diseases.



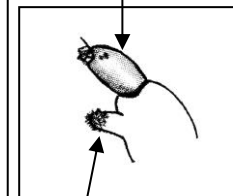
Mosquito pupa has a large head end, it wriggles to the surface.

Family Chaoboridae: Chaoborus, the phantom midge larva. Is glassy clear in life, opaque white when preserved, it lies horizontally in the water and is predatory on Daphnia, mosquito larvae and other small invertebrates. Sensitive to pesticides. Pupa is shown at right below. 1-2 cm long.



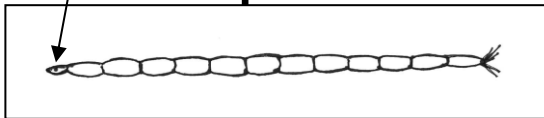
Family Chironomidae: has prolegs, most are non-biting midges. There are many kinds of chironomids in wetlands, and the number of kinds (genera) goes down when pollution increases. There is one type of chironomid that makes red blood (hemoglobin) and is able to tolerate lower oxygen conditions in wetland sediments. In wetlands, the presence of some red chironomids does not necessarily indicate pollution (they are considered "pollution indicators" in streams). What is a good indicator in both wetlands and streams is finding many kinds of chironomids. They are killed by BTI, a pesticide used to control mosquitoes. They are very important in the food web of wetlands. They are eaten by many of the predatory invertebrates in wetlands. 2mm – 30mm long.

Head capsule

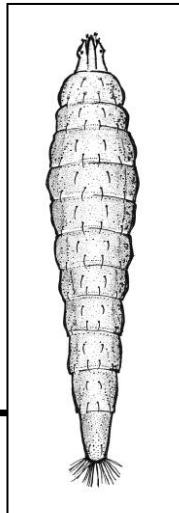


Proleg

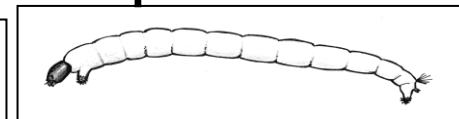
Family Ceratopogonidae, has no prolegs, are biting midges. Very stiff in life, long and thin. Tiny head capsule. Around 1 cm long.



There are several other kinds of Dipterans in wetlands. Some have larvae that are sluggish and lie near the surface. **Family Stratiomyidae**, the brownish soldier fly is an example. Head capsule is hard to distinguish in this kind of larva. 1 – 5 cm. Brush at end.



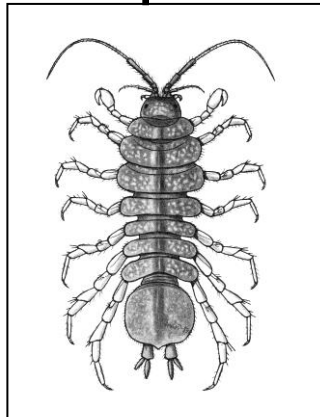
Some midge larvae are gray, green or white (right), others are red (above) from hemoglobin in their blood.



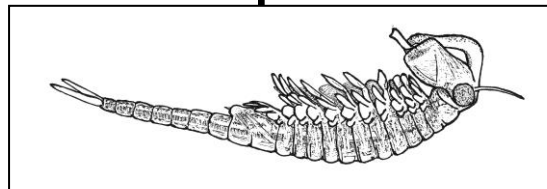
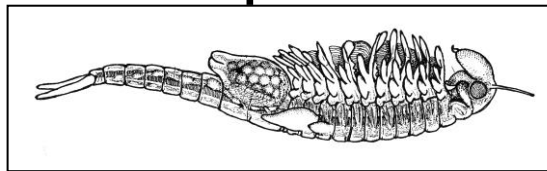
Crustaceans in Wetlands. Class Crustacea

KEY PAGE 12

7 pairs of laterally projecting legs, body flattened dorso-ventrally, crawls on the bottom:
Order Isopoda, isopods. to 2 cm long.



Fairy Shrimp: has 11 pairs of flattened appendages, no carapace, swims on back, 1.5 – 2.5 cm long. Female with eggs (top figure), male with enlarged clasping antennae. **Order Anostraca**

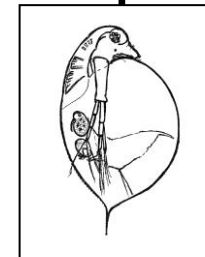


Body flattened laterally, swims on its side, 7 pairs of jointed legs:
Amphipods or scuds. To 2.5 cm long. GO TO Page 13

Five pairs of walking legs, front pair of enlarged claws: **Decapoda, Crayfish.** GO TO Page 13

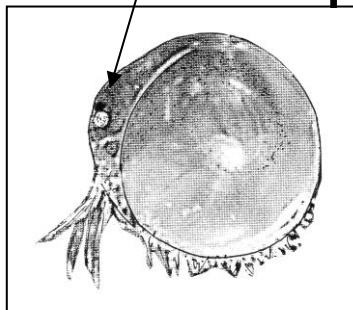
Microscopic, swim in water. May have eggs in dorsal brood space. Not counted as macroinvertebrates.

Daphnia, water fleas (Order Cladocera). 1- 3 mm long.

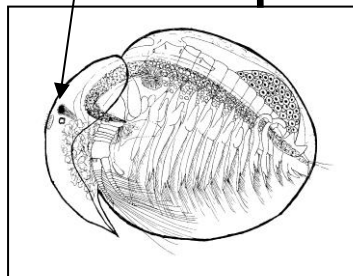


Clam shrimp are rounded, 4-7 mm, pinkish in life; eye spot is at front end. Legs not usually visible through the leathery, compressible carapace.
Order Conchostraca. We do record clam shrimp. Swims and crawls.

Eye spot

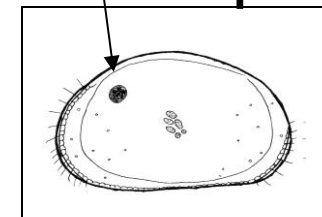
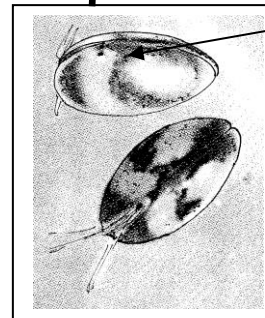


Eye spot



Seed shrimp, oval, carapace is hard, not compressible or leathery. 2-5 mm, usually < 2.5 mm long; eye spot is off center, not at front end. **Order Ostracoda.** We don't count them as macroinvertebrates.

Eye spot



**Crustaceans in Wetlands. Class Crustacea.
Order Amphipoda and Order Decapoda**

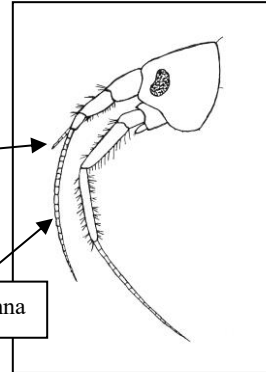
KEY PAGE 13

Order Amphipoda. Body flattened laterally, 7 pairs of jointed legs, swims on sides.
Amphipods or "scuds."

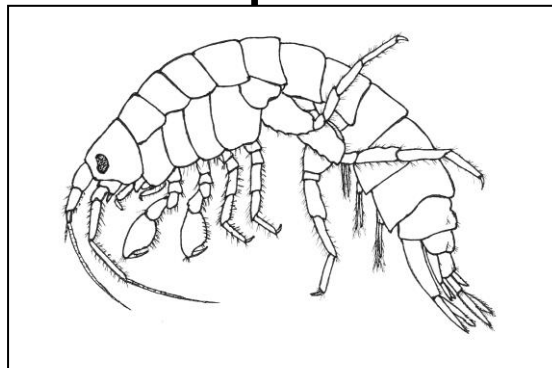
There is **no accessory flagellum** on the first antenna:
Hyaella. Small, 4 – 8 mm long. Look carefully.
Not pictured.

There is a little **accessory flagellum** on the first antenna.

First antenna



Gammarus has **3-7 segments** in its accessory flagellum (this requires very careful viewing!). Larger amphipod, to 2.2 cm long.

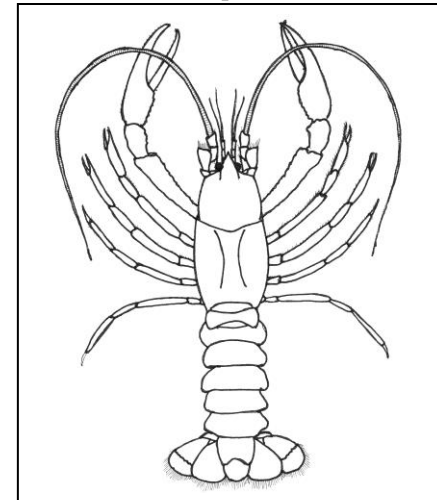
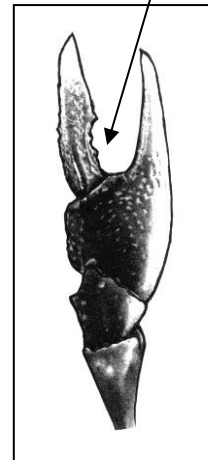


Crangonyx and **Pseudocrangonyx** (no picture) have **only two segments** in the small accessory flagellum (you must look carefully with the microscope!). Larger amphipods, to 2.2 cm long.

Order Decapoda. Crayfish. Five pairs of walking legs, front pair are enlarged claws (chela).

Two kinds of crayfish you might see in wetlands are **Orconectes immunis**, which can burrow into the mud and has a notch in the inner edge of the "thumb" of its claw, and **Orconectes rusticus**, the exotic rusty crayfish which has rusty colored spots on either side of the thorax.

Notch in chela of *Orconectes immunis*



SNAILS Common in Wetlands (first page of 2 pages)

SNAILS common in Wetlands (second of two pages): FAMILY PLANORBIDAE

KEY PAGE 14

HAS LUNGS, no hard cover over opening, called "pond snails"

HAS GILLS (not visible from outside), hard cover (perculum) over opening in live snail, most occur in streams and lakes. Left, *Campeloma*. Right, Oriental Mystery snail, exotic species to 63 mm.

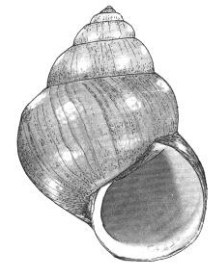
FLATTENED DISC SHAPE. Family Planorbidae. **GO TO Key Page 15**

ELEVATED SPIRE SHAPE. Shell height is given in mm.

Cover

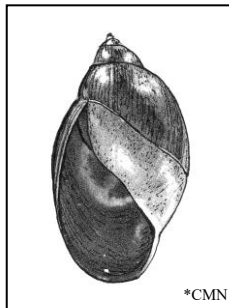


*CMN



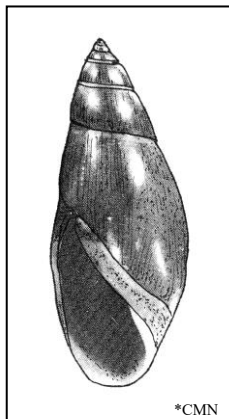
*CMN

LEFT COILED
(opening is on the left side)



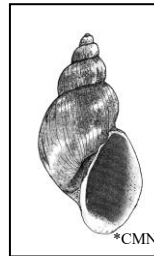
*CMN

Physa, to 24 mm, most are smaller, very common



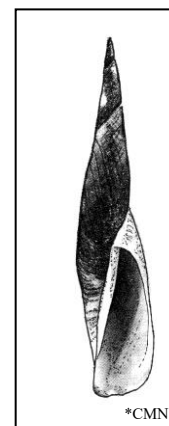
*CMN

Aplexa, 18 mm, dark and shiny in life, opening smaller than Physa's, more likely in ephemeral wetlands



*CMN

Fossaria 8-9 mm, small with 4-5 turns in shell

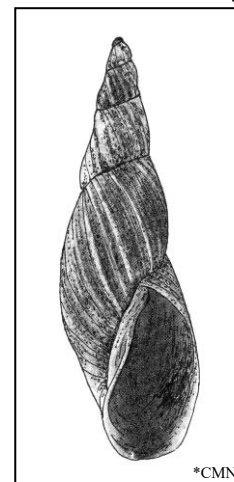


*CMN

Acella to 25 mm, very thin

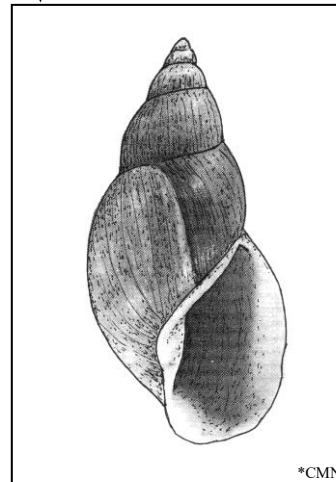
RIGHT COILED (opens on right side when held vertically)

Stagnicola reflexa, to 35 mm, may be striped



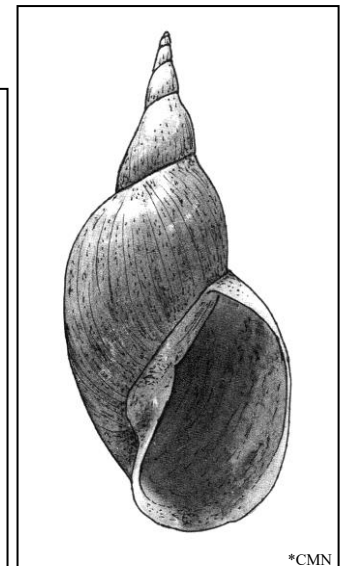
*CMN

Stagnicola elodes, to 32 mm, evenly wide



*CMN

Lymnaea stagnalis, to 56 mm, thin shell, sharp point, wide whorl above the opening of the shell.

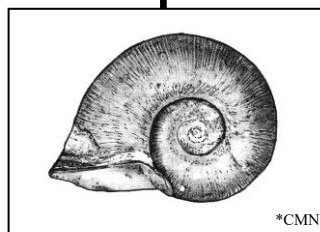


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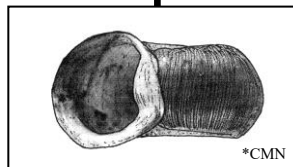
Family Planorbidae. Flattened disc shape. Shell width is given (in mm). See Tips in Guide Page 23 how to tell top from bottom and coiling.

LEFT COILED

Planorbella trivolvis (formerly *Helisoma*) to 32 mm wide; top and side

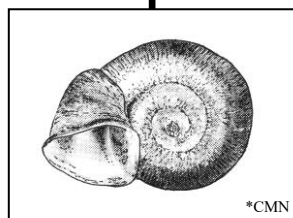


*CMN

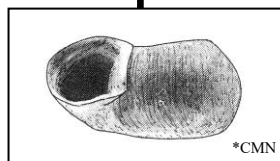


*CMN

Planorbella campanulata (formerly *Helisoma*) to 15 mm; top and side views



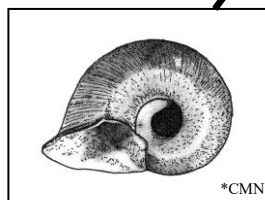
*CMN



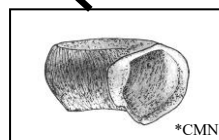
*CMN

RIGHT COILED

Helisoma anceps, to 20 mm wide

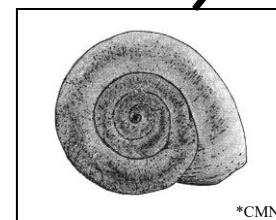


*CMN

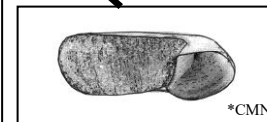


*CMN

Planorbula 8 mm, look for white "teeth" just inside shell opening. Coils are even and flat across the top of the snail.

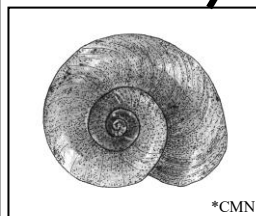


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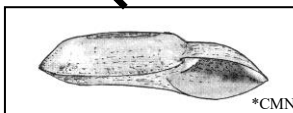


*CMN

Promenetus 7–9 mm wide, note the acute edges in side view

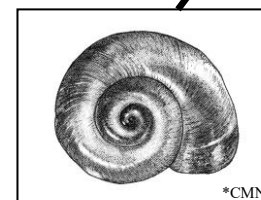


*CMN

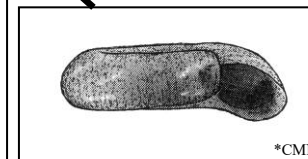


*CMN

Gyraulus 5-8mm, coils rounded. Two species are shown, and side view. Note rounding of coils in side view.

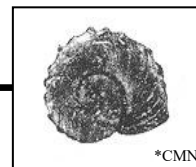


*CMN

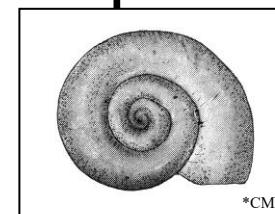


*CMN

Armiger, very tiny, 3mm, often has longer spines project from edge than pictured here.



*CMN

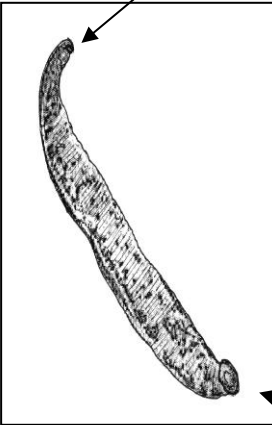


*CMN

Leeches (Order Hirudinea) in Wetlands: Background

KEY PAGE 16

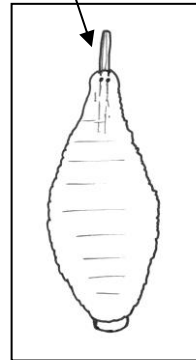
Mouth, anterior end



Leeches are members of the Phylum Annelida, which includes worms. Leeches have more than 20 body segments and no projecting stout hairs (setae). Most worms have setae. Leeches have a sucker at the posterior end larger than the mouth end. The anterior end has eyes and the mouth, these structures differ among the kinds of leeches. Leeches eat a variety of invertebrate prey types, or feed on amphibians, turtles, fish or birds. Only a few leeches (like *Macrobdella*) suck blood from mammals.

Sucker on posterior end

Proboscis extruded for feeding



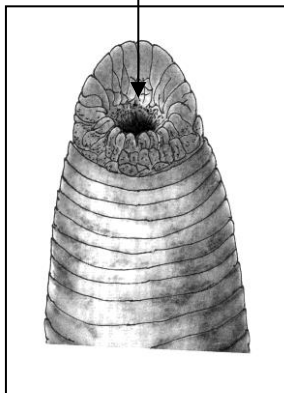
Family Glossiphonidae: mouth is a tiny pore in the front sucker. **Small** leeches (1/2" – 2.5") with a flattened, **pear-shaped body**. Poor swimmers, usually creep over substrates. Females carry their eggs and young on the underside. Eyes various.

Glossiphonid leeches feed with a structure (**proboscis**) that projects out from the front and sucks juices from prey such as snails and insects, turtles and frogs. The food type differs for the species of leech. The anterior end is not filled with an open pore of the mouth. **GO TO PAGE 17 Family Glossiphonidae**

Family Erpobdellidae:

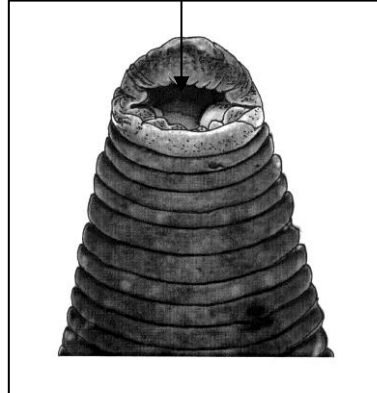
worm-like or ribbon-like body shape, elongated, moderate, size body: (roughly 1-4" long). Mouth is an obvious opening in anterior end, for swallowing prey whole.

GO TO PAGE on Families Erpobdellidae and Hirudinidae Page 18

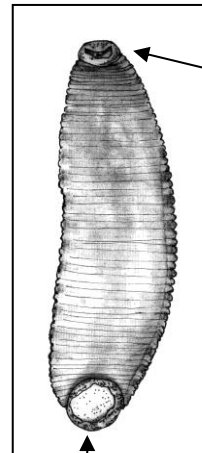


Family Hirudinidae: large (4-12"), thick leeches with various patterns. Some have hidden jaws and "teeth" in anterior end.

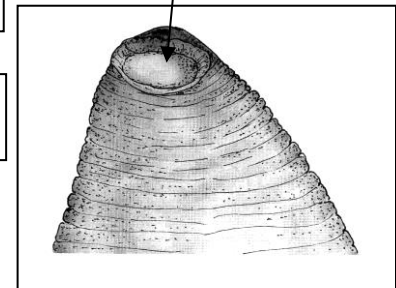
Eye pattern an arched array of five pairs of eyes. **GO TO PAGE on Families Erpobdellidae and Hirudinidae Page 18**



Anterior end of Glossiphonid leech with proboscis not extruded, no open mouth area, ventral view



Sucker on posterior end

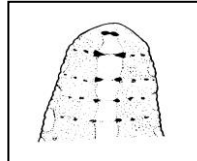
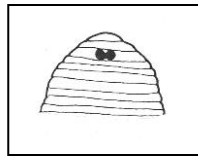
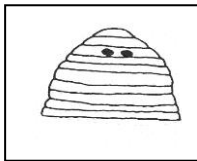


Leeches (Order Hirudinea) in Wetlands: Family Glossiphonidae

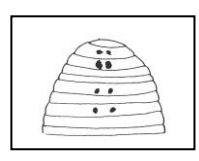
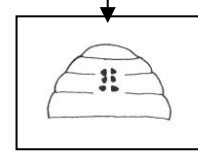
KEY PAGE 17

FAMILY GLOSSIPHONIDAE: the mouth is a tiny pore in the front sucker. When feeding, a proboscis extrudes from the pore to penetrate invertebrate or vertebrate prey. Proboscis is usually hidden. Small leeches with a **flattened, pear-shaped body**, **head is narrower than the body**. They are poor swimmers, usually creep over substrates. Glossiphonid females carry their eggs and young on the underside.

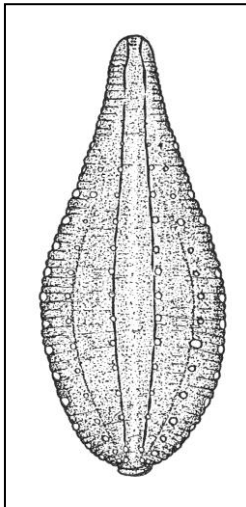
Glossiphonid species differ in the number or pattern of the **eyes, and the body patterns**. Eyes are tiny dark spots at the very front end of the leech, dorsal side. Placobdella has just one pair of eyes, while Glossiphonia has three pairs of eyes arranged in a vertical row.



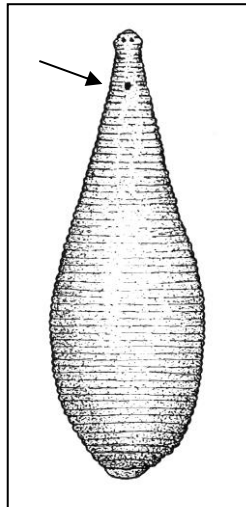
One pair of **eyes** (left three), closest figure shows accessory pigments below one true pair of eyes. To right, 3 pairs and 4 pairs are shown. Press top of head down to view under microscope.



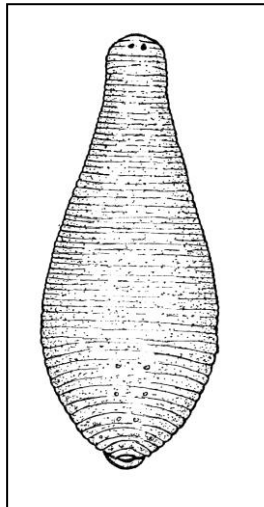
Eyes are difficult to see in contracted, preserved specimens. Look for body patterns, look for patterns of bumps (papillae) on the surface, or for stripes (Glossiphonia). Look for a dark small patch near the head (Helobdella). A few species are shown below.



Glossiphonia complanata less than 20 mm long; 3 pairs of eyes

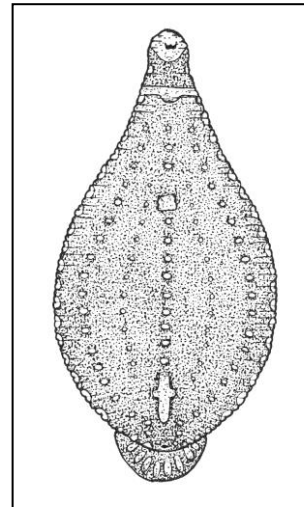


Helobdella stagnalis, 9-14 mm, one pair eyes; note dark patch near head

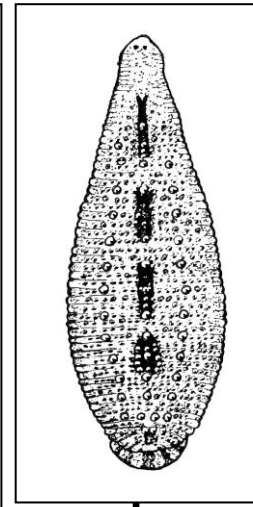


Helobdella fusca

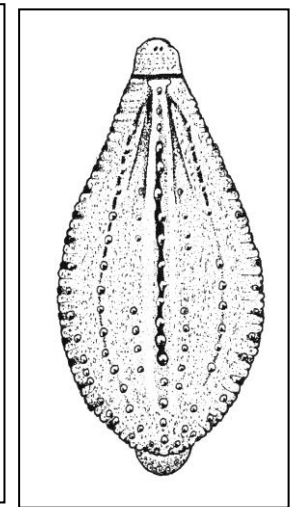
NOTE: you may see other genera and species!



Batracobdella, 1-2 cm



Placobdella ornata, a beautiful leech, decorated with papillae! 2-4 cm. One pair eyes.

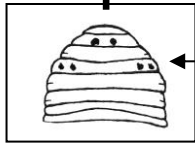


Placobdella papillifera to 1.5 cm

LEECHES in Wetlands: Families Erpobdellidae and Hirudinidae

KEY PAGE 18

FAMILY ERPOBDELLIDAE: worm-like or ribbon-like leeches, roughly 1- 4" long, mouth is pore-like opening in the front end



Eye patterns, dorsal view, hard to see in preserved specimens

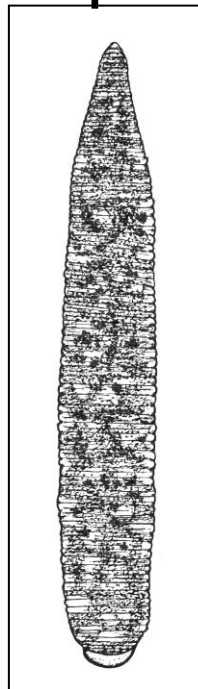
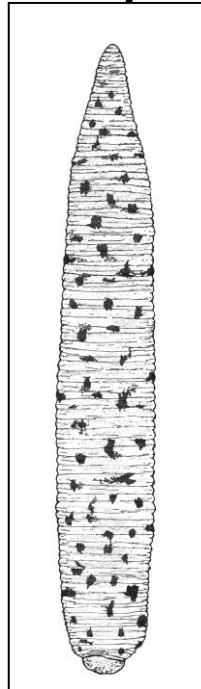
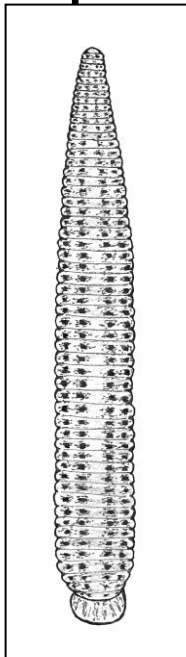
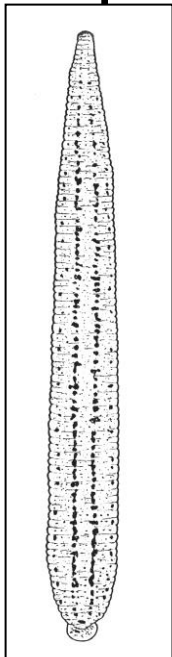


Erpobdella punctata. Worm-like body shape, striped. Sometimes the pattern varies, or is not visible, especially in preserved specimens. Increases in pollution.

Egg case

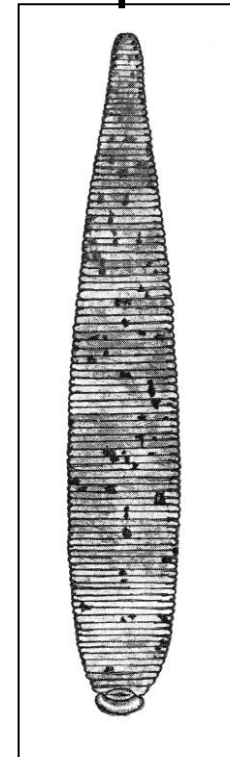
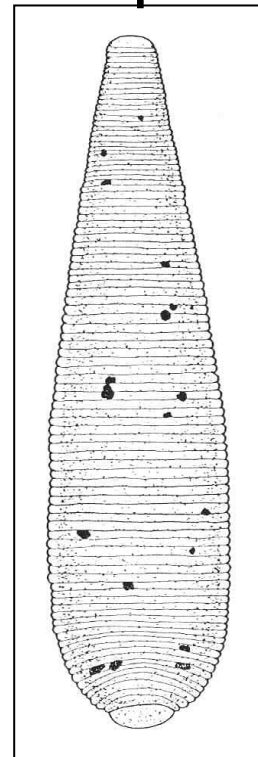


Nephelopsis. Flat ribbon-like body shape. May be mottled so much it looks solid in color.



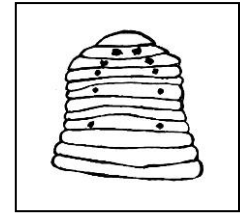
FAMILY HIRUDINIDAE: large, thick leeches with various patterns, some have hidden jaws and "teeth." Shown: **Haemopsis** and **Macrobdella**

Haemopsis grandis, our biggest leech, 6-12"

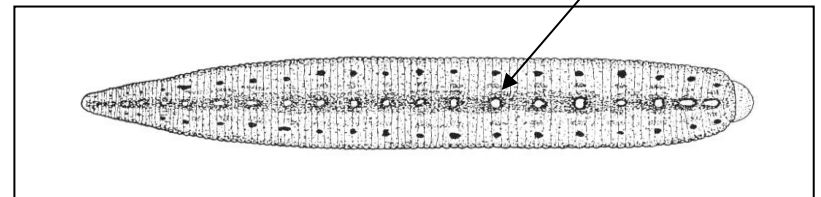


You may be able to see the arched pattern of 5 pairs of single eyes at the front, even in dark specimens.

HIRUDINIDAE EYES



Macrobdella decora 4-6", decorated with rows of orange-red spots down the back, greenish color alive. This one swims, and sucks blood!



Appendix 1. Permissions for use of figures modified and used in the Citizen Guide to Biological Assessment of Wetlands: The Macroinvertebrate Index of Biological Integrity (IBI).

Most of the figures used in this guide were modified from figures in existing publications by darkening the lines on the figures so when reduced in size the lines would still show. All figures were scanned and then imported into the document. A few figures were drawn from images of organisms in MPCA's collections.

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The dragonfly nymph *Macromia* and the damselfly *Argia* (shown in key page 2 to insects) were from the 1915 publication: C.H. Kennedy. 1915. Notes on the life history and ecology of the dragonflies of Washington and Oregon. Proc. U.S. National Museum. 49:259-345. These figures are in the public domain, but we are grateful to the Smithsonian Institution Press for letting us know that.

The figures of leeches are from the publication from Roy T. Sawyer: North America Freshwater Leeches Exclusive of the Piscicolidae with a Key to All the Species. 1972. Illinois Biological Monographs 46, University of Illinois Press. Urbana Illinois. Permission was obtained from Dr. Sawyer and from University of Illinois Press.

The following figures were used from Freshwater Invertebrates of the United States, 2nd edition, Robert W. Pennak, 1978, John Wiley & Sons: dorsal view of *Aeshna*, alderfly *Sialis*, notonectid *Bueno* (dorsal and ventral views), beetle larvae *Tropisternus*, *Hydrochara*, *Berosus*, and *Enochrus*, ceratopogonid midge *Palpomyia*, *Chaoborus* larva and pupa, *Coenagrionidae* labium, corixid adult *Sigara*, corixid immature nymph, *Culex* pupa, the amphipod *Gammarus*, corduliid dragonfly *Helocordulia*, Lestidae damselfly *Lestes*, Lestidae labium, clamshrimp *Lynceus*, water mite, *Notonecta*, roundworm *Rhabditis*, snail operculum, ostracod *Cypria*, crayfish, and the soldierfly *Odontomyia*. This material is used by permission of John Wiley & Sons, Inc.

Numerous figures were used from: W. Patrick McCafferty, *Aquatic Entomology*, 1998, illustrations by Arwin V. Provonsa: Jones & Bartlett Learning, Sudbury, MA. www.jblearning.com. Reprinted with permission. Figures used in the Guide included the dragonflies *Anax* and *Aeshna*, the Coenagrionid damselfly *Argia*, *Asellus*, *Chironomus*, Coenagrionid labium, Corixid head diagram, Cricotopus, *Culex* larva, *Dineutus* adult and larva, dragonfly antennae and labium, *Dytiscus* adult and larva, *Gerris*, *Gomphus*, *Hydrometra*, *Lestes* and *Lestidae* mouthpart, *Lethocerus*, *Libellula* larva, *Libellulidae* labium, *Neoplea*, *Notonecta*, *Notonectidae* head, *Oecetis*, *Peltodytes*, *Pseudodiamesa*, *Ranatra*, *Sigara*, *Tropisternus* adult and larva, *Berosus* adult, *Coptotomus* larva and adult.

Figures of caddisflies were reproduced with permission from the Royal Ontario Museum of Canada from the second edition of Glenn B. Wiggins' 1977 *Larvae of North American Caddisfly Genera* illustrated by Anker Odum. University of Toronto Press. Toronto, Canada. ISBN 0-8020-5344-0. The figures used are *Anabolia* larva and case, *Banksiola* larva and case, *Ceraclea* larva and case, *Limnephilus* larva and case, *Phryganea* larva and case, *Triaenodes* larva and case.

The figures from photographs of clam shrimp and an ostracod were used by permission from Matthew Burne from the publication by Matthew Burne and Leo Kenney, May 2001. *A Field Guide to the Animals of Vernal Pools*. Massachusetts Division of Fisheries and Wildlife Natural Heritage and Endangered Species Program and the Vernal Pool Association. Westborough, MA.

Appendix 2. Sources for identifications of invertebrates

Burne, Matthew and Leo Kenney. May 2001. A Field Guide to the Animals of Vernal Pools. Massachusetts Division of Fisheries and Wildlife Natural Heritage and Endangered Species Program. Westborough, MA.

Clarke, Arthur H. 1981. The Freshwater Molluscs of Canada. National Museum of Natural Sciences. National Museums of Canada. Ottawa, Canada K1A 0M8. 446 pp. (has nice photographs and individual descriptions).

Edmunds, Jr., George F, S.L. Jensen, L. Berner. 1976. The Mayflies of North and Central America. University of Minnesota Press. Minneapolis. (not sure if available anymore).

Jokinen, Eileen H. 1992. The Freshwater Snails (Mollusca: Gastropoda) of New York State. New York State Museum Bulletin 482. New York State Museum Biological Survey. Albany. New York.

Klemm, Donald J. 1982. Leeches (Annelida: Hirudinea) of North America. US EPA Cincinnati, OH. EPA-600/3-82-025.

Knopp, Malcolm and Robert Comier. 1997. Mayflies, An Angler's Study of Trout Water Ephemeroptera. Lyons Press. Guilford, CT.

Hilsenhoff, William L. 1995. Aquatic Insects of Wisconsin. Publication Number 3 of the Natural Museums Council. University of Wisconsin - Madison. 79 pp. (not expensive and regional).

Legler, Karl and Dorothy, Dave Westover. 1998. Common Dragonflies of Wisconsin. Revised. \$18.95 Available through karlndot@bankpds.com.

McCafferty, W. Patrick with Illustrations by Arwin Provonsha. 1998. Aquatic Entomology. Jones and Bartlett Publishers, Inc. Sudbury, MA.

Merritt, Richard W. and Kenneth W. Cummins. 1996. An Introduction to the Aquatic Insects of North America, 3rd Edition. Kendall/Hunt Publishing. Dubuque, Iowa. 862 pp. (this is used by everyone doing identifications).

Pennak, Robert W. 1978. Freshwater Invertebrates of the United States, 2nd ed. John Wiley and Sons, Inc. NY.

Pennak, Robert W. 1989. Freshwater Invertebrates of the United States, 3rd ed. Protozoa to Mollusca. Wiley Interscience. New York. (has the non-insect invertebrates).

Sawyer, Roy T. 1972. North American Freshwater Leeches Exclusive of the Piscicolidae with a Key to All the Species. Illinois Biological Monographs 46. University of Illinois Press. Urbana Illinois.

Smith, Douglas Grant. 2001. Pennak's Freshwater Invertebrates of the United States. Porifera to Crustacea. 4th ed. John Wiley and Sons, Inc. NY.

Thorpe, James H. and Alan P. Covich. 1991. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc. Boston. (covers all invertebrates).

Wiggins, Glenn B. 1996. Larvae of the North American Caddisflies (Trichoptera), 2nd edition. University of Toronto Press. Toronto.

Appendix 3. Basic Equipment and Sources of Equipment

Equipment per team of citizens

Chest high waders (be sure they fit the heel tightly)
Dipnet, D frame Aquatic Dip Net 52" handle 425-A46 Wildco
Tote tray to hold 2 Coleman cooler trays for sampling Fleetwood large Tote Tray,
Part # 51201-0100 Dick Blick
Two Coleman white cooler trays to fit into Tote tray to hold sampling screen Coleman
Two white plastic trays for sorting invertebrates 10 x 13 x 1.5" or 9.75 x 7.75 x 1.5 " Bioquip
Sorting screen to fit over cooler trays for dipnetting; ½" hardware cloth screen
attached to 1x1" wood frame 12" x 16" (handmade)
20 sample containers, e.g. 16 oz white plastic wide mouth jars
Two squirt (wash) bottles, cut tip to get stronger flow
One compass
One clear plastic ruler
One gallon 95-100% alcohol (can get at home supply stores)
Twelve bottletraps with brackets and 4 ft plastic rods or dowels Don Wik
One log book for field notes
Forceps Bioquip at least two pair, preferably 4 Part # 4731 Fine Forceps Bioquip

Suppliers

Wildlife Supply Company Buffalo, NY 800- 799-8301 www.wildco.com
Dick Blick Art Materials Tote #51201-0100 www.dickblick.com
Coleman Co. trays part # 5270-1171 www.coleman.com
Bioquip Gardena, CA 310 324 0620 www.bioquip.com
Don Wik Prototype Fabrications Menomonie, WI 715-664-8699
dwik_protofab@hotmail.com