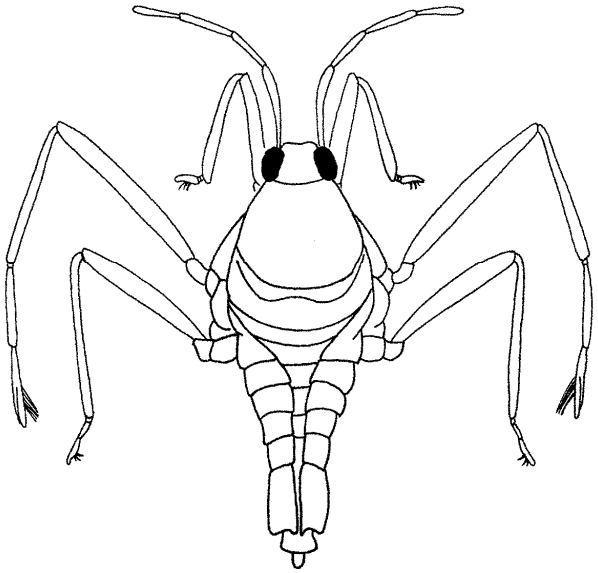
APPENDICES



Draft
June 17, 2009

A APPENDIX A

Summary of Aquatic Invertebrates

Appendix A is a list of the aquatic invertebrates in this guide. To help synthesize information and to provide a reference, the scientific name, common name, primary feeding group, tolerance value, and primary habitat information have been collated for each taxon into the following table. When possible the most common feeding group or habitat is listed, but in many cases a single designation is not sufficient, so multiple terms must be applied. In addition, because these are primary designations, the taxa you collect may not fit the descriptions in this appendix. These designations should apply to most taxa and/or the most commonly collected taxa. For further descriptions of feeding groups and habitats see Appendix C. The following are lists of abbreviations used in this appendix.

Abbreviations used in Appendix A:

Primary Feeding Group (FG)

CG = Collector/Gatherer
CF = Collector/Filterer
SC = Scraper
SH = Shredder
PR = Predator
PI = Piercer
PA = Parasite

Primary Habitats (HAB)

Lo = Lotic
LoE = Lotic Erosional
LoD = Lotic Depositional
LoL = Lotic Littoral
LoM = Lotic Margin
LoS = Lotic Surface
Le = Lentic
LeD = Lentic Depositional
LeE = Lentic Erosional
LeL = Lentic Littoral
LeLm = Lentic Limnetic
LeM = Lentic Margin
LeS = Lentic Surface

Other Abbreviations

A = Adult
L = Larva
FG = Feeding Group
TV = Tolerance Value
HAB = Habitat
U = Undetermined

APPENDIX A: SUMMARY OF AQUATIC INVERTEBRATES

FAMILY	COMMON NAME	FG	TV	HAB
PLATYHELMINTHES (Phylum)	Free-living Flatworms			
TURBELLARIA (Class)	Flatworms & Planarians	CG	4	Lo; Le
NEMATODA (Phylum)	Roundworms	PA; PI; SH	5	Lo; Le
NEMATOMORPHA (Class)	Horsehair Worms	PA	U	LeD; LoD
ANNELIDA (Phylum)	Worms & Leeches			
HIRUDINEA (Class)	Leeches	PA; PR	10	LeD; LoD
OLIGOCHAETA (Class)	Aquatic Earthworms	CG	8	LeD; LoD
MOLLUSCA (Phylum)	Clams & Snails			
GASTROPODA (Class)	Snails & Limpets	SC	7	Le; Lo
BIVALVIA (Class)	Mussels & Clams	CF	7	Le; Lo
ARTHROPODA (Phylum)	Insects, Arachnids, & Crustaceans			
CHELICERATA (Subphylum)				
ARACHNIDA (Class)	Spiders & Mites			
Araneae (Order)	Spiders	PR	U	LeL; LoL
Trombidiformes (Suborder)	Water Mites	PR	4	Le
CRUSTACEA (Subphylum)				
MALACOSTRACA (Class)				
Decapoda (Order)	Shrimps & Crayfishes			
Cambaridae	Crayfishes	CG	6	Le; Lo
Palaemonidae	Shrimps	SC	4	LeD; LoD
Isopoda (Order)	Aquatic Sow Bugs	CG	8	Lo
Amphipoda (Order)	Scuds & Side-Swimmers	CG	4	Le; Lo
BRANCHIOPODA (Class)				
Cladocera (Suborder)	Water Fleas	CF	U	LeLm
MAXILLOPODA (Class)				
COPEPODA (Subclass)	Copepods	CG; CF	U	Le; Lo
OSTRACODA (Class)	Seed Shrimps	CF	U	Le
ATELOCERATA (Subphylum)				
HEXAPODA (Class)	Insects & Related Orders			
Collembola (Order)	Springtails	CG	10	Le; Lo
INSECTA (Subclass)	Insects			
Ephemeroptera (Order)	Mayflies			
Acanthametropidae	Acanthametropodid Mayflies	PR	U	Lo
Ameletidae	Ameletid Minnow Mayflies	SC; CG	0	Lo
Ametropodidae	Sand Minnow Mayflies	CF; CG	U	Lo

FAMILY	COMMON NAME	FG	TV	HAB
Ephemeroptera (Continued)	Mayflies			
Baetidae	Small Minnow Mayflies	CG; SC	4	LoE; LoD
Baetiscidae	Armored Mayflies	CG	3	LoD
Caenidae	Small Square-Gill Mayflies	CG; SC	7	LoD; LeD
Ephemerellidae	Spiny Crawler Mayflies	CG	1	LoE
Ephemeridae	Common Burrowing Mayflies	CG	4	LoD; LeD
Heptageniidae	Flathead Mayflies	SC	4	LoE; LeE
Isonychiidae	Brush-Legged Mayflies	CF	2	LoE; LoD
Leptophlebiidae	Prong-Gilled Mayflies	CG	2	LoE
Metretopodidae	Cleft-Footed Minnow Mayflies	PR; CG	2	LoE
Oligoneuriidae	Brush-Legged Mayflies	CF	U	Lo
Polymitarcyidae	Pale Burrowing Mayflies	CG; CF	2	LoE; LoD
Potamanthidae	Hacklegill Mayflies	CF	4	LoE; LoD
Siphlonuridae	Primitive Minnow Mayflies	CG	7	LeE
Tricorythidae	Little Stout Crawler Mayflies	CG	4	LoD; LeL
Odonata (Order)	Damselflies and Dragonflies			
Zygoptera (Suborder)	Damselflies			
Calopterygidae	Broad-Winged Damselflies	PR	5	LoD
Coenagrionidae	Narrow-Winged Damselflies	PR	9	Le; Lo
Lestidae	Spread-Winged Damselflies	PR	9	Lentic
Anisoptera (Suborder)	Dragonflies			
Aeshnidae	Darner Dragonflies	PR	3	Le; Lo
Cordulegastridae	Spike-Tail Dragonflies	PR	3	LoD
Corduliidae	Green-Eyed Skimmers	PR	4	LeL
Gomphidae	Club-Tail Dragonflies	PR	1	LoD; LeL
Libellulidae	Common Skimmer Dragonflies	PR	9	LeL
Plecoptera (Order)	Stoneflies			
Capniidae	Small Winter Stoneflies	SH	1	LoE; LoD
Chloroperlidae	Green Stoneflies	PR	1	LoE
Leuctridae	Roll-Winged Stoneflies	SH	0	LoE; LoD
Nemouridae	Brown Stoneflies	SH	2	Lo; LeE
Perlidae	Common Stoneflies	PR	1	LoE
Perlodidae	Patterned Stoneflies	PR	2	LoE
Pteronarcyidae	Giant Stoneflies	SH	0	LoE; LoD
Taeniopterygidae	Winter Stoneflies	SH	2	LoE; LoD
Hemiptera (Order)	True Bugs			
Belostomatidae	Giant Water Bugs	PR	10	LoD; LeL

FAMILY	COMMON NAME	FG	TV	HAB
Hemiptera (Continued)	True Bugs			
Corixidae	Water Boatmen	CG	9	LoD; LeL
Gelastocoridae	Toad Bugs	PR	U	LoM; LeM
Gerridae	Water Striders	PR	U	LeS; LoS
Hebridae	Velvet Water Bugs	PR	U	LoM; LeM
Hydrometridae	Marsh Treaders	PR	U	LoM; LeM
Mesoveliidae	Water Treaders	PR	U	LoM; LeM
Naucoridae	Creeping Water Bugs	PR	5	LoD; LeL
Nepidae	Water Scorpions	PR	8	LoD; LeL
Notonectidae	Backswimmers	PR	U	LeL; LD
Pleidae	Pygmy Backswimmers	PR	U	Le
Saldidae	Shore Bugs	PR	U	LoM; LeM
Veliidae	Broad-Shouldered Water Striders	PR	6	LeS; LoS
Megaloptera (Order)	Dobsonflies, Fishflies, Alderflies			
Corydalidae	Dobsonflies, Fishflies	PR	0	Lo; LeE
Sialidae	Alderflies	PR	4	Lo; LeE
Neuroptera (Order)	Antlions, Lacewings, Owlflies			
Sisyridae	Spongillaflies	PR	U	LoE
Trichoptera (Order)	Caddisflies			
Apataniidae	Apataniid Case-Maker Caddisflies	SC	1	Lo
Brachycentridae	Humpless Case-Maker Caddisflies	CF	1	LoE
Goeridae	Goerid Case-Maker Caddisflies	SC	1	Lo
Glossosomatidae	Saddle Case-Maker Caddisflies	SC	0	LoE
Helicopsychidae	Snail Case-Maker Caddisflies	SC	3	LoE; LeE
Hydropsychidae	Common Net-Spinner Caddisflies	CF	4	LoE
Hydroptilidae	Micro Caddisflies	SC	4	Lo; Le
Lepidostomatidae	Lepidostomatid Case-Maker Caddisflies	SH	1	LoE
Leptoceridae	Long-Horned Case-Maker Caddisflies	CG	4	Le; Lo
Limnephilidae	Northern Case-Maker Caddisflies	SH	4	Lo; Le
Molannidae	Hood Case-Maker Caddisflies	SC	6	Le; LoD
Odontoceridae	Strong Case-Maker Caddisflies	SC	0	LoE; LoD
Philopotamidae	Finger-Net Caddisflies	CF	3	LoE
Phryganeidae	Giant Case-Maker Caddisflies	PR	4	Le; LoD
Polycentropodidae	Tube-Making & Trumpet-Net Caddisflies	CF	6	Le; LoD
Psychomyiidae	Tube-Making & Trumpet-Net Caddisflies	CG	2	LoE
Rhyacophilidae	Free-Living Caddisflies	PR	1	LoE
Sericostomatidae	Sericostomatid Case-Maker Caddisflies	SH	3	LoE; LeE

FAMILY	COMMON NAME	FG	TV	HAB
Trichoptera (Continued)	Caddisflies			
Stenopsychidae	Stenopschid Net-Spinner Caddisflies	CF	U	Lo
Uenoidae	Uenoid Case-Maker Caddisflies	SC	3	LoE
Lepidoptera (Order)	Butterflies & Moths			
Pyralidae or Crambidae	Aquatic Moths	SH	5	Le; Lo
Coleoptera (Order)	Beetles			
Chrysomelidae	Leaf Beetles	SH	U	Le
Curculionidae	Weevils	SH	U	Le
Dryopidae	Long-Toed Water Beetle	SC	5	Adults: LoE
Dytiscidae	Predaceous Diving Beetles	PR	5	A & L: Le; LoD
Elmidae	Riffle Beetles	SC	5	Adults: LoE
Gyrinidae	Whirligig Beetles	PR	4	A: LoD; LoS; LeS L: LoD; Le
Haliplidae	Crawling Water Beetles	SH	7	A & L: LeL; LoD
Heteroceridae	Variegated Mud-Loving Beetles	CG	U	LeM, LoM
Hydraenidae	Minute Moss Beetles	CG	U	LeM, LoM
Hydrophilidae	Water Scavenger Beetles	L: PR. A: CG	5	A & L: Le; LoD
Psephenidae	Water Pennies	SC	4	A: LoE
Scirtidae	Marsh Beetles	SC; CG; SH	7	L: Le, LoD
Staphylinidae	Rove Beetles	PR;(CG; SH)	8	LeM, LoM
Diptera (Order)	True Flies			
Athericidae	Aquatic Snipe Flies	PR	2	LoE
Blephariceridae	Net-Winged Midges	SC	0	LoE
Ceratopogonidae	Biting Midges; No-See-Ums; Punkies	PR	6	Le; LoD
Chaoboridae	Phantom Midges	PR	8	LeLm
Chironomidae	Non-Biting Midges	CG	6,8	L; Le
Culicidae	Mosquitoes	CF	8	Le; LoD
Cylindrotomidae	Crane Flies	SH	U	Le; LoD
Deuterophlebiidae	Mountain Midges	SC	0	LoE
Dixidae	Dixid Midges; Meniscus Midges	CG	1	Le; LoD
Dolichopodidae	Long-Legged Flies	PR	4	Le; LoD
Empididae and Hybotidae	Dance Flies	PR	6	Le; LoD
Ephydridae	Shore Flies; Brine Flies	CG	6	LeM; LoM
Limoniidae and Pediciidae	Short-palped Crane Flies	SH	3	LeM, LoM
Muscidae	House Flies; Stable Flies	PR	6	Le; Lo
Psychodidae	Moth Flies	CG	10	LeM; LoM
Ptychopteridae	Phantom Crane Flies	CG	7	LeM; LoM

FAMILY	COMMON NAME	FG	TV	HAB
Diptera (Continued)	True Flies			
Sciomyzidae	Snail-Killing Flies; Marsh Flies	PR	6	Le; Lo
Simuliidae	Black Flies; Buffalo Gnats	CF	6	LoE
Stratiomyidae	Soldier Flies	CG	8	LeM; LoM
Syrphidae	Rat-Tailed Maggots; Flower Flies	CG	10	LeM; LoM
Tabanidae	Horse Flies; Deer Flies	PR	6	Le; Lo
Tipulidae	Crane Flies	SH	3	Le; Lo

B APPENDIX B
Orientations

anterior: toward the front or head of an invertebrate (see Figs. B.1, B.2).

posterior: toward the back or tail end of an invertebrate (see Figs. B.1, B.2).

basal: pertaining to the base of attachment or origin of a structure (see Fig. B.1).

medial: toward the longitudinal midline of the body of an invertebrate or a structure (see Fig. B.2).

distal: pertaining to the end of a structure that is farthest away from the point of attachment with the body (see Fig. B.1).

dorsal: pertaining to the top of an invertebrate or structure (see Fig. B.1).

ventral: pertaining to the bottom of an invertebrate or structure (see Fig. B.1).

lateral: pertaining to the side of an invertebrate or structure (see Fig. B.2).

apex: tip or furthermost end of a structure (see Fig. B.2 – apex of antenna).

dorsoventrally flattened: referring to an invertebrate body or structure that is flattened from top to bottom.

laterally flattened: referring to an invertebrate body or structure that is flattened from side to side.

posterolateral: referring to the back and side of an invertebrate body or structure.

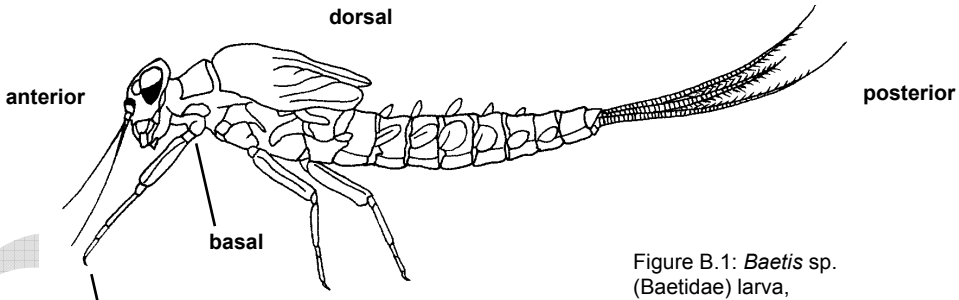


Figure B.1: *Baetis* sp. (Baetidae) larva, Lateral View.

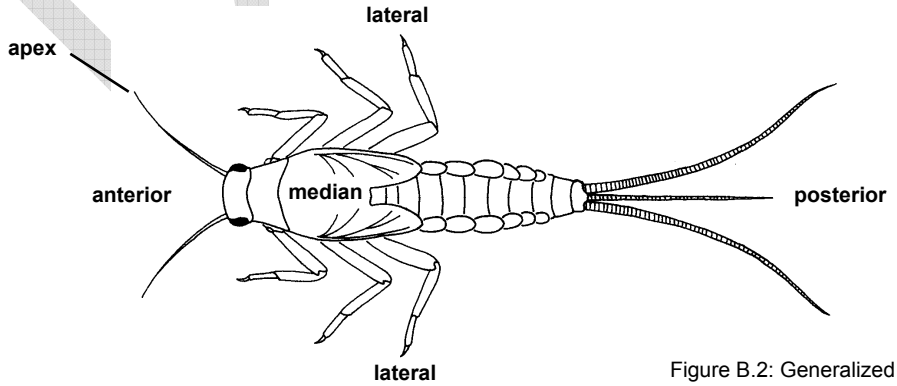


Figure B.2: Generalized Baetidae nymph, Dorsal View.

C APPENDIX C
Feeding Groups and Habitats

FEEDING GROUPS

collector/gatherers: deposit feeders and detritivores feeding on decomposing fine particulate organic matter (FPOM) that has settled out of the water.

collector/filterers: detritivores feeding on decomposing FPOM that is filtered or strained from the water. There are two types of collector/filterers: passive and active. Passive collector/filterers depend on water flow to bring suspended food to them and are generally restricted to lotic or flowing waters. However, some caddisflies use gravity to passively carry food to their nets in lentic habitats. Active collector/filterers create their own current to transport suspended food into a net or setae.

parasites: predators living in or on another organism to obtain nutrition, but without contributing to the prey (*e.g.*, Nematoda).

piercers: predators that capture prey, pierce the prey's body or cells, and suck the prey's fluids (*e.g.*, Hemiptera).

predators: predators that capture prey and consume the whole animal body or whole animal parts (*e.g.*, Odonata).

scrapers: herbivores and omnivores feeding by scraping periphyton and associated materials attached to rocks, logs, and other solid substrates.

shredders: herbivores and detritivores feeding on whole live or dead plant tissue. Some shredders feed on live aquatic macrophytes while others feed on decomposing coarse particulate organic matter (CPOM) such as leaves. Still others feed on dead wood. Many of the species feeding on CPOM are actually utilizing microbes on the material for most of their nutrition rather than the CPOM itself.

HABITATS

depositional: describing habitat where sediments are deposited; usually used to describe pools in streams and most lentic habitats.

erosional: describing habitat where sediments are eroded; usually used to describe riffles in streams but can also refer to windswept shores of lakes and ponds.

lentic: pertaining to standing waters or the organisms that inhabit these habitats (*e.g.* lakes, ponds, wetlands, and bogs).

limnetic: pertaining to open water; usually refers to habitat in lakes and ponds, but can also be used to describe habitat in large rivers.

littoral: pertaining to the shallow habitat along the edge of a water body.

lotic: pertaining to flowing waters or the organisms that inhabit these habitats (*e.g.*, streams, rivers)

margin: used to refer to the edge of a habitat such as the shore of a stream or pond.

surface: air-water interface; organisms living on top of the water's surface (surface film) rather than under water (*e.g.*, Gerridae).

D APPENDIX D
Glossary

abdomen: the most posterior tagma in insects. This tagma houses the viscera and reproductive organs and is responsible for a variety of functions (*e.g.*, reproduction, digestion, respiration, locomotion) depending on the organism and the life stage.

aestivation: passing hot or dry periods in a torpid state (see hibernation).

antenna (*plural* – antennae)**:** elongate sensory appendage on the head.

anterior: see Appendix B.

apex: see Appendix B.

Arthropoda: a phylum of organisms with an exoskeleton, distinct tagma, and segmented legs. This group includes the Insecta (insects), Crustacea (crayfish, shrimp, isopods, amphipods), Chelicerata (spiders, scorpions), and Myriapoda (centipedes, millipedes).

basal: see Appendix B.

benthic: relating to the bottom of a body of water.

bifid: forked; a structure that is split or divided into two lobes.

caudal filament: elongate appendage originating from the tip of the abdomen.

cercus (*plural* – cerci)**:** elongate appendage (usually paired) originating from the 10th abdominal segment generally considered to be sensory.

Chelicerata: a subphylum of organisms recognized by the presence of chelicerae, two body divisions (prosoma & opisthosoma) and generally six pairs of appendages. This group includes the Araneae (spiders), Scorpiones (scorpions), and Xiphosura (horseshoe crabs).

chloride epithelia: patches of cells on the integument of invertebrates that are used for the uptake of ions.

collector/filterer: see Appendix C.

collector/gatherer: see Appendix C.

complete metamorphosis: see **holometabolous**.

coxa (*plural* – coxae)**:** first segment of an insect leg.

CPOM (Coarse Particulate Organic Matter): organic particles greater than 1 mm consisting of leaves, needles, woody debris, dead macrophytes, other plant parts, and animal parts.

creeping welt: fleshy lumps that are often covered in spines or setae and are used for locomotion in some dipteran larvae.

Crustacea: a subphylum in the Arthropoda with members that possess two pairs of antennae, generally two body regions (cephalothorax and abdomen), three pairs of mouthparts, and at least five pairs of legs. The majority of crustaceans are marine, but there is also considerable diversity in freshwater habitats.

depositional: see Appendix C.

DOM (Dissolved Organic Matter): organic particles less than 5 μm.

diapause: a resting stage with reduced metabolic activity generally associated with aestivation and hibernation.

dissolved oxygen (DO): oxygen (O_2) dissolved in water.

distal: see Appendix B.

dorsal: see Appendix B.

epiproct: dorsal plate of the 11th abdominal segment (as in Anisoptera).

erosional: see Appendix C.

exoskeleton: outer covering (body wall) of arthropods.

facultative: pertaining to organisms with flexible requirements and therefore able to survive under a variety of conditions.

femur: the third segment of an insect leg.

FPOM (Fine Particulate Organic Matter): organic particles less than 1 mm and greater than 5μm. Most commonly derived from the breakdown of CPOM.

gill: respiratory organ of aquatic insects generally consisting of a thin walled structure that permits diffusion of oxygen.

hemimetabolous: partial or incomplete metamorphosis; metamorphosis of immature stages occurs in gradual steps with morphologically similar instars until the emergence of the adult; in most cases, the adult can be identified by the presence of fully developed wings, although wing pads are often present in the immature stages (*e.g.*, Hemiptera, Plecoptera, Ephemeroptera, Odonata).

Hexapoda: a subphylum in the group Arthropoda that includes the insects and related orders.

hibernation: passing cold periods in a torpid state (see aestivation).

holometabolous: complete metamorphosis with a distinct egg, larva, pupa, and adult with clear morphological differences between life stages (*e.g.*, Diptera, Trichoptera, Coleoptera, Megaloptera).

homologous: structures with the same ancestry, but not necessarily maintaining the same structure.

hygropetric: habitat consisting of water flowing over a vertical surface such as a rock ledge.

incomplete metamorphosis: *see* **hemimetabolous**.

Insecta: the largest class within the Arthropoda characterized by the possession of three tagma (head, thorax, abdomen), three pairs of segmented legs, and wings.

instar: the stage of an insect between molts.

integument: the outer covering or cuticle of an insect. This organ provides protection, structure, coloration, and gas exchange. The integument can be thought of as the skin of insects and other invertebrates.

labrum: the "upper lip" of an insect head which creates the roof of the insect mouth.

lamellar gills: gills that are plate-like or leaf-like and function in dissolved oxygen uptake, ventilation, or protection of filamentous gills.

larva: the immature stage of insects; specifically used to refer to the stage in holometabolous insects between the egg and pupal stages.

lateral: see Appendix B.

lentic: see Appendix C.

limnetic: see Appendix C.

littoral: see Appendix C.

lotic: see Appendix C.

mandibular tusk: mandibles in some burrowing Ephemeroptera which have been elongated into horn-like projections used to aid in burrowing.

mandible: the most anterior oral appendage. It is located behind the labrum and is modified in a variety of ways depending on the feeding mode of the organism.

medial: see Appendix B.

mesothorax: second thoracic segment.

metathorax: third thoracic segment.

morphology: the study of the form and function of structures in organisms.

Mollusca: a phylum of unsegmented invertebrates that usually secretes a protective shell. This groups includes Gastropoda (snails, limpets) and Bivalvia (clams, mussels).

notum (*plural* – nota)**:** a tergite (dorsal sclerite) of the thorax.

nymph: the immature stages of non-holometabolous insects between the egg and adult stages.

obligate: restricted to specific conditions (*e.g.*, thermal obligate – restricted to a specific range of temperatures) or life history (*e.g.*, obligate predator – restricted to a predatory feeding strategy).

ocellus (*plural* – ocelli)**:** simple eye.

operculate: a lid-like covering.

operculum: a lid-like covering.

paraproct: plates of the 11th abdominal segment located on either side of the anus (as in Anisoptera).

periphyton: a film of tiny aquatic organisms such as diatoms, bacteria, fungi, protozoa, small invertebrates, etc., living on a variety of substrates (*e.g.*, rocks, wood, sand, etc.).

pleurite: sclerites located on the sides of an insect. These plates are often reduced or fused to the tergites and/or sternites.

posterior: see Appendix B.

posterolateral: see Appendix B.

predator: see Appendix C.

proleg: a structure that serves a similar function to a leg, but is generally fleshy in appearance.

pronotum: the notum of the prothorax (first thoracic segment).

prosternal horn: an elongate protuberance arising from the sternum (ventral) of the prothorax in some Trichoptera taxa.

prothorax: first thoracic segment.

pupa (*plural* – pupae)**:** a transitional stage between larval and adult stages in holometabolous insects where the larval characters are lost and the adult characters gained.

raptorial: adapted for seizing prey.

riparian: pertaining to the banks or edges of rivers and streams.

scraper: see Appendix C.

sclerite: a hardened (sclerotized) plate of an arthropod.

sclerotized: referring to hardened invertebrate integument (skin).

seta (*plural* – setae)**:** hair-like projection of the integument produced by epidermal cells used for sensory, adhesion, defense, camouflage, and coloration.

spiracle: holes in the integument which facilitate gas exchange between the internal and external environment of an insect.

sternite: sclerites on the ventral side (bottom) of an insect.

sternum: ventral side of an insect.

tagma: a number of segments that become fused to form a distinct region often with specific functions (*e.g.*, head, thorax, abdomen).

tarsal claw: claw at the end of the leg in insects.

tarsus (*plural* – tarsi)**:** an insect's "foot" usually located at the end of the tibia and possessing 1-5 segments.

taxon (*plural* – taxa)**:** a taxonomic group officially recognized as separate from other groups (*e.g.*, order, family, genus, species) and containing all lower groups.

tergite: a sclerite (plate) located on the dorsal side of an insect.

tergum: the dorsal side of an insect.

thorax: the second or middle tagma in insects that bears the true segmented legs and wings when these structures are present.

tibia: forth segment of an insect leg.

trochanter: second segment of an insect leg.

urogomphus (*plural* – urogomphi)**:** filamentous or tail-like structures at the apex of the abdomen of some coleopteran larvae. These structures are not homologous to the cerci in other insects.

ventral: see Appendix B.

E APPENDIX E
List of References

The following are references used in the development of this guide. You may want to refer to these publications for more information on aquatic insects and for genus- and species-level resolution keys.

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F APPENDIX F
Illustration Acknowledgements

Many of the illustrations in this key are redrawn and modified from figures in other references. The following is a list references from which they were redrawn.

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