

Mayfly Larvae OF WISCONSIN

Tom H. Klubertanz



Dolania americana larva, *Paraleptophlebia volitans* larva, *Heptagenia pulla* larva, *Pseudiron centralis* larva

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*This book is dedicated to my family,
including my wife and best friend, Theresa,
and my children, Katie, John, and Luke.
No man could be more blessed.*

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Preface

The lakes and streams of Wisconsin provide larval habitat for over 150 species of a curious and ancient group of insects called the mayflies, the Order Ephemeroptera. Mayfly larvae commonly are found under stones, crawling on woody debris, and clinging to vegetation in our unimpaired waters. Though their shape and size can vary greatly, all mayfly larvae have a simple, primitive body plan, two or three long caudal filaments (tails), and abdominal gill filaments or plates. If they avoid predators and other hazards of their aquatic world, they emerge as adults and complete their brief terrestrial existence entirely focused on reproduction. Our largest species of mayflies burrow as larvae in silty substrates, emerging as adults in tremendous numbers that soon litter the ground with dying insects. It is during these episodes of mass emergence along large rivers that most of the public becomes aware of the presence of these important insects.

Mayflies are important insects in many ways. There is, of course, value in documenting biodiversity, regardless of the taxon. I must confess that most of my interest in mayflies is in regards to their taxonomy and natural history. Mayflies, however, are more than just innocuous, curious organisms. They are key parts of the aquatic food chain, being one of the dominant herbivorous

insect groups in such habitats (Morgan 1913). Their presence or absence also tells us about the quality of aquatic habitats. Mayflies are sensitive to habitat degradation, with impaired waters having lower species diversity (Hilsenhoff 1982, 1977; Hubbard and Peters 1978). Ecologists and citizen scientists use mayflies and other aquatic insects to monitor water quality, an economic alternative to chemical analyses.

A detailed taxonomic study of the Wisconsin mayfly fauna is badly needed. The last keys for identifying all known species of mayfly larvae from any Midwest state in the United States were in Burks (1953). That publication, focused on the Illinois fauna, is very outdated because of countless taxonomic changes and a dramatic increase in the number of species known from the region. Along with Burks' monograph, access to an entire research library of monographs, papers, and book chapters would be needed to correctly identify Wisconsin's mayfly species. Few biologists have such library resources, and not all of those publications are sufficiently illustrated. Several papers and reports on Wisconsin mayflies and other aquatic insects were published from the laboratory of Dr. William Hilsenhoff, then Professor of Entomology at University of Wisconsin–Madison,

from 1970 to 1995. These publications included faunal studies, keys to the Wisconsin genera, and keys to the species of several families. Unfortunately, even those publications are now dated and should be used at the species level with considerable caution.

My field work and examination of existing collections have uncovered a large number of new state and county records of Wisconsin mayflies. These records now provide a clearer picture of the distribution, conservation status, and ecological requirements of these insects in the state. Arguably, the mayfly fauna of Wisconsin now is better known than for any other Midwest state.

The specific purpose of this book, then, is to provide taxonomic keys, new distribution records, and biological information for larvae of Wisconsin mayflies. The taxonomic keys in this book will allow fairly accurate identification of mayflies from other Midwest states, especially those bordering Wisconsin. This book is intended for a wide variety of enthusiasts of the Ephemeroptera, including those with training and experience in the identification of insects and those new to the pleasures of taxonomic and faunal study. It is richly illustrated, makes consistent use of terminology, and has a complete glossary of terms.

Acknowledgments

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I am grateful for the collaborative spirit, willingness to share specimens and records, and taxonomic advice of fellow students of the Ephemeroptera, including (in alphabetical order): Steven Burian (Department of Biology, Southern Connecticut State University), Jeffrey Dimick (Wisconsin Cooperative Fishery Research Unit, Aquatic Biomonitoring Laboratory, University of Wisconsin–Stevens Point), Boris Kondratieff (Department of Bioagricultural Sciences, Colorado State University), Richard Lillie (Portage, WI), W. Patrick McCafferty (Department of Entomology, Purdue University), Arwin Provonsha (Department of Entomology, Purdue University), Kurt L. Schmude (UW–Superior), William Smith (Bureau of Natural Heritage Conservation, Wisconsin Department of Natural

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1

BIOLOGY AND IMPORTANCE OF WISCONSIN MAYFLIES

This first chapter examines the ecology of mayflies in Wisconsin, including their habitat use and preferences, and discusses methods of collection of larvae.

Life Cycle

The major life stages of the mayfly are the egg, larva (also known as the *nymph* or *naiad*), subimago, and imago. The eggs of mayflies are finely sculptured capsules of life that are deposited on or beneath the surface of water. All mayfly larvae are freshwater insects, usually living in flowing (lotic) rather than sluggish or stationary (lentic) waters. They have numerous features that function well in an aquatic environment, including tracheal gills for oxygen absorption and body shapes for either swimming in or avoiding water current. The mayfly larva, as with all juvenile insects, molts its exoskeleton periodically to allow for growth. After each molt, the insect briefly is soft and vulnerable until its cuticle hardens. It will have as many as thirty molts during larval development—few groups of insects have more than mayflies. The earliest instar, as the insect is called between each molt, looks little like a mature larva. As it grows, it will develop more distinctive color patterns and well-developed wingpads. The last instar, just prior to emergence, has darkened wingpads. Such “blackwing” larvae are useful indicators of when in the season a particular species will emerge as adults (Morgan 1913; Needham et al. 1935).

But the mayfly has a trick up its sleeve. In all other insects, whether or not there is a pupal stage between the larva and the adult, there is only one winged stage. As every student of backyard entomology quickly learns, once a fly, beetle, or butterfly has wings, molting is finished. Growth, for the most part, is finished

as well. In the mayflies, however, it is the subimago that emerges from the old larval skin (called *exuviae*) and flies away. Some mayflies accomplish this feat right on the surface of the water whereas others have larvae that cling to vegetation or stones during the transition. The subimago has semiopaque wings with numerous fine hairs along its posterior margins. It may have different, typically more subdued, dull coloration than the imagos. After minutes, hours, or days, depending upon the species, the subimago finally molts into the imago, completing one of the rarest versions of life history in the insect world—a winged insect molting into a winged insect (Morgan 1913).

Adult mayflies are, to me, graceful and beautiful insects. Their two or three long caudal filaments, uniquely shaped wings, and delicate bodies make them easily identifiable. Adults do not feed; they rely solely upon nutrients stored during larval development. Their mouthparts and digestive tract are vestigial. Most mayflies reproduce sexually, with both males and females present in populations. Males almost always have larger eyes than females (a difference usually visible in mature larvae as well), with the greatest sexual dimorphism occurring in the Baetidae. Males also have distinctive genitalia at the posterior tip of the abdomen. Some mayflies can reproduce asexually, a process called *parthenogenesis*. In species that reproduce only in this way, such as in some *Neocloeon* (Baetidae) and *Ameletus* (Ameletidae), males do not occur. Adult female mayflies are masters of egg production, nearly filling their body cavities with eggs.

Despite their common name, flights of mayflies do not always occur in spring. Many mayflies, especially smaller species,

have two generations of larvae in the summer months (Edmunds et al. 1976). Eggs deposited by females in autumn may remain dormant throughout winter or may hatch in autumn with young larvae overwintering. Species with nearly mature larvae in autumn usually emerge in very early spring and are absent in samples of larvae collected in May.

Larval Feeding Types

Mayflies have a considerable variety of feeding types (Morgan 1913; Cummins 1973; Edmunds et al. 1976; Cummins and Klug 1979). The generally recognized feeding types of larvae are collectors, scrapers, shredders, filter feeders, and invertebrate predators. The collectors feed on fine detritus and diatoms and occur in all of the most diverse mayfly families. Scrapers (grazers), such as species in *Maccaffertium* (Heptageniidae) and *Ameletus* (Ameletidae), remove living diatoms, algae, and protists attached to rocks, logs, and other surfaces. The shape and armature of their mouthparts, particularly their maxillae, are different than the typical mayfly. A limited number of mayfly larvae shred plant debris, including leaves, stems, and roots. Larvae of *Callibaetis* (Baetidae), a common genus in lentic habitats, and *Leptophlebia*, mayflies most commonly occurring in shallow, riparian backwaters, feed in this fashion. Mayflies from the ecological guild known as the filter feeders gather nutrients floating in the water, generally using dense, long rows of leg setae. This feeding type is best demonstrated in *Isonychia* (Isonychiidae). Predatory mayflies include some of our rarer genera such as *Pseudiron* (Pseudironidae), *Spinadis* (Heptageniidae), and *Dolania* (Behningiidae). These taxa usually feed extensively on midge larvae (Diptera: Chironomidae). Mature larvae of at least

some *Siphonurus* (Siphonuridae) are predators of midge and mosquito larvae (Edmunds et al. 1976).

Larval Body Types

The diversity in mayfly body types reflects their diversity in feeding types and habitat preferences (Morgan 1913; Cummins 1973). The two most diverse and common families of mayflies in Wisconsin differ significantly in body type. The Baetidae, with 46 species known from Wisconsin, has streamlined, minnow-shaped larvae capable of considerable athletic prowess as swimmers. They swim dolphin-like, with all movement in the vertical plane. Trying to catch one in a pan of water is not an easy task. The Heptageniidae, with 25 species known from the state, are adapted to avoiding current. They have flattened hydrodynamic heads and legs that are held laterally from the body. More likely to behave like stoneflies (Plecoptera) and cling tightly to rocks or logs, they swim more laboriously with either lateral or vertical movements. Most heptageniids are scrapers, removing living biofilm from the substrate. Most genera of mayflies fall into one of these two general descriptions.

Some taxa are best described as crawlers, rarely leaving their protective silt-covered root masses or mats of algae and venturing out into the current. These include tiny larvae of the Caenidae and Leptoheptageniidae, and the tank-shaped Baetiscidae. Another unusual body type occurs in burrowing species. These mayflies have soft bodies, large feathery gills, fossorial legs, and long mandibular tusks. They include some of our largest mayflies, such as adults of *Hexagenia* (Ephemeridae) that emerge from the Mississippi River in great numbers. Other families with burrowing larvae include Polymitarcyidae and Palingeniidae. All of these mayflies construct tubular burrows in soft silt, soft or hard clay, or sand. Though species of *Anthopotamus* (Potamanthidae) also have

mandibular tusks, they lack most of the other features of burrowing mayflies and live in more erosional habitats.

Environmental Importance

The species of Ephemeroptera are key components of aquatic systems, located near the base of the food chain (Morgan 1913; Cummins et al. 1966), and are important food items for fish (Schwiebert 1973). They also are important processors of detritus, recycling nonliving materials and making them available for consumers.

Mayflies also are ecologically important as indicators of water quality (Hilsenhoff 1982, 1977; Hubbard and Peters 1978). The presence of a diverse and balanced assemblage of mayfly species in a river or stream is a sign of both current and past environmental health. Other insect groups, such as stoneflies, also are indicators of good water quality.

Wisconsin Habitats for Mayfly Larvae

There are 72 counties in Wisconsin (Fig. 1). The major rivers of the state are shown in Figure 2. Most of the state's border miles are large rivers, including the Mississippi, St. Croix, and Menominee Rivers. Other medium to large rivers in the state include the Black, Chippewa, Flambeau, Fox, Rock, and Wisconsin Rivers. The last is 692 miles long and is the longest and largest inland river system in the state (Lillie and Hilsenhoff 1992), draining over 12,000 square miles of land. The free-flowing Lower Wisconsin River below the Prairie du Sac Dam contains rare macroinvertebrate communities. Sand-bottom segments of such large rivers, particularly the Wisconsin, St. Croix, and Chippewa Rivers, have the greatest number of rare and endangered mayfly taxa. These species are in the genera *Acanthametropus* (Acanthametropodidae), *Dolania* (Behningiidae), *Pseudocentropiloides*

(Baetidae), and *Spinadis* (Heptageniidae), among others. They also can be quite difficult to collect, resulting in only superficial knowledge of the biology of most of these species.

A great number of mayfly species occur in smaller streams and rivers, including the many cold-water trout streams in the northern half of the state. In such habitats, if they are undisturbed and in good health, mayfly diversity is at its greatest level. Most impressive are the mayfly communities in the Brule, Flambeau, Namekagon, and Popple Rivers and their tributaries. Mayflies are much less common and in low diversity in medium to large warm-water rivers of southern and southeastern Wisconsin, such as the intensively managed Rock and Fox Rivers. Farther west, the Sugar River in Green and Rock Counties is in better condition and supports populations of unusual mayflies such as *Homoeoneuria* (Oligoneuriidae) and *Cercobrachys* (Caenidae). Some small creeks and streams in southern Wisconsin, such as Otter Creek in Sauk County, Turtle Creek in Walworth and Rock Counties, and Jericho Creek in Waukesha County, still have good species diversity. Taxa rarely occurring in far southern Wisconsin, such as several species of *Proclleon*, *Anafroptilum*, and *Dipheter* in the Baetidae, *Dannella* (Ephemerelellidae), and *Ameletus* (Ameletidae) can be found in these waters. These few sites give us a glimpse of what must have been spectacular communities of mayflies across the region prior to changes in land use and stream flow. Many of the streams in the Grant River drainage basin in southwestern Wisconsin are severely degraded, with the basin having one of the lowest levels of mayfly diversity of any in the Midwest (Randolph and McCafferty 1998). Beginning with the studies by Bill Hilsenhoff in the 1970s, extensive, statewide sampling of small to medium streams and rivers has provided us with a clear picture of the mayfly fauna of such waters.

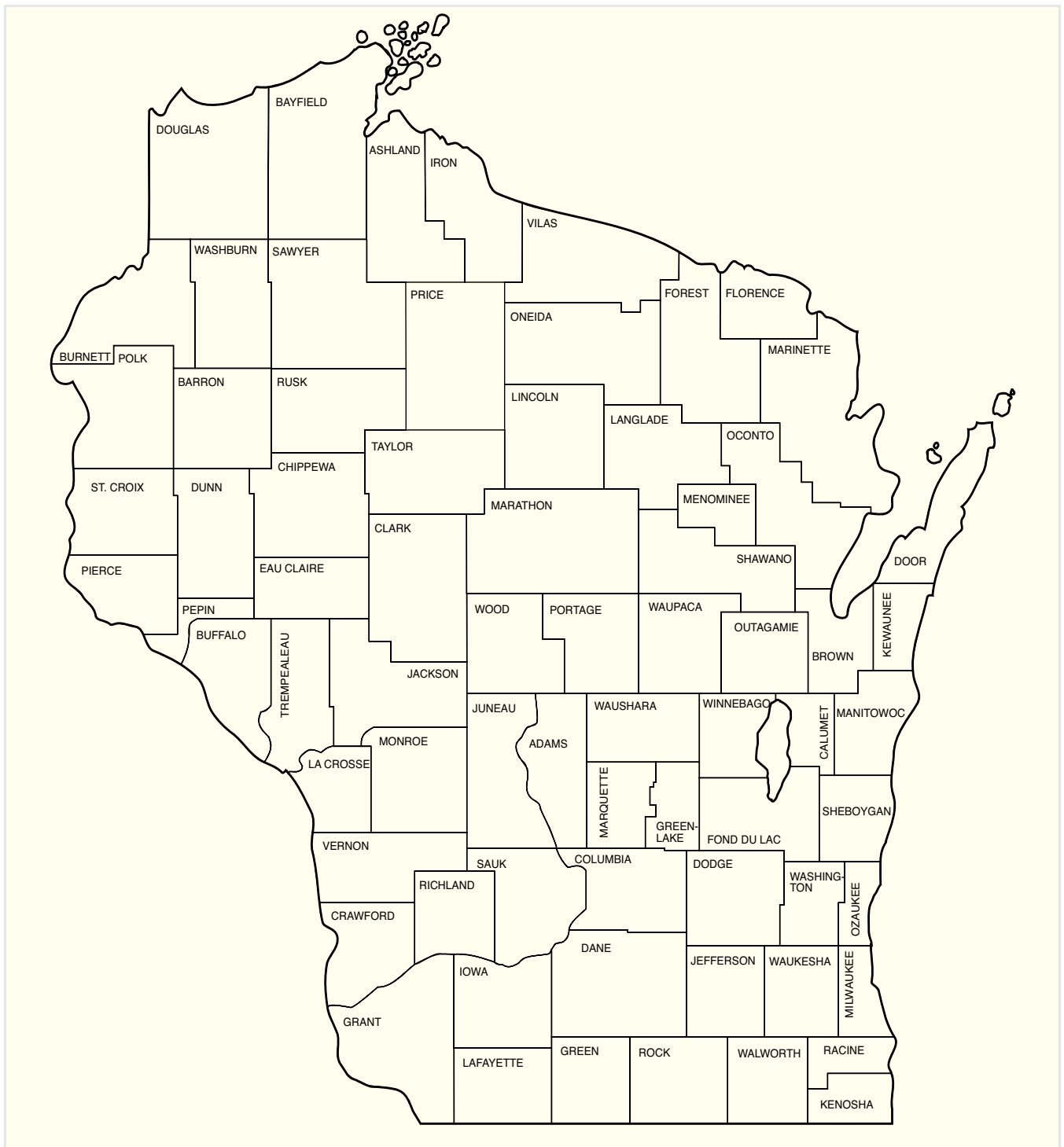


Figure 1. Wisconsin counties.

Relatively few mayflies occur in lakes and ponds. These include species less dependent upon water current and high levels of dissolved oxygen. The most common small mayflies of lentic habitats are in *Callibaetis* (Baetidae), *Caenis* (Caenidae), and *Tricorythodes* (Leptohyphidae). In northern lakes, *Stenonema* (Heptageniidae) and ephemereids such as *Eurylophella* are typical. Also common in lentic habitats, including Lakes Michigan and Superior, are species of large burrowing mayflies in *Hexagenia* and *Ephemera* (Ephemeridae). In general, lentic habitats in Wisconsin have been sampled for mayflies less intensively than lotic habitats.

Conservation and restoration of aquatic habitats in Wisconsin are needed to sustain the state's diversity of mayflies and other macroinvertebrates. As discussed later in this book, many of Wisconsin's mayflies are uncommon to rare, consisting of only a few isolated populations. Such populations are very susceptible to habitat degradation and localized extinction. I hope that the information provided in this book encourages better stewardship of Wisconsin's aquatic resources.

Substrates

Mayflies as a group use a wide variety of substrates (Morgan 1913; Lillie and Hilsenhoff 1992). The greatest taxonomic diversity occurs on gravel- to cobble-sized rocky substrates and woody debris. Often, larvae occur

beneath such structures, or in crevasses, sheltered from the current. Other species remain more exposed to the current. Vegetation is a common substrate for larvae, especially for members of the Baetidae. Mayflies in the Ephemeridae and related families burrow in soft silt and clay. Sandy substrates support several of Wisconsin's rarest species, especially those of large rivers.

Collection Methods

Mayflies can be collected using a variety of methods. Simple inspection of surfaces of logs and rocks is productive, particularly for acquiring undamaged specimens for rearing. Species inhabiting finer substrates or vegetation can be collected by disturbing the substrate, usually with the feet, while holding a D-framed aquatic net or drift net just downstream. Knowledge of microhabitat associations can improve the chances of collecting less common species. Some species are associated with calm eddies behind stones, sandbars, shallow backwaters, or current-swept vegetation. Mayflies of large rivers are most difficult to collect, requiring the use of boats and specialized equipment. Fine-meshed drift nets can be used to collect larvae and exuviae floating downstream. Larvae should always be handled gently to reduce specimen damage that can interfere with identification.

The most commonly used preservative for mayfly larvae collected in the field is

80% ethanol. This preservative should be changed to 70% ethanol in the lab for long-term storage. Alcohol is much preferred over formalin, which tends to make specimens brittle and has greater environmental impact. Formalin has the advantage, however, of being easily transported in more concentrated solutions that can be diluted in the field. Regardless of the preservative or additives, integumentary patterns on specimens eventually fade. Bleached specimens may be unidentifiable since some species are separable only by coloration. Photographs and notes taken when specimens were fresh can be quite valuable decades later.

All specimens should be properly labeled using indelible ink. Pencil should be used only for temporary labels. Each label should contain information about the precise sampling location, including the name of the body of water. It should have sufficient information to help others relocate the sample site, including detail about the nearest road access, town and range, and/or geographical positioning system (GPS) coordinates. Finally, the label should contain the sample date and name of the sampler(s). The month should always be indicated with a Roman numeral. If the sample was taken from one substrate or with one methodology, then that information also can be placed on the label.

2

ANATOMY OF MAYFLY LARVAE

This chapter focuses on the anatomical features used as characters in larval keys for mayflies, providing clarification and explanation of the relevant terminology. The content of this chapter assumes some general knowledge of insect anatomy

but provides much support for those unfamiliar with the Ephemeroptera. For more detail on mayfly anatomy, see Morgan (1913), Needham et al. (1935), Burks (1953), and Edmunds and Waltz (1996). This book follows the recommendations for mayfly

anatomical terminology outlined by Hubbard (1995). Specific definitions of such terms are given in the glossary. The major anatomical features of the typical mayfly larva are shown in Figure 3.

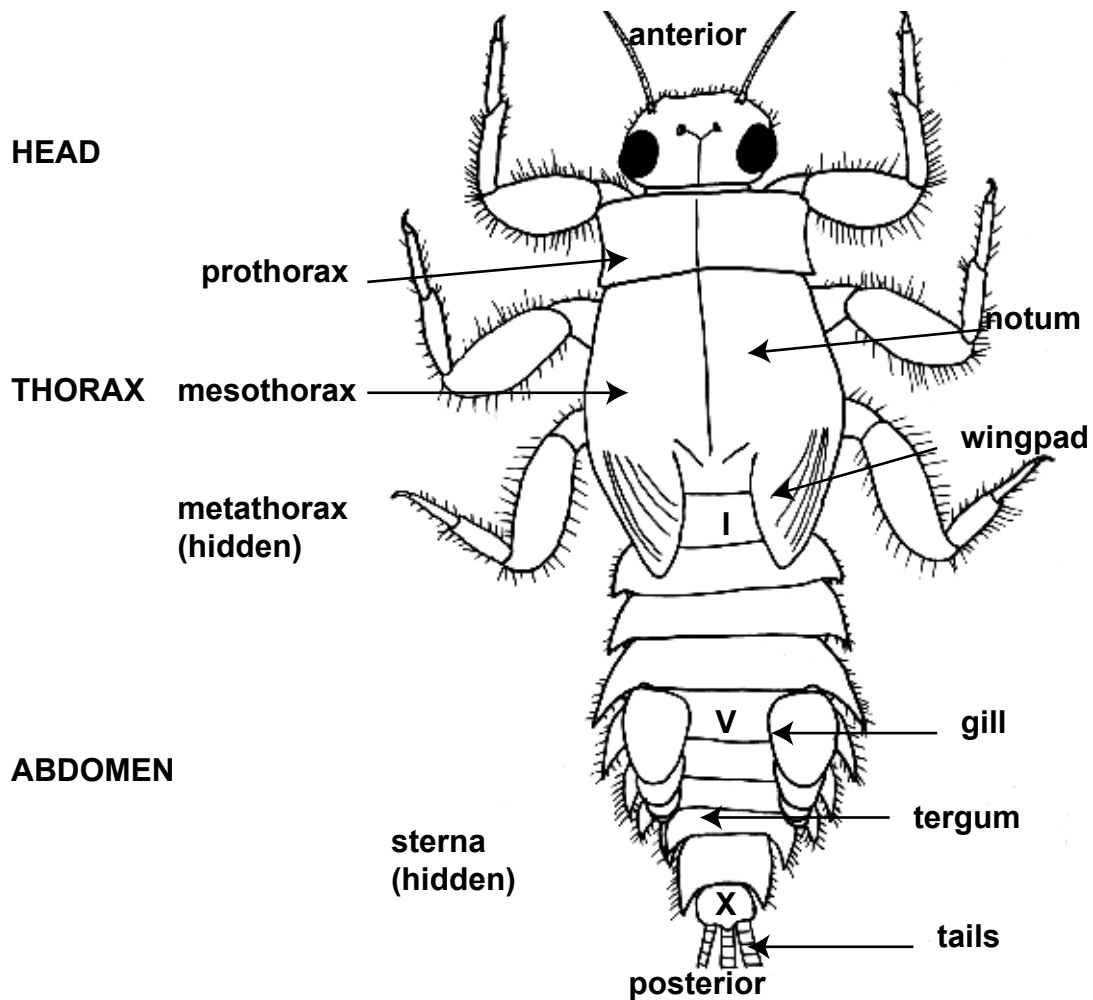


Figure 3. Major anatomical features of the larval mayfly.

Head

The dorsal surface of the head capsule has two compound eyes (Fig. 4). Though preserved mayflies almost always have black eyes, live specimens have bronze, greenish, or golden-colored eyes. Mature male larvae of most species have larger eyes than females, making it relatively easy to

determine gender. Adult males of some taxa, such as the Baetidae and Leptophlebiidae, have compound eyes subdivided into two regions, with the dorsal portion more brightly colored. This structure becomes visible in males towards the end of larval development, as in Figure 88.

Between and anterior to the compound eyes are three simple eyes called *ocelli*. These consist of two lateral ocelli and one slightly anterior median ocellus. The ocelli are light sensitive but do not produce visual images. Characters related to the ocelli are rarely used in taxonomic keys.

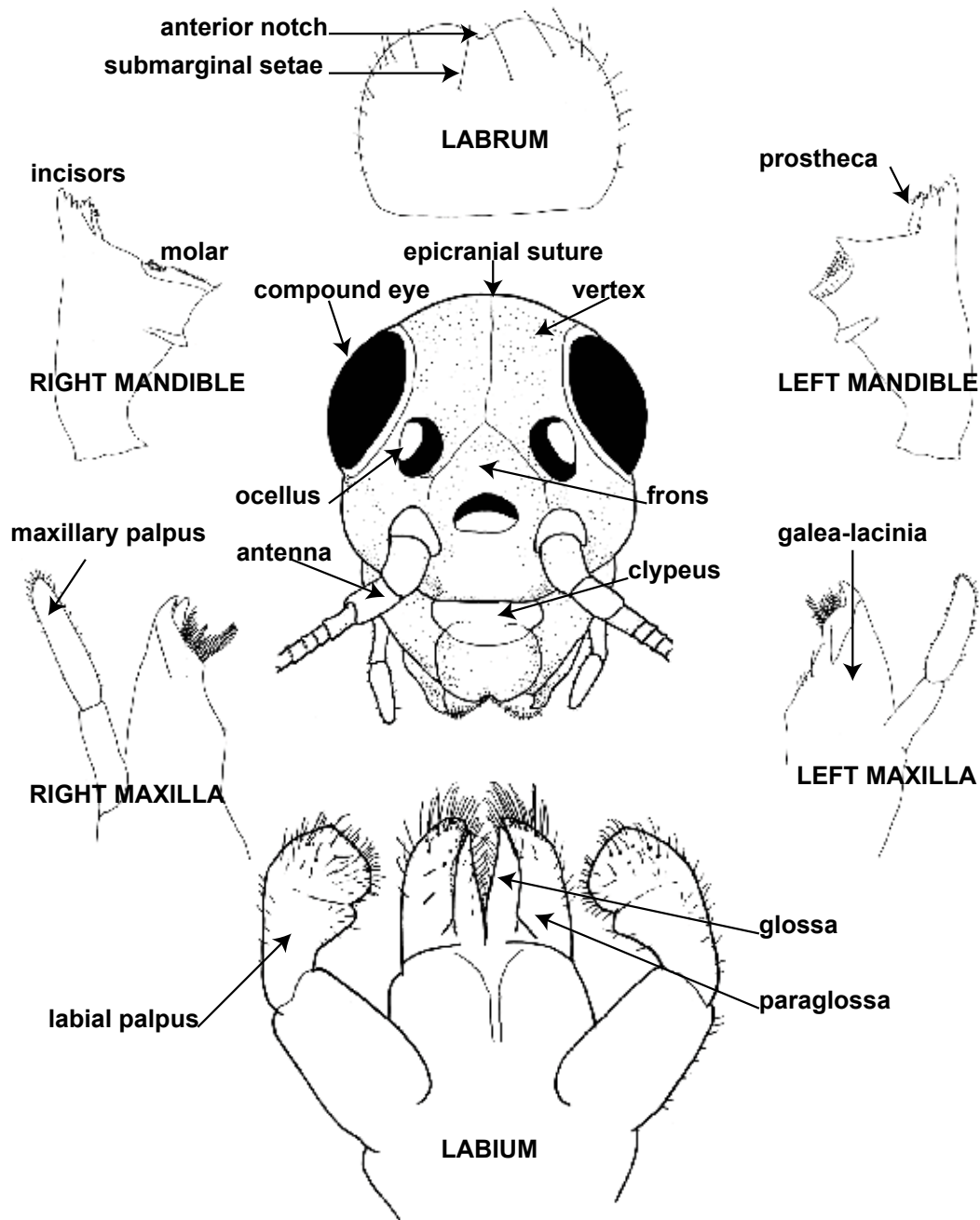


Figure 4. Head and mouthparts of the larval mayfly.

The dorsal surface of the head capsule is divided into the clypeus, frons, vertex, and occiput. The occiput is a sclerite posterior of the occipital suture, which generally is limited in mayflies and not visible in dorsal view. The region anterior to the occiput is the vertex. It consists of two sclerites connected medially along the epicranial suture and mostly located between the compound eyes. Dorsal tubercles and other structures on the vertex are used in the keys for the species of Caenidae, Ephemerellidae, and Ephemeridae. The anterior end of the occipital suture forks into two lateral epicranial sutures, which pass anterior to (as in the Baetidae, Fig. 7n) or bisect the lateral ocelli (Fig. 7a). Anterior to the lateral epicranial sutures is the frons. It is uncommonly encountered in keys. The presence of freckles on the frons is a distinctive feature of the heptageniids *Leucrocuta* and *Nixe* (Fig. 255b). At the anterior margin of the frons is a narrow sclerite called the *clypeus*. The clypeus attaches to the dorsal, lid-like labrum that covers the remaining mouthparts. The dorsal surface of the head capsule bears one pair of antennae. Each antenna is divided into a basal scape, a middle pedicel, and a long, filamentous flagellum. The flagellum is subdivided into numerous segments. Antennal structure occasionally is used in keys. The presence or absence of whorls of long setae on the antennae is used to separate *Litobrancha* from *Hexagenia* in the Ephemeridae, and to determine species of *Cercobrachys* in the Caenidae. Preparation of slide mounts of antennae is recommended in the Baetidae for the identification of *Labiobaetis* and for differentiation of *Baetis brunneicolor* McDunnough and *B. tricaudatus* Dodds.

The major mouthparts of mayfly larvae, from dorsal to ventral, are the labrum, mandibles, maxillae, and

labium (Fig. 4). The hypopharynx is located between the mandibles but is not used in the keys. The labrum is the dorsal covering of the mouthparts. It articulates with the clypeus of the head capsule. All taxonomically important labral setae are on the dorsal surface, including marginal and submarginal setae, and slide mounts should be made accordingly. Both the location and the microstructure of these setae can be taxonomically important, especially in the Baetidae. The anterior edge of the labrum usually has a medial notch, the shape of which is used occasionally in the keys.

Beneath the labrum is a pair of mandibles (Fig. 4). In most species, the mandibles are similar to those of many chewing insects, with both posterior molar and anterior (apical) incisor regions. The molar region is flat topped and heavily sclerotized. It generally is not visible unless the mandible is dissected. The incisors are more conical and may have associated setae. Between these two regions may be a loosely articulated sclerite called the *prosthema*, which usually has an elongate, roughly rectangular shape. Dissection of mandibles commonly is required in the keys. Note that in most taxa, the right and left mandibles are structurally different. Dorsal and ventral views of the same mandible can appear quite different as well, requiring care when preparing slide mounts. The mandibles of some mayfly larvae are produced into tusks, as in the burrowing families Ephemeridae (Fig. 7b), Palingeniidae, and Polymitarciidae, as well as in the striking larvae of Potamanthidae (Fig. 7a). The shape of the tusks and the distribution of spines on their surface commonly are used in the keys for those families.

Ventral to the mandibles are the paired maxillae. Each maxilla consists of a medial, relatively flat galea-lacinia that

is armed distally with various spines and setae, and a maxillary palpus consisting of up to four segments. In contrast to the mandibles, the left and right maxillae are similar. Slide mounts of maxillae commonly are required in the keys, such as for identifying the species of *Maccaffertium*, *Stenacron*, and *Procloeon*. The ventral view is most useful, unless otherwise indicated. In *Ameletus*, the setae at the distal end of the galea-lacinia are curved and pectinate, forming a plankton rake (Fig. 8p). The shape of the maxillary palpi is the key feature for separating *Labiobaetis* from other baetids. Articulation of the palpal segments may be indistinct, for example causing difficulty in identifying the species of *Anafroptilum*, *Neocloeon*, and *Procloeon* (Baetidae). In a few taxa, such as certain members of the Ephemerellidae and Leptohiphidae, the palpi are reduced or absent.

The ventral-most mouthpart is the labium. It is composed of two pair of lobes, the glossae and paraglossae, and the fingerlike labial palpi. The glossae are medial to the paraglossae. Structural features of the glossae and paraglossae are uncommonly used in keys. In the Baetidae, they are extremely useful in separating the species of *Pseudocentropiloides*. The labial palpi, composed of two or three segments, are commonly used in keys. The third segment, if present, may be indicated by only a weakly formed crease across the palpus. The shape of the third segment of the labial palpus is one of the most frequently used characters in the keys for the Baetidae. In the Leptophlebiidae, the number of specific setae on the dorsal surface of this segment is used to separate *Leptophlebia cupida* (Say) and *L. nebulosa* (Walker). The shape of setae on the first segment of the labial palpi is used in the Caenidae to separate *Sparbarus* from other genera.

The ventral view of the labium is most useful in slide mounts, as it more likely will give a clear view of the shape of the palpi. Slide mounts should be prepared in that orientation unless indicated otherwise in the keys.

Thorax

The three segments of the thorax are, from anterior to posterior, the pro-, meso-, and metathorax (Fig. 3). These three prefixes commonly are used to refer to particular sclerites or leg parts on the thorax (e.g., *metatarsus*, *pronotum*). Thoracic coloration occasionally is used in the keys, but not as often as in adult keys. Each thoracic segment has dorsal sclerites forming the notum. The pronotum simply has two sclerites fused along the midline. Coloration of the pronotum is used, for example, in separating the species of *Baetis* (Baetidae) and in field recognition of *Stenacron* (Heptageniidae). Structural features of the pronotum are used in the keys for species of *Serratella* (Ephemereillidae) and *Caenis* (Caenidae). Behind the pronotum is the mesonotum. In the

Baetiscidae, the mesonotum is expanded to form a domed carapace over the thorax (Fig. 7f). The distribution of spines on the carapace is used in the key for the species of *Baetisca*. The mesonotum and metanotum essentially are fused in mayfly larvae and not easily visible as separate segments in dorsal view. Metanotal characters rarely are used in the keys, except in regard to the wingpads.

The ventral surfaces of the thoracic segments are called *sterna*, a term also used for the ventral surfaces of the abdominal segments. Surprisingly, the thoracic sterna are uncommonly used in keys. In the Caenidae, the distribution of median tubercles on the thoracic sterna is used to separate the genera and species of brachycercines—those species in the family with ocellar tubercles on the head.

The posterior margin of the mesonotum always bears a pair of wingpads. Wingpads increase in relative size with each successive molt. Highly folded subimagal wing membranes are visible inside the wingpads of last instars, with

the wingpads becoming nearly black just before emergence. Mayflies with such wingpads, therefore, are called “blackwing” larvae. Records of blackwing larvae provide useful information regarding phenology. The metanotal wingpads always are much smaller and beneath the mesonotal pads. Metathoracic wingpads, and therefore the adult hind wings, are absent in several independent lineages of the Baetidae, such as in some *Acentrella*, *Neocloeon*, and *Procloeon*.

Legs

The keys in this book use the prefixes *pro-*, *meso-*, and *meta-* to refer to particular legs or segments on those legs. Mayflies have the typical major regions of the insect leg, from base to tip: coxa, trochanter, femur, tibia, and tarsus (Fig. 5). The coxa is the proximal segment that articulates with the thorax. Though *Ametropus* (Ametropodidae) is not yet known from Wisconsin, species in that genus have each coxa with an unusual spinous pad (Fig. 8b). Rarely, such as in some

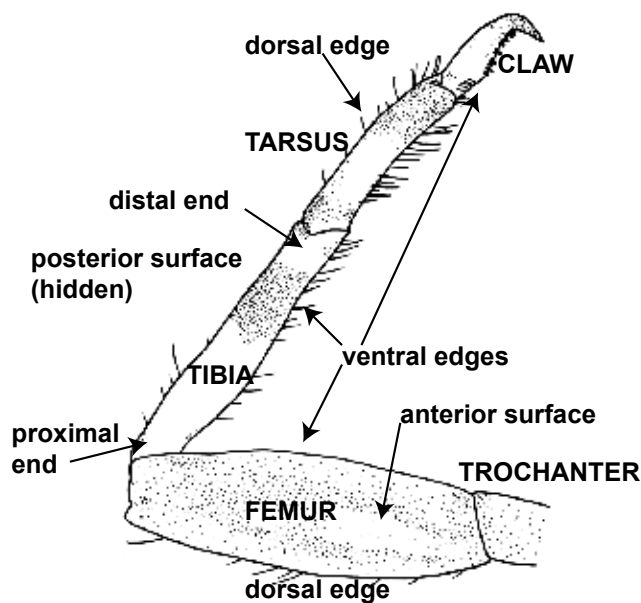


Figure 5. Leg of the larval mayfly.

Heterocloeon and *Camelobaetidius* (Baetidae), the coxae bear gill-like osmobranchiae (Fig. 20l). The trochanter is fairly generalized and not used in Wisconsin keys. The largest segment of the insect leg is the femur. Many different aspects of femoral structure and coloration are used in the taxonomic keys. In *Drunella* (Ephemereididae), the profemur is larger than the other femora, with a row of large spines. The tibia generally is more slender, except in the fossorial legs of the Ephemeridae and other burrowing mayflies (Fig. 7d). In the Isonychiidae and Oligoneuriidae, the tibiae have long setae used for collecting food (Fig. 8e). The tarsus is unsegmented and almost always has a single claw. In the Metretopodidae, the protarsal claw is bifid. The claws of mayfly larvae most often have one row of tooth-like denticles, but two rows occur in some taxa such as *Heterocloeon* (Baetidae). Slide mounts of tarsi commonly are required in keys, with appropriate orientation of the tarsus on the slide being important.

Throughout this text, the dorsal, ventral, anterior, and posterior surfaces of legs refer to those indicated in Figure 5, following Hubbard (1995). This nomenclature refers to the surfaces of the primitive insect leg, not the surfaces of the leg typically maintained by the insect in its natural posture. As such, the laterally projecting and flattened legs of the heptageniid mayflies have the anterior surface facing upward and the posterior surface against the substrate.

Abdomen

The mayfly abdomen consists of dorsal sclerites called *terga* (singl. *tergum*) and ventral sclerites called *sterna* (singl. *sternum*) (Fig. 3). There are ten terga and nine sterna visible on the mayfly larva. Particular sclerites are referred to by Roman numerals in this text. As expected, abdominal characters often are used in keys. In many older keys, tergal coloration often was used to differentiate species. Such characters fade in alcohol, however, and are avoided whenever possible in the keys, or are combined with structural characters. Abdominal coloration is extremely helpful in making preliminary identifications of larvae in the field or in sorting fresh specimens, but should be used only by experienced individuals familiar with all of the species in the region. Identifications based solely upon comparison with photographs, such as those provided in this book, will have an unacceptable error rate.

Each of the first seven abdominal segments can bear a pair of external respiratory gills. The structure and distribution of these gills are frequently used in keys. Unfortunately, specimens with missing gills are common and can be frustratingly difficult to identify, particularly in the Leptophlebiidae. As with the abdominal segments, the gills are referred to by Roman numerals. Almost all species have the gills directed dorsally, but ventrally oriented gills are present in larvae of *Rhithrogena* (Heptageniidae) and *Dolania* (Behningiidae). There are

several terms referring to gill structure. Lamellate gills are flattened and plate-like. Many mayflies with lamellate gills also have filamentous or tuft-like gills in addition to the lamellae. Some mayflies have multiple gill lamellae, though these usually are formed from dorsal or ventral folds or flaps of a single lamella. Examples of such gills occur in species of *Callibaetis* and *Procloeon* (Baetidae), *Siphloplecton* (Metretopodidae), *Siphonurus* (Siphonuridae), and *Leptophlebia* (Leptophlebiidae). Entirely filamentous gills are less common but occur in *Paraleptophlebia* (Leptophlebiidae). Operculate gills, as in the Caenidae and Leptohyphidae, are expanded to serve as protective gill covers over more posterior gills. The gills of larvae in the Baetiscidae are beneath the thoracic carapace and not normally visible from dorsal view.

Most mayflies have three caudal filaments, or “tails,” a well-known field mark used by beginning students of aquatic insects. Stoneflies, in contrast, always have two caudal filaments. The three tails in mayflies consist of two lateral caudal filaments (modified cerci) and one median caudal filament. Length, setation, and banding of the caudal filaments are used in the keys. In most species, the median caudal filament is shorter than the other two. In a few mayflies, such as species of *Epeorus* (Heptageniidae) and the baetids *Acentrella*, *Heterocloeon*, *Iswaeon*, and *Plauditus*, the median caudal filament is greatly reduced or vestigial (as in Fig. 20f). These two-tailed mayflies are the exception to the rule.

3

TAXONOMY, DIVERSITY, AND CONSERVATION OF WISCONSIN MAYFLIES

Previous Studies of Wisconsin Mayflies

Forty-one publications have contributed new Wisconsin state records of mayflies (Table 1). The earliest, documented mayfly record from the state is of the ubiquitous heptageniid *Stenacron interpunctatum* (Say) by Wodsedalek (1912). Muttkowski (1918) added three species, including the only historical record for *Leucrocuta maculipennis* (Walsh) from Wisconsin. Randolph and McCafferty (1998), however, considered this identification dubious. By 1970, the number of species known from

Wisconsin had grown to seventeen, with no single publication adding more than three species (Traver 1935; Spieth 1941; Hamilton 1959; Britt 1962; Leonard and Leonard 1962; Allen and Edmunds 1963b; Allen and Edmunds 1965; Peterka 1969). Of these records, that of *Pentagenia vittigera* (Walsh) (Ephemeroidea) by Hamilton (1959) was most notable, as records of this species remain scarce. In the 1970s, UW–Madison’s Bill Hilsenhoff began a long series of contributions with the landmark survey of species from the Pine and

Popple River systems in Florence and Forest Counties (Hilsenhoff et al. 1972). That publication was the source of 32 of our current state records, bringing the total at that time to 49 species—but just 31% of today’s known diversity. The 1970s continued as the most prolific decade for new state records, with seven more species added from 1974 and 1975 (Edmunds and Jensen 1974; Lewis 1974a; Selgeby 1974; Flowers and Hilsenhoff 1975; McCafferty 1975). Edmunds and Jensen (1974) added *Spinadis simplex* (Walsh) (Heptageniidae), which today

Table 1. Chronological list of literature contributions to the known mayfly diversity of Wisconsin.

Author	Species
Wodsedalek (1912)	<i>Stenacron interpunctatum</i> (Say)
Muttkowski (1918)	<i>Caenis diminuta</i> Walker, <i>Leucrocuta maculipennis</i> (Walsh), <i>Siphonurus alternatus</i> (Say)
Traver (1935)	<i>Callibaetis ferrugineus</i> (Walsh), <i>Eurylophella lutulenta</i> (Clemens)
Spieth (1941)	<i>Hexagenia limbata</i> (Serville)
Hamilton (1959)	<i>Hexagenia bilineata</i> (Say), <i>Pentagenia vittigera</i> (Walsh)
Britt (1962)	<i>Ephemera simulans</i> Walker, <i>Ephoron album</i> (Say)
Leonard and Leonard (1962)	<i>Procloeon rufostriatum</i> (McDunnough)
Allen and Edmunds (1963b)	<i>Eurylophella funeralis</i> (McDunnough), <i>E. temporalis</i> (McDunnough)
Allen and Edmunds (1965)	<i>Ephemerella invaria</i> (Walker), <i>E. subvaria</i> McDunnough
Peterka (1969)	<i>Baetis tricaudatus</i> Dodds
Hilsenhoff et al. (1972)	<i>Acentrella parvula</i> (McDunnough), <i>A. turbida</i> (McDunnough), <i>Acerpenna pygmaea</i> (Hagen), <i>Anafroptilum album</i> (McDunnough), <i>Attenella attenuata</i> (McDunnough), <i>Baetis brunneicolor</i> McDunnough, <i>B. intercalaris</i> McDunnough, <i>B. pluto</i> McDunnough, <i>Baetisca obesa</i> (Say), <i>Dannella simplex</i> (McDunnough), <i>Drunella cornuta</i> (Morgan), <i>Ephemerella needhami</i> McDunnough, <i>Ephoron leukon</i> Williamson, <i>Eurylophella bicolor</i> (Clemens), <i>Heterocloeon curiosum</i> (McDunnough), <i>Labiobaetis frondalis</i> (McDunnough), <i>Maccaffertium mediopunctatum arwini</i> (Bednarik & McCafferty), <i>M. modestum</i> (Banks), <i>M. pulchellum</i> (Walsh), <i>M. vicarium</i> (Walker), <i>Neocloeon alamance</i> Traver, <i>Paraleptophlebia debilis</i> (Walker), <i>P. mollis</i> (Eaton), <i>Plauditus cingulatus</i> (McDunnough), <i>P. dubius</i> (Walsh), <i>P. punctiventris</i> (McDunnough), <i>Procloeon bellum</i> (McDunnough) [removed from the state list herein], <i>Rhithrogena manifesta</i> Eaton, <i>Serratella serrata</i> (Morgan), <i>Siphonopteron basale</i> (Walker), <i>Stenonema femoratum</i> (Say), <i>Teloganopsis deficiens</i> (Morgan)
Edmunds and Jensen (1974)	<i>Spinadis simplex</i> (Walsh)
Lewis (1974a)	<i>Maccaffertium exiguum</i> (Traver), <i>M. terminatum terminatum</i> (Walsh)
Selgeby (1974)	<i>Heptagenia pulla</i> (Clemens)
Flowers and Hilsenhoff (1975)	<i>Maccaffertium mexicanum integrum</i> (McDunnough)
McCafferty (1975)	<i>Hexagenia atrocaudata</i> McDunnough, <i>H. rigida</i> McDunnough

(continued)

Table 1. (continued)

Author	Species
Shapas and Hilsenhoff (1976)	<i>Epeorus vitreus</i> (Walker), <i>Ephemerella aurivillii</i> (Bengtsson), <i>E. catawba</i> Traver, <i>Heptagenia elegantula</i> (Eaton), <i>Labiobaetis propinquus</i> (Walsh), <i>Leucrocuta hebe</i> (McDunnough), <i>Maccaffertium luteum</i> (Clemens), <i>Nixe lucidipennis</i> (Clemens), <i>Rhithrogena impersonata</i> (McDunnough), <i>R. jejuna</i> Eaton, <i>Siphonurus quebecensis</i> (Provancher)
Bergman and Hilsenhoff (1978a)	<i>Acerpenna macdunnoughi</i> (Ide), <i>Dipheter hageni</i> (Eaton)
Flowers and Hilsenhoff (1978)	<i>Arthroplea bipunctata</i> (McDunnough), <i>Heptagenia flavescens</i> (Walsh)
Morihara and McCafferty (1979b)	<i>Labiobaetis longipalpus</i> (Morihara & McCafferty)
Peckarsky (1980)	<i>Baetis flavistriga</i> McDunnough
Pescador and Berner (1981)	<i>Baetisca laurentina</i> McDunnough
Hilsenhoff (1984)	<i>Baetisca lacustris</i> McDunnough
Kondratieff and Voshell (1984)	<i>Isonychia sayi</i> Burks
Lillie et al. (1987)	<i>Acanthametropus pecatonica</i> (Burks)
Jacobs (1990)	<i>Choroterpes basalis</i> (Banks), <i>Dolania americana</i> Edmunds & Traver, <i>Habrophlebiodes americana</i> (Banks), <i>Leptophlebia cupida</i> (Say)
Provonsha (1990)	<i>Caenis amica</i> Hagen, <i>C. hilaris</i> (Say), <i>C. latipennis</i> Banks, <i>C. punctata</i> McDunnough
Bae and McCafferty (1991)	<i>Anthopotamus myops</i> (Walsh), <i>A. verticis</i> (Say)
Lillie (1992)	<i>Homoeoneuria ammophila</i> (Spieth), <i>Macdunnoa persimplex</i> (McDunnough), <i>Metretopus borealis</i> (Eaton), <i>Pseudiron centralis</i> McDunnough
Lillie and Hilsenhoff (1992)	<i>Caenis tardata</i> McDunnough, <i>C. youngi</i> Roemhild, <i>Isonychia bicolor</i> (Walker), <i>Paracloeodes minutus</i> (Daggy), <i>Siphloplecton interlineatum</i> (Walsh), <i>Sparbarus nasutus</i> (Soldan), <i>Susperatus prudens</i> (McDunnough), <i>Tricorythodes explicatus</i> (Eaton)
Lillie (1995)	<i>Labiobaetis dardanus</i> (McDunnough), <i>Parameletus</i> sp. A (as <i>P. chelifer</i> Bengtsson)
Hilsenhoff (1996)	<i>Ameletus lineatus</i> Traver, <i>Leptophlebia nebulosa</i> (Walker)
Randolph and McCafferty (1998)	<i>Caenis anceps</i> Traver, <i>Callibaetis fluctuans</i> (Walsh), <i>Ephemerella dorothea</i> Needham, <i>E. excrucians</i> Walsh, <i>Eurylophella aestiva</i> (McDunnough), <i>Heterocloeon amplum</i> (Traver), <i>Isonychia sicca</i> (Walsh), <i>Nixe inconspicua</i> (McDunnough), <i>Paraleptophlebia guttata</i> (McDunnough), <i>Rhithrogena undulata</i> (Banks), <i>Sparbarus lacustris</i> (Needham)
Klubertanz and Hess (2001)	<i>Dannella lita</i> (Burks), <i>Procloeon viridoculare</i> (Berner)
McCafferty and Jacobus (2001)	<i>Plauditus cestus</i> (Provonsha & McCafferty)
McCafferty et al. (2004)	<i>Anafroptilum conturbatum</i> (McDunnough), <i>A. victoriae</i> (McDunnough), <i>Callibaetis pallidus</i> Banks, <i>C. skokianus</i> Needham, <i>Neocloeon triangulifer</i> (McDunnough), <i>Procloeon pennulatum</i> (Eaton), <i>P. simplex</i> (McDunnough), <i>Pseudocentropiloides usa</i> Waltz & McCafferty
McCafferty et al. (2005)	<i>Iswaeon anoka</i> (Daggy)
Sun and McCafferty (2008)	<i>Brachycercus harrisella</i> Curtis, <i>B. ojibwe</i> Sun & McCafferty, <i>Cercobrachys etowah</i> Soldan, <i>C. fox</i> Sun & McCafferty, <i>C. lilliei</i> Sun & McCafferty, <i>C. winnebago</i> Sun & McCafferty, <i>Sparbarus maculatus</i> (Berner)
McCafferty (2009)	<i>Paraleptophlebia praepedita</i> (Eaton)
McCafferty (2011)	<i>Isonychia rufa</i> McDunnough, <i>Tricorythodes albilineatus</i> Berner, <i>T. allectus</i> (Needham), <i>T. robacki</i> (Allen), <i>T. stygiatus</i> McDunnough
Schmude et al. (2012)	<i>Neophemera bicolor</i> McDunnough

is one of only two state-endangered mayflies in Wisconsin. Shapas and Hilsenhoff (1976) added eleven species and made significant contributions to our understanding of mayfly biology

in Wisconsin. The remainder of the decade produced five additional state records (Bergman and Hilsenhoff 1978a; Flowers and Hilsenhoff 1978; Morihara and McCafferty 1979b).

Five species were documented from the state for the first time in the 1980s (Peckarsky 1980; Pescador and Berner 1981; Hilsenhoff 1984; Kondratieff and Voshell 1984; Lillie et al. 1987).

Table 2. New Wisconsin records of mayflies reported in this publication.

Family	Species
Ameletidae	<i>Ameletus subnotatus</i> Eaton
Baetidae	<i>Anafroptilum bifurcatum</i> (McDunnough), <i>A. minor</i> (McDunnough), <i>Callibaetis pictus</i> (Eaton), <i>Cloeon dipterum</i> (Linnaeus), <i>Fallceon quilleri</i> (Dodds), <i>Labiobaetis ephippiatus</i> (Traver), <i>Procloeon fragile</i> (McDunnough), <i>P. rivulare</i> (Traver), <i>P. rubropictum</i> (McDunnough), <i>Pseudocentroptiloides morihari</i> Wiersema & McCafferty
Ephemerellidae	<i>Drunella cornutella</i> (McDunnough)
Ephemeridae	<i>Litobranchea recurvata</i> (Morgan)
Heptageniidae	<i>Leucrocuta aphrodite</i> (McDunnough)
Leptophlebiidae	<i>Paraleptophlebia adoptiva</i> (McDunnough), <i>P. ontario</i> (McDunnough)
Siphonuridae	<i>Siphonurus phyllis</i> McDunnough, <i>S. rapidus</i> McDunnough

During this period was the discovery of *Acanthametropus pecatonica* in the Wisconsin River by Lillie et al. (1987). Today, this species is on the Wisconsin Endangered Species List. The tremendous mayfly diversity in Wisconsin was being realized, with 77 species on record by 1990.

Thirty-seven new state records were documented in the 1990s in a long list of publications (Jacobs 1990; Provonsha 1990; Bae and McCafferty 1991; Lillie 1992; Lillie and Hilsenhoff 1992; Lillie 1995; Hilsenhoff 1996; Randolph and McCafferty 1998). During this time, records of several rare and unusual mayflies were added, including the discovery of *Dolania americana* in the St. Croix River by Jacobs (1990). Lillie (1992) added four rare species to the Wisconsin state list: *Macdunnoa persimplex*, *Homooneuria ammophila*, *Pseudiron centralis*, and *Metretopus borealis*. Taxonomic revisions not specifically targeting Wisconsin mayflies, such as that of *Caenis* by Provonsha (1990) and of ephemeroid families by Bae and McCafferty (1991), not only added Wisconsin records, but allowed reliable identification of many larvae in existing collections. The last publication of the 1990s adding to the Wisconsin list was the comprehensive survey of Midwest mayflies by Randolph and McCafferty (1998), which added eleven species

and summarized all previous state and county records.

The next decade added nineteen species, as currently recognized, to the list of Wisconsin species (Klubertanz and Hess 2001; McCafferty and Jacobus 2001; McCafferty et al. 2004; McCafferty et al. 2005; Sun and McCafferty 2008; McCafferty 2009). Difficult to identify baetids from *Callibaetis*, *Anafroptilum*, *Procloeon*, and *Pseudocentroptiloides* and other genera were added by Klubertanz and Hess (2001) and McCafferty et al. (2004). The record of *Procloeon rubropictum* in Klubertanz and Hess (2001) is corrected to *Neocloeon triangulifer* in this book, and is replaced by numerous other specimens. In their revision of the brachycercine Caenidae, Sun and McCafferty (2008) added seven species to the Wisconsin list, described several new species, and designated a Wisconsin specimen as the holotype of *Cercobrachys lilliei*.

The current decade already has added several species to the state list. McCafferty (2011) added five species, including the remarkable records of *Tricorythodes albilineatus* and the enigmatic *T. robacki*. Finally, in the most recent Wisconsin publication, Schmude et al. (2012) added *Neophemera bicolor* to the state's faunal list, bringing the total to 140 species.

This book documents eighteen new state records (Table 2) discovered during field work and extensive examination of existing collections, including the reassignment of the state record for *Procloeon rubropictum*. It also removes *Procloeon bellum* from the state records based upon the uncertain taxonomic status of that species. With these records, Wisconsin's known mayfly diversity is 157 species. A complete checklist of these species is given in taxonomic order before the glossary at the end of this book.

With 157 species already documented for Wisconsin, how many undiscovered state records remain? *Fallceon quilleri* (Baetidae) was not known from Wisconsin until this book was nearly completed, when my colleague Jeffrey Dimick at the University of Wisconsin-Stevens Point found it in the southwest corner of the state. I believe that many *Fallceon*-like additions to Wisconsin's known mayfly fauna will be made in the coming decades. Based upon faunal lists of other Midwest states, I estimate that at least 39 additional species are possible or likely in the state (Table 3). Surprisingly, discovery of all of these species would be nearly a 25% increase in the known mayfly diversity for Wisconsin. Most of these species have records in eastern Iowa (as was the case for *F. quilleri*), northern Illinois, Minnesota, the

Key to the Families of Wisconsin Mayfly Larvae

1. Mandibular tusks present, visible in dorsal view (Fig. 7a–c) 2
Mandibular tusks absent 5
2. Prothoracic legs normal, cylindrical; mandibular tusks as in Fig. 7a **POTAMANTHIDAE: *Anthopotamus***
Prothoracic legs fossorial (Fig. 7d); mandibular tusks not as above 3
3. Mandibular tusks curved upward (Fig. 7b) 4
Mandibular tusks not curved upward (Fig. 7c) **POLYMITARCYIDAE**
4. Mandibular tusk with robust spines on dorsolateral margin (Fig. 7e) **PALINGENIIDAE: *Pentagenia vittigera***
Mandibular tusk smooth, without dorsolateral spines (Fig. 7b) **EPHEMERIDAE**
5. Thorax expanded into dome-shaped carapace (Fig. 7f) **BAETISCIDAE: *Baetisca***
Thorax not expanded into carapace. 6
6. Head and prothorax with dorsal pad of long spines (Fig. 7g); gills ventral **BEHNINGIIDAE: *Dolania americana***
Head and prothorax without dorsal pad of long spines; gills variable 7
7. Gill II forming a complete or partial plate-like operculum, covering more posterior gills (Fig. 7h–i) 8
Gill II, if present, not forming a complete or partial operculum; more posterior gills sometimes operculate 10
8. Operculate gill II roughly triangular, with corners varying from angular to broadly rounded (Fig. 7h); gill I absent
. **LEPTOHYPHIDAE: *Tricorythodes***
Operculate gill II roughly quadrate (Fig. 7i); gill I a slender filament 9
9. Mesonotum with rounded lobe on anterolateral corner (Fig. 7j); operculate gills fused medially; rare
. **NEOEPHEMERIDAE: *Neophemera bicolor***
Mesonotum without lobe on anterolateral corner (Fig. 7k); operculate gills not fused medially; common **CAENIDAE**
10. Gill II present; terga rarely with paired tubercles. 11
Gill II absent; terga often with paired, submedian tubercles or clusters of spicules (Fig. 7l). **EPHEMERELLIDAE**
11. Body and head dorsoventrally flattened (Fig. 7m) 12
Head not dorsoventrally flattened (Fig. 7n); body usually cylindrical 14
12. Claws elongate; tarsi bowed (Fig. 7o) **PSEUDIRONIDAE: *Pseudiron centralis***
Claws short; tarsi not bowed (Fig. 7p). 13
13. Maxillary palpi very long and pectinate, visible from above (Fig. 8a) **ARTHROPLEIDAE: *Arthroplea bipunctata***
Maxillary palpi variable, but rarely visible from above **HEPTAGENIIDAE**
14. Protarsal claw much shorter than other claws, either simple or bifid (Fig. 8b–c); meso- and metatarsal claws simple and
about as long as their respective tibiae (Fig. 8d) 15
All claws similar in structure and length; meso- and metatarsal claws of variable length. 16
15. Protarsal claws simple (Fig. 8b); procoxa with a spinous pad; not known from Wisconsin
. **AMETROPODIDAE: *Ametropus neavei***
Protarsal claws bifid (Fig. 8c); procoxa without spinous pad. **METRETOPODIDAE**

16. Prothoracic leg with a dense row of long, ventral setae, setae longer than protarsus (Fig. 8e)	17
Prothoracic leg without a dense row of ventral setae, or such setae shorter than protarsus	18
17. Gills I–VII plate-like and rounded, with delicate, branched basal tufts (Fig. 8f); gill I not projecting between metacoxae.	ISONYCHIIDAE: <i>Isonychia</i>
Gills II–VII narrow with posterior fringes (Fig. 8g); gill I elongate and projecting between metacoxae	OLIGONEURIIDAE: <i>Homooneuria ammophila</i>
18. Gills forked, tufted, as slender filaments, or plate-like with terminal filaments (Figs. 8h, 334e)	LEPTOPHLEBIIDAE
Gills plate-like and without terminal filaments (Fig. 8i).	19
19. Lateral ocelli located posterior to anterolateral branches of epicranial suture (Fig. 7n); each femur with a down-curved dorsal lobe at apex, visible in anterior view (Fig. 8j); labrum usually with a deep medial notch (Fig. 8k); antennae usually more than twice as long as width of head capsule	BAETIDAE
Lateral ocelli located anterior to or bisected by anterolateral branches of epicranial suture (Fig. 8l); each femur with a truncate or rounded dorsal lobe at apex (Fig. 8m); labrum with medial notch of various depths (Fig. 8n); antennae usually less than twice as long as width of head capsule.	20
20. Tarsi bowed; metatarsal claw as long as metatarsus (Fig. 8o) ACANTHAMETROPODIDAE: <i>Acanthametropus pecatonica</i>	
Tarsi not bowed; metatarsal claw shorter than metatarsus.	21
21. Maxillary crown with a dense row of pectinate spines (Fig. 8p); each gill with a lateral sclerotized band	AMELETIDAE: <i>Ameletus</i>
Maxillary crown with a dense row of simple spines (Fig. 8q); gills without lateral sclerotized bands	SIPHLONURIDAE

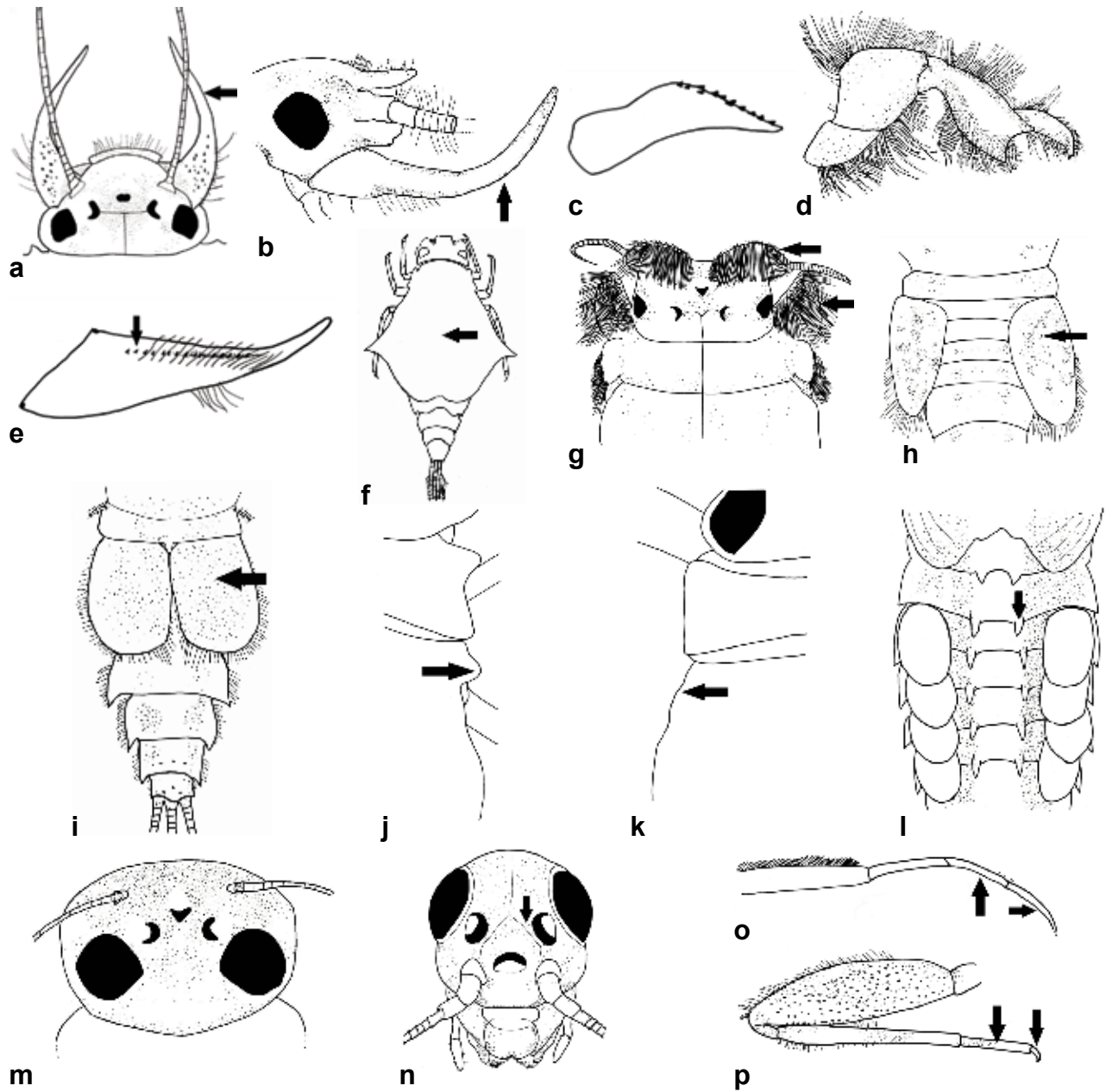


Figure 7. Mayfly families. **a**, *Anthopotamus myops* (Potamanthidae), head (dorsal); **b**, *Hexagenia limbata* (Ephemeridae), head (lateral); **c**, *Ephoron album* (Polymitarcyidae), mandible (lateral); **d**, *Hexagenia limbata* (Ephemeridae), front leg (lateral); **e**, *Pentagenia vittigera* (Palingeniidae), mandible (lateral); **f**, *Baetisca lacustris* (Baetiscidae), larva (dorsal); **g**, *Dolania americana* (Behningiidae), head and pronotum; **h**, *Tricorythodes* sp. (Leptohiphidae), terga; **i**, *Caenis latipennis* (Caenidae), terga; **j**, *Neoephemera bicolor* (Neoephemeridae), mesonotum; **k**, *C. latipennis* (Caenidae), mesonotum; **l**, *Ephemerella needhami* (Ephemerellidae), terga; **m**, *Heptagenia elegantula* (Heptageniidae), head (dorsal); **n**, *Baetis intercalaris* (Baetidae), head (anterior); **o**, *Pseudiron centralis* (Pseudironidae), front tarsus; **p**, *Stenacron interpunctatum* (Heptageniidae), middle leg (anterior).

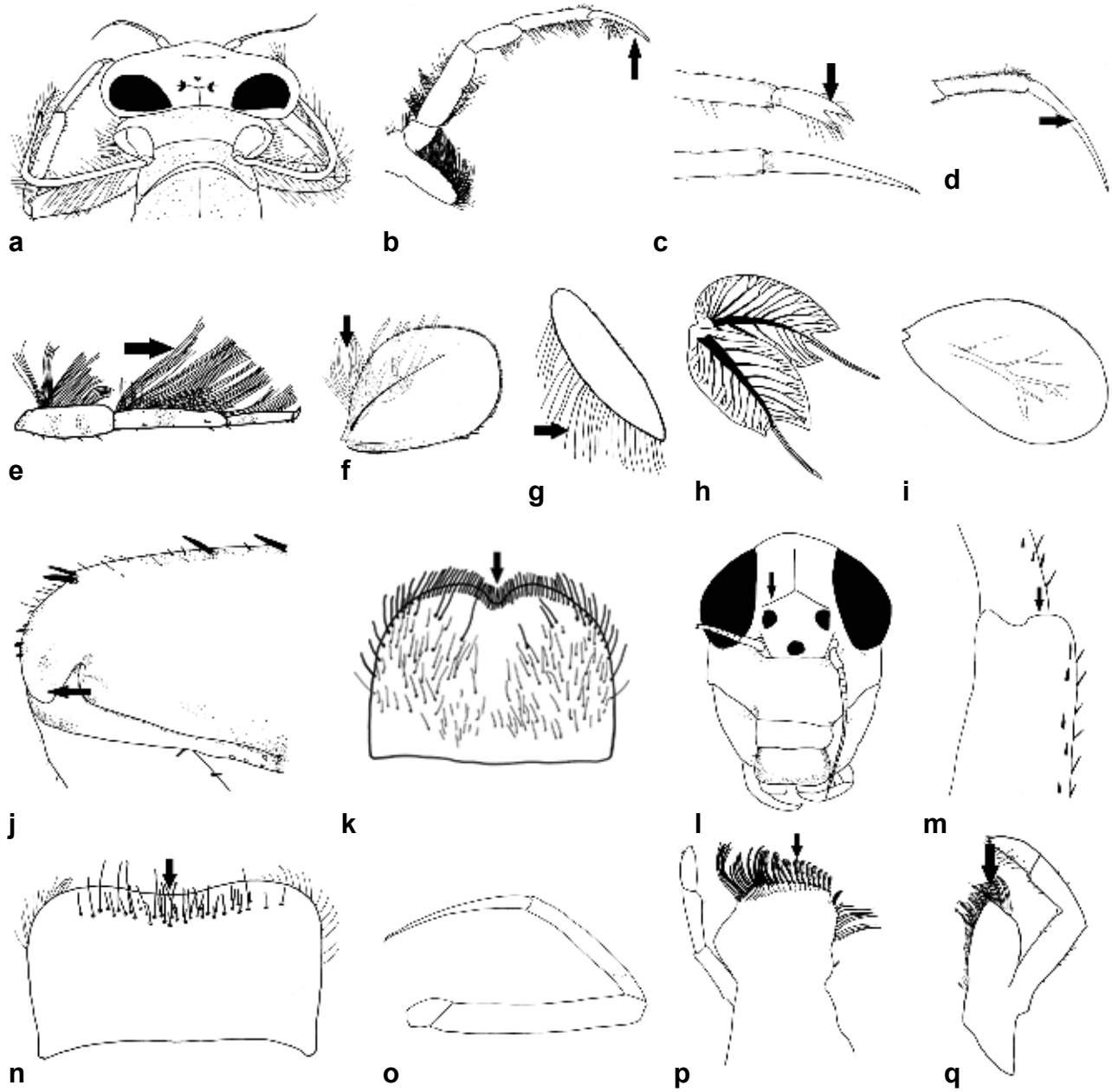


Figure 8. Mayfly families. **a**, *Arthroplea bipunctata* (Arthropleidae), head and pronotum; **b**, *Ametropus neavei* (Ametropodidae), front leg (posterior); **c**, *Siphloplecton interlineatum* (Metropodidae), front and middle tarsi; **d**, *A. neavei* (Ametropodidae), middle tarsus; **e**, *Isonychia rufa* (Isonychiidae), front leg (anterior); **f**, *I. rufa* (Isonychiidae), gill V; **g**, *Homoeoneuria ammophila* (Oligoneuriidae), gill V; **h**, *Leptophlebia* sp. (Leptophlebiidae), gill V; **i**, *Baetis intercalaris* (Baetidae), gill V; **j**, *Labiobaetis propinquus* (Baetidae), front femur (anterior); **k**, *L. propinquus* (Baetidae), labrum (dorsal); **l**, *Siphonurus* sp. (Siphonuridae), head (anterior); **m**, *Siphonurus* sp. (Siphonuridae), right front femur (anterior); **n**, *Siphonurus* sp. (Siphonuridae), labrum (dorsal); **o**, *Acanthametropus pecatonica* (Acanthametropodidae), hind leg; **p**, *Ameletus lineatus* (Ameletidae), maxilla (ventral); **q**, *Siphonurus* sp. (Siphonuridae), maxilla.

8

BAETIDAE

The Baetidae is a diverse family of mayflies, both in North America as well as globally (Anonymous 2014a; Kluge 2014). There have been numerous nomenclatural and other taxonomic changes in the group since the baetid keys of Burks (1953),

Bergman and Hilsenhoff (1978a), Morihara and McCafferty (1979b), and Hilsenhoff (1982). With the new state records presented in this book, Wisconsin's known baetid fauna now includes sixteen genera and 46 species. The baetids, commonly called *small*

minnow mayflies, generally have small and agile larvae. As with most mayflies, they are more diverse in lotic habitats, though some such as *Callibaetis* are common in lentic systems.

Key to the Genera of Baetidae

1. Claws spatulate (Fig. 19a); not known from Wisconsin *Camelobaetidius*
Claws simple..... 2
2. Caudal filaments with thin, dark bands on every three to five segments (Fig. 19b); labial palpi truncate (Fig. 19c); gill tracheae usually palmate and asymmetrical..... 3
Caudal filaments rarely with thin, dark bands as above (when such bands are faintly present as in some *Callibaetis*, then labial palpi rounded); labial palpi and gills variable, but usually not as above 7
3. Antennae longer than half of body length (Fig. 70); gills I–VI bilamellate with large dorsal flaps (Fig. 19d); labial palpus with distinctly pointed projection at anterior corner of apex (Fig. 19e); metathoracic wingpads absent; maxillary palpus three-segmented with terminal segment subequal in length to second segment (Fig. 19f); rare *Cloeon dipterum*
Antennae shorter than half of body length; gills I–VI with or without dorsal flaps, but not as wide as above; labial palpus lacking pointed projection at anterior corner of apex (Fig. 19c); metathoracic wingpads present or absent; maxillary palpus two- or three-segmented, with third segment, if present, of variable length; fairly common in unpolluted streams and rivers..... 4
4. Glossa distinctly shorter than paraglossa, with apex broadly rounded or truncate (Fig. 19i); labrum relatively elongate, with apicolateral corners appearing acutely angled because of a broad V-shaped notch that is nearly as wide as labrum (additional narrower, deeper notch sometimes present right at midline, especially towards ventral surface) (Fig. 19h); claws subequal to or longer than respective tarsi (Fig. 19g); labial palpus truncate and greatly widened at tip.....
..... *Pseudocentropiloides*
Glossa subequal in length to paraglossa, with apex lanceolate (Fig. 19c); labrum relatively short, with apicolateral margins evenly rounded, and with only a narrow, U-shaped medial notch (Fig. 19j); claws varying widely in length, but usually shorter than respective tarsi; labial palpus truncate but only slightly widened at tip..... 5
5. Maxillary palpus two-segmented and metathorax lacking wingpads, or maxillary palpus three-segmented with terminal segment much shorter than second segment (Fig. 19k) and metathorax with wingpads (examination of slide-mounted maxillae recommended); tergum IX never with medial tooth-like projection along posterior margin; all gills simple or one or more gills (especially gill I) with a dorsal flap; caudal filaments with lateral bristles to apices; mandibular incisors fused at a variable distance from base; at least some (especially posterior) abdominal segments with robust lateral spines (Fig. 19l)..... *Procloeon*
Maxillary palpus three-segmented (examination of slide-mounted maxillae recommended), with third segment at least two-thirds length of second (Fig. 19m), although sometimes obscure or poorly articulated from second segment; metathoracic wingpads present or absent; tergum IX sometimes with medial tooth-like projection along posterior margin (Fig. 19n); gills always simple, never with dorsal flap; caudal filaments without lateral bristles to apices;

- mandibular incisors of both mandibles fused to each at a distance equal to or less than half way up from their bases; abdominal segments variable with minute, small, or robust lateral spines on at least posterior segments 6
6. Metathoracic wingpads small but present (or if absent, then lateral margins of abdominal terga with very minute spines that are restricted to posterior segments) *Anafroptilum*
- Metathoracic wingpads absent; abdominal terga with moderately robust lateral spines (similar in length to those in Fig. 19l) *Neocloeon*
7. Lamella of each gill with one or more recurved flaps, appearing multilamellate (Fig. 19o) *Callibaetis*
- Gills composed of simple lamellae, without recurved flaps 8

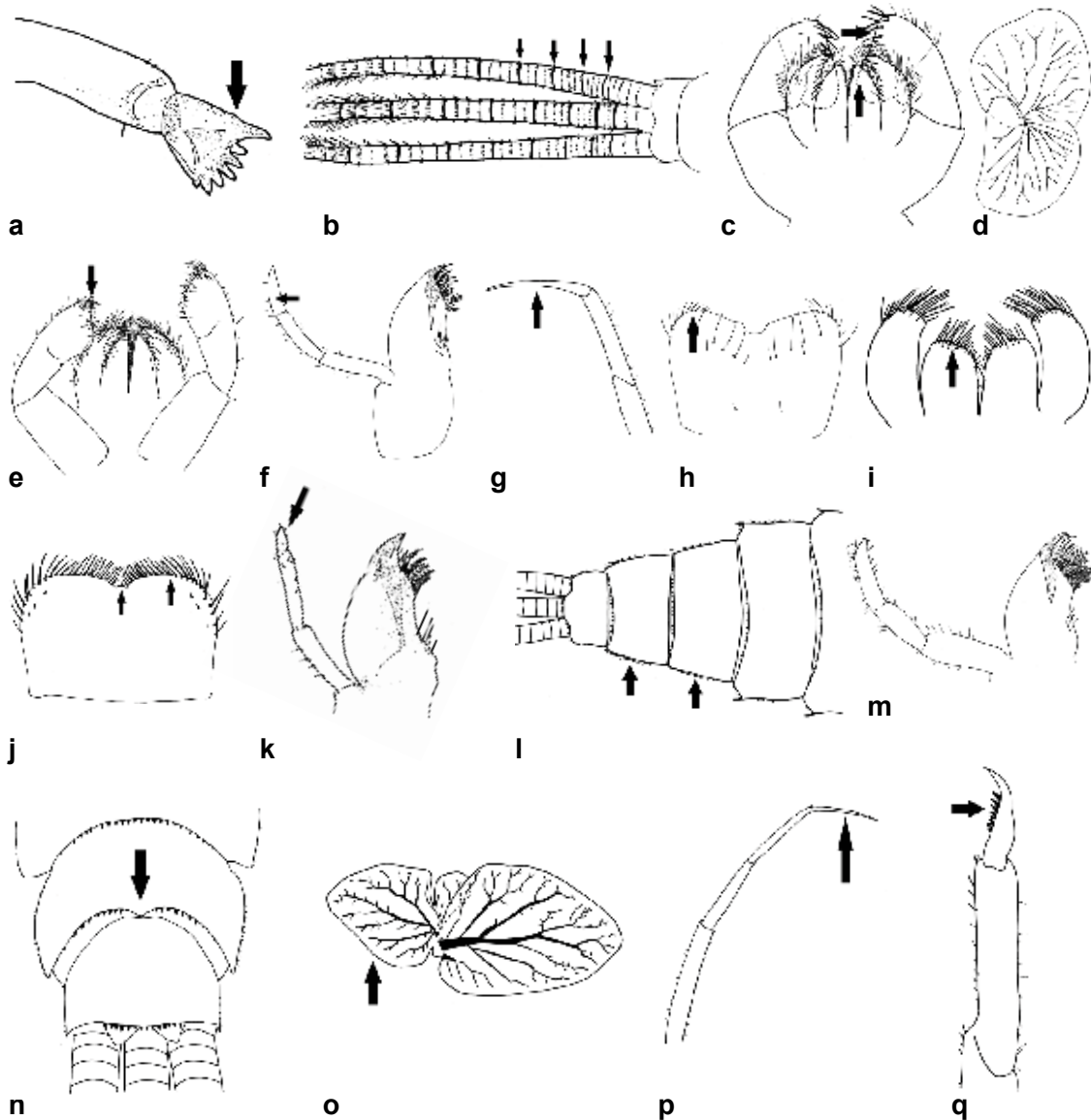


Figure 19. Baetidae. **a**, *Camelobaetidius waltzi*, front tarsus; **b**, *Procloeon viridoculare*, tails; **c**, *P. viridoculare*, labium (dorsal); **d**, *Cloeon dipterum*, gill III; **e**, *C. dipterum*, labium (ventral); **f**, *C. dipterum*, maxilla (right, ventral); **g**, *Pseudocentroptiloides morihari*, hind tarsus; **h**, *P. morihari*, labrum; **i**, *P. morihari*, glossae and paraglossae (ventral); **j**, *Procloeon viridoculare*, labrum (dorsal); **k**, *P. pennulatum*, maxilla (ventral); **l**, *P. viridoculare*, terga VI–X; **m**, *Anafroptilum bifurcatum*, maxilla (ventral); **n**, *A. bifurcatum*, terga VIII–X; **o**, *Callibaetis fluctuans*, gill V (unfolded); **p**, *Apobaetis etowah*, front leg; **q**, *Baetis intercalaris*, front tarsus.

Labiobaetis

Comments: In North America, *Labiobaetis* includes a discrete group of species that was in *Baetis* for many years and was known as the *propinquus* group. They were moved to *Labiobaetis* by McCafferty and Waltz (1995). Lugo-Ortiz et al. (1999), based upon adult morphology, reassigned the *propinquus* group to *Pseudocloeon* Klapalek, a name once applied to many of the two-tailed baetids in North America (now in *Acentrella*, *Plauditus*, and several other genera). This was a controversial placement since the larvae of *P. kraepelini* Klapalek, the type species of *Pseudocloeon*, are not known. McCafferty et al. (2010),

without explanation, resumed the use of *Labiobaetis* for the *propinquus* group. This is the current generic placement of these species on Mayfly Central (Anonymous 2014a) and in this text. The use of *Labiobaetis* in this context also follows the conservative approach of Kubendran et al. (2014). Proper identification of *Labiobaetis* species in the *propinquus* group can be challenging, involving slide mounting of mouthparts. Four of the five species are known from Wisconsin.

Determination: Identification of *Labiobaetis* larvae is **Slightly Difficult** for the genus, and **Slightly to Moderately Difficult** for identification of species within the genus. *Labiobaetis*

larvae are larger and more robust than in most species of *Baetis*. Identification of the genus requires good magnification with a dissecting microscope to detect the subapical constriction of the maxillary palpi (Fig. 21b), or examination of a slide mount of an antenna to detect a notch along the distal margin of the scape (Fig. 21a). The structure of the labral setae is most commonly used for species determination.

Larval Keys: Traver (1935), Burks (1953), Bergman and Hilsenhoff (1978a), Morihara and McCafferty (1979b), Soluk (1981), and Hilsenhoff (1982), all as *Baetis*; McCafferty and Waltz (1995).

Key to the Species of *Labiobaetis*

1. Labrum with dense dorsal setation, especially in distal third (Fig. 83a); labial palpus with second segment not expanded medially, appearing narrow and elongate (Fig. 83b) *L. longipalpus*
 Labrum with moderate number of setae evenly distributed over dorsal surface (Fig. 8k) or with submarginal dorsal setae differing in structure from other setae (Fig. 83e); labial palpus with second segment expanded medially (Fig. 83c) 2
2. Labrum with submarginal dorsal setae terminating in numerous spiny projections, appearing branched (Fig. 83e); medial surface of maxillary palpus usually abruptly and strongly narrowed at tip (Fig. 83f) 3
 Labrum with submarginal dorsal setae simple (Fig. 8k) or slightly spatulate (Fig. 83h); medial surface of maxillary palpus with less distinctive narrowing at tip (Fig. 83d) 4
3. Right mandible with abrupt prominence between incisor and molar region (Fig. 83g) *L. ephippiatus*
 Right mandible with only a rounded projection between incisor and molar region (Fig. 83i) *L. dardanus*
4. Labrum with spatulate dorsal submarginal setae arranged as in Fig. 83h *L. frondalis*
 Labrum with simple dorsal submarginal setae arranged as in Fig. 8k *L. propinquus*

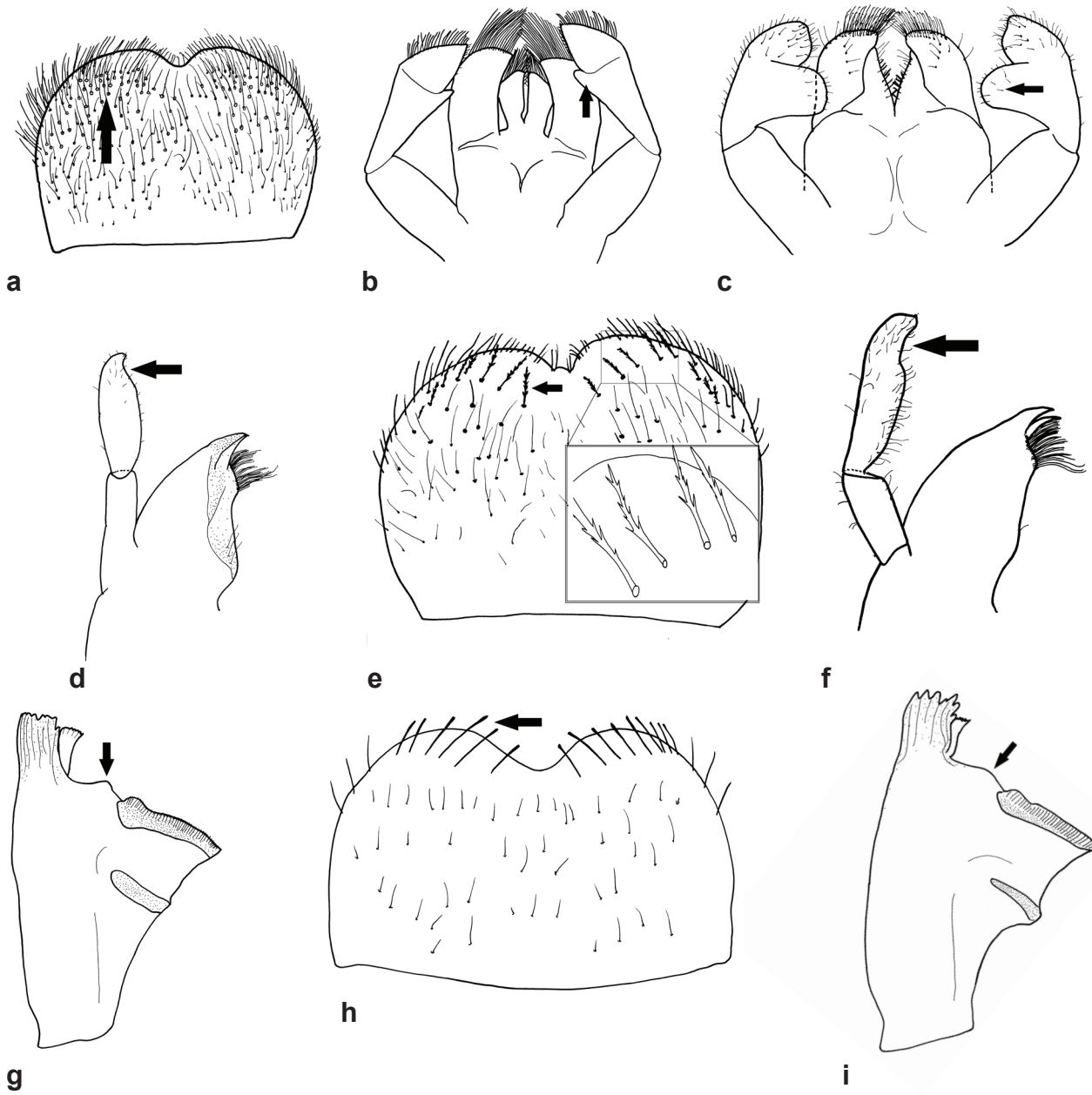


Figure 83. *Labiobaetis* (Baetidae). **a**, *L. longipalpus*, labrum (dorsal); **b**, *L. longipalpus*, labium (ventral); **c**, *L. propinquus*, labium (ventral); **d**, *L. propinquus*, maxilla (ventral); **e**, *L. ephippiatus*, labrum (dorsal); **f**, *L. ephippiatus*, maxilla (ventral); **g**, *L. ephippiatus*, mandible (right, ventral); **h**, *L. frondalis*, labrum (dorsal); **i**, *L. dardanus*, mandible (right, ventral).

Labiobaetis dardanus (McDunnough), 1923 (Figs. 84 and 85)

Taxonomic History: *Baetis dardanus* McDunnough, 1923 (orig.); *Baetis elachistus* Burks, 1953 (syn.); *Labiobaetis dardanus* (McDunnough), 1923 (curr. comb. sensu McCafferty and Waltz 1995); *Pseudocloeon dardanum* (McDunnough), 1923 (comb.).

Larval Descriptions: Soluk 1981, as *Baetis dardanus*.

Larval Habitus: Bergman and Hilsenhoff (1978a), as *Baetis propinquus*; Soluk (1981), as *B. dardanus*.

Determination: Identification of *L. dardanus* larvae is **Moderately Difficult**. Field determination is virtually impossible, as dissection of mouthparts is required. The species structurally is most similar to *L. ephippiatus*, but has a rounded protuberance between the incisor and

molar regions of the right mandible (Fig. 83i).

Previous Wisconsin Records: Lillie (1995), misidentified as *Baetis caelestis* Allen & Murvosh (Randolph and McCafferty 1998). Bergman and Hilsenhoff (1978a) reported and described larvae of *B. propinquus* from Wisconsin. These larvae were corrected to *B. longipalpus* by Morihara and McCafferty (1979a). Soluk (1981) subsequently corrected the same larvae to *B. dardanus*.

New County Records: **BURNETT:** 1L, St. Croix R., canoe landing on S. Markville Rd., 1000 ft. W. of St. Rd. 35 bridge, 46°4'26"N 92°15'3"W, VII-13-2011, THK (THK); **COLUMBIA:** 1L, Wisconsin R., Levee Rd., Pine Island Wildl. Area, 43°32'35"N 89°34'57"W, VII-26-2011, THK (THK); **POLK:**

1L, St. Croix R., Nevers Landing, 1 mi. S. of Wolf Creek, 45°32'10"N 92°43'25"W, VII-13-2011, THK (THK); **RICHLAND:** Wisconsin R., Gotham, IX-28-1986, R. A. Lillie, (UW); **SAUK:** 1L, Wisconsin R., St. Rd. 130/133 bridge, 43°9'55"N 90°11'34"W, VII-26-2011, THK (THK).

Status: *Labiobaetis dardanus* is listed as a Species of Special Concern on the Wisconsin Department of Natural Resources Natural Heritage Working List, as *Pseudocloeon dardanum* (Anonymous 2014b).

Biological Information: Very little biological information has been published for *L. dardanus*. In Wisconsin, Iowa, and Nebraska, I have found it most commonly in medium to large rivers.

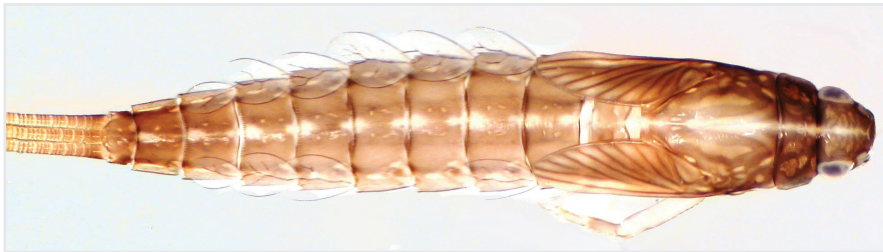


Figure 84. *Labiobaetis dardanus*, larva.

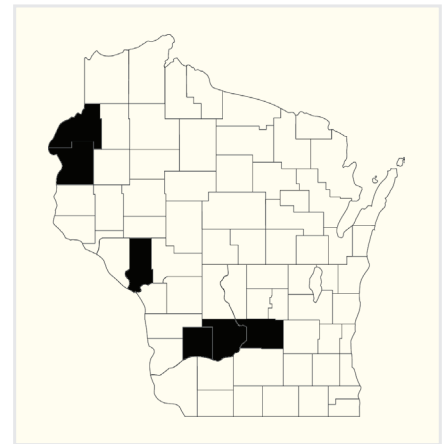


Figure 85. Wisconsin records of *Labiobaetis dardanus*.

Labiobaetis ephippiatus (Traver), 1935 (Figs. 86 and 87)

Taxonomic History: *Acentrella ephippiatus* (Traver), 1935 (comb.); *Baetis ephippiatus* Traver, 1935 (orig.); *Labiobaetis ephippiatus* (Traver), 1935 (curr. comb. sensu McCafferty and Waltz 1995); *Pseudocloeon ephippiatum* (Traver), 1935 (comb.).

Larval Descriptions: Berner (1940), as *Acentrella ephippiatus*; Morihara and McCafferty (1979a,b), as *Baetis ephippiatus*.

Determination: Identification of *L. ephippiatus* larvae is **Moderately Difficult**. Mature larvae taken from the Sugar River in extreme northern Illinois were darkly colored, as shown in Fig. 86. Slightly less mature larvae have abdominal terga II and V–VI distinctly darker than other terga. Abdominal sterna I–VII each has a dark, median spot on anterior margin, suggestive of *Plauditus punctiventris*. In very young larvae, the only remaining dark coloration on the terga is a median spot on abdominal tergum II, suggestive of *Paracloeodes minutus*, while the sternal markings are similar to those

of more mature larvae. Though these notes on the coloration of *L. ephippiatus* may assist in sorting, dissection of mouthparts is required for reliable identification. The right mandible bears a more sharp and angular projection between the incisor and molar regions (Fig. 83g) than in larvae of *L. dardanus* (Fig. 83i). The angle of view is important, being best from an awkward, unnatural angle. The mandible often will not lie in a suitable position in a permanent slide mount, making a wet mount more desirable. The dissected mandible should be retained with the specimen in a microvial.

Previous Wisconsin Records: None, with the first Wisconsin records given below. Closest records of *L. ephippiatus* were from northwestern Indiana (Randolph and McCafferty 1998) and in the Sugar River in extreme northern Illinois (Klubertanz and Hess 2001). It is likely that other populations in Wisconsin have been overlooked.

New Wisconsin Records: **COLUMBIA:** 1L, Wisconsin R., Levee Rd., Pine Island

Wildl. Area, 43°32'35"N 89°34'57"W, VII-26-2011, THK (THK); **GREEN:** 2L, Sugar R., Co. Rd. C, 0.2 mi. E. of Attica, 42°46'12"N 89°28'35"W, VIII-8-2011, THK, E. Wolf, and C. Brown (THK); **JACKSON:** 2L, Black R., River Rd. Canoe Launch, VII-11-2013, K. L. Schmude (UWS); **LA CROSSE:** 2L, Black R., St. Rd. 35, N. side of Rd., VII-10-2013, K. L. Schmude (UWS); **PEPIN:** 1L, Chippewa R., St. Rd. 35, W. side, VII-10-2013, K. L. Schmude (UWS).

Biological Information: *Labiobaetis ephippiatus* is known from a variety of stream sizes in Kansas, including small, intermittent streams to large rivers (Liechti 1980). Berner and Pescador (1988) described the habitat of this species in Florida as sand-bottomed stream margins, where larvae cling to vegetation. It also has been reported from woody debris (Berner 1950; Lager 1985).



Figure 86. *Labiobaetis ephippiatus*, larva.

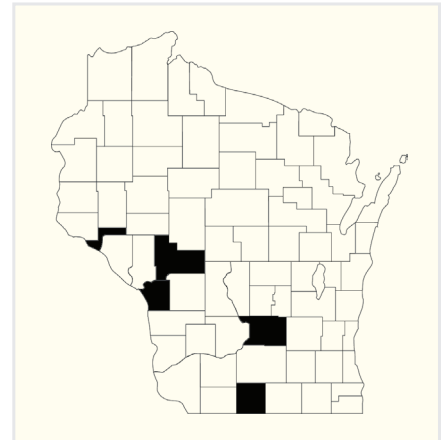


Figure 87. Wisconsin records of *Labiobaetis ephippiatus*.

Labiobaetis frondalis (McDunnough), 1925 (Figs. 88 and 89)

Taxonomic History: *Baetis australis* Traver, 1932 (syn.); *Baetis baeticatus* Burks, 1953 (syn.); *Baetis frondalis* McDunnough, 1925 (orig.); *Labiobaetis frondalis* (McDunnough), 1925 (curr. comb. sensu McCafferty and Waltz 1995); *Pseudocloeon frondale* (McDunnough), 1925 (comb.).

Larval Descriptions and Habitus: Bergman and Hilsenhoff (1978a) and Morihara and McCafferty (1979a,b), both as *Baetis frondalis*.

Determination: Identification of *L. frondalis* larvae is **Moderately Difficult**. They are easily misidentified as the more common *L. propinquus* unless

a slide mount of the labrum is made. Dorsal submarginal setae of the labrum are only slightly spatulate in *L. frondalis* (Fig. 83h) and easily misinterpreted. In *L. frondalis*, these setae are more evenly spaced than in larvae of *L. propinquus* (Fig. 8k).

Previous Wisconsin Records: Hilsenhoff et al. (1972), as *Baetis frondalis*; Randolph and McCafferty (1998).

New County Records: SAUK: 1L, Otter Crk., St. Rd. 60, 2.5 mi. W. of Sauk City, 43°16'16"N 89°47'5"W, VII-26-2011, THK (THK).

Biological Information: *Labiobaetis frondalis* is a common species of depositional areas and backwaters of small streams and rivers, where silt or sand is on the bottom (Berner 1950; Bergman and Hilsenhoff 1978a; Berner and Pescador 1988). It is widespread in Wisconsin and is second in abundance in the genus to *L. propinquus*. Burian and Gibbs (1991) reported *L. frondalis* as most common on submerged, long-leaved vegetation and on the stems and leaves of rushes and sedges.

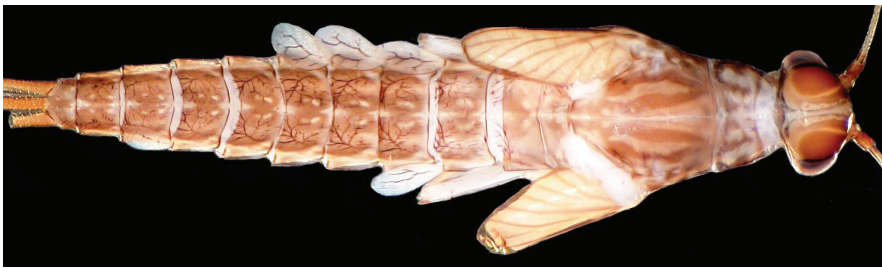


Figure 88. *Labiobaetis frondalis*, larva.

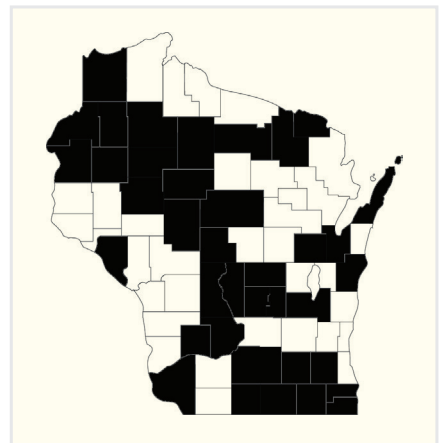


Figure 89. Wisconsin records of *Labiobaetis frondalis*.

Labiobaetis longipalpus (Moriyara & McCafferty), 1979 (Figs. 90 and 91)

Taxonomic History: *Baetis longipalpus* Moriyara and McCafferty, 1979 (orig.); *Labiobaetis longipalpus* (Moriyara and McCafferty), 1979 (curr. comb. sensu McCafferty and Waltz 1995); *Pseudocloeon longipalpus* (Moriyara and McCafferty), 1979 (comb.).

Larval Description and Habitus: Moriyara and McCafferty (1979a,b), both as *Baetis longipalpus*.

Determination: Identification of *L. longipalpus* larvae is **Slightly Difficult**. They have the combination of dense setation of the labrum (Fig. 83a), narrow shape of the labial palpi (Fig. 83b), and distinct dorsal coloration. The species is the only member of the

genus that readily can be identified without slide mounts. Some larvae of *L. longipalpus* are similar in dorsal coloration to *Acerpenna macdunnoughi*.

Previous Wisconsin Records: Moriyara and McCafferty (1979b), as *Baetis longipalpus*; Randolph and McCafferty (1998). Bergman and Hilsenhoff (1978a) reported and described larvae of *B. propinquus* from Wisconsin. These larvae were corrected to *B. longipalpus* by Moriyara and McCafferty (1979a). Soluk (1981) corrected the same larvae to *B. dardanus*.

Status: *Labiobaetis longipalpus* is listed as a Species of Special Concern on

the Wisconsin Department of Natural Resources Natural Heritage Working List, as *Pseudocloeon longipalpus* (Anonymous 2014b). It is known in the state only from the Wisconsin and Black Rivers.

Biological Information: *Labiobaetis longipalpus* occurs in larger rivers, in stronger currents, and in deeper waters than other members of the genus (Moriyara and McCafferty 1979b; Lillie and Hilsenhoff 1992; Klubertanz 1995). Klubertanz (1995) reported it from large stones and logs in deep riffles in Iowa, while Liechti (1980) reported it from various debris piles in a sandy river in Kansas.

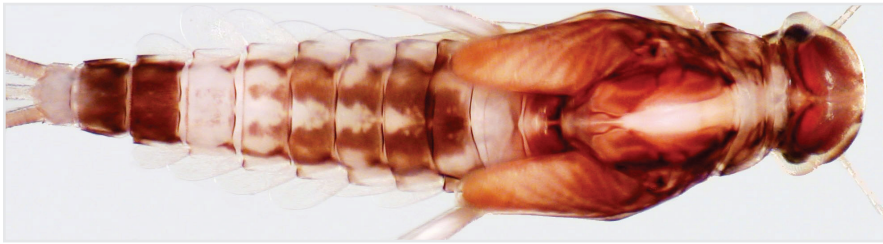


Figure 90. *Labiobaetis longipalpus*, larva.

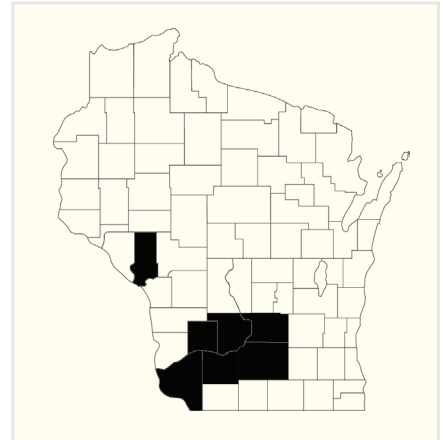


Figure 91. Wisconsin records of *Labiobaetis longipalpus*.

Labiobaetis propinquus (Walsh), 1863 (Figs. 92 and 93)

Taxonomic History: *Acentrella propinquus* (Walsh), 1863 (comb.); *Baetis propinquus* (Walsh), 1863 (comb.); *Baetis spinosus* McDunnough, 1925 (syn.); *Cloe propinqua* Walsh, 1863 (renam.); *Cloe vicina* Walsh, 1862 (hom. *C. vicina* Hagen, 1861); *Labiobaetis propinquus* (Walsh), 1863 (curr. comb. sensu McCafferty and Waltz 1995); *Pseudocloeon propinquum* (Walsh), 1863 (comb.).

Larval Descriptions and Habitus: Clemens (1913, 1915c), as *Baetis propinquus*; Bergman and Hilsenhoff (1978a), as *B. spinosus*; Morihara and McCafferty (1979a,b), as *B. propinquus*.

Determination: Identification of *L. propinquus* larvae is **Moderately Difficult**. They are larger and more robust than most stream baetids, but are not easily separated from other species in the genus. Preparation of slide mounts of mouthparts is required for proper identification. In *L. propinquus*, the dorsal submarginal setae of the labrum are fewer in number than in *L. frondalis*, with clear and consistent submedian gaps (Fig. 8k).

Previous Wisconsin Records: Shapas and Hilsenhoff (1976), as *Baetis spinosus*; Bergman and Hilsenhoff (1978a), as *B. spinosus*; Lillie and Hilsenhoff (1992), as *B. propinquus*; Hilsenhoff (1996); Randolph and McCafferty (1998). Bergman and Hilsenhoff (1978a) reported and described larvae of *B. propinquus* from Wisconsin. These larvae were corrected to *B. longipalpus* by Morihara and McCafferty (1979a). Soluk (1981) corrected the same larvae to *B. dardanus*.

New County Records: **BARRON:** 2L, Brill R., 29th Ave., 1.5 mi. N. of Brill, 45°37'28"N 91°40'38"W, VII-15-2011, THK (THK); 1L, Red Cedar R., St. Rd. 48, 2 mi. NE. of Rice Lake, 45°31'49"N 91°42'11"W, VII-15-2011, THK (THK); **WALWORTH:** 1L, Turtle Crk., Klug Rd. (formerly Pounder Rd.), 2 mi. NW. of Delavan, VIII-4-2000, THK (THK); 2L, Turtle Crk., Klug Rd. (formerly Pounder Rd.), 2 mi. NW. of Delavan, VI-23-2011, THK, C. Brown, and E. Wolf (THK); 4L, Turtle Crk., School Section Rd., T2NR15E S15, VI-23-2011, THK, C. Brown, and E. Wolf (THK); **WASHBURN:** 1L, Brill R., Bridge

Rd., 2.5 mi. N. of Brill, 45°38'21"N 91°40'27"W, VII-15-2011, THK (THK); 2L, Hay Crk., Hamilton Rd., 0.6 mi. NW. of Springbrook, 45°57'27"N 91°41'29"W, VII-15-2011, THK (THK); 1L, Namekagon R., Groat Landing, Brickman Rd., 7 mi. WSW. of Hayward, 45°59'45"N 91°38'6"W, VII-15-2011, THK (THK); 11L, Namekagon R., Stinnett Landing on Stinnett Landing Rd., 45°59'9"N 91°35'34"W, VII-15-2011, THK (THK); **WINNEBAGO:** 1L, Fish Trap Pond (likely in Rush Crk.), T18NR14E S36, IX-17-2007, J. Meyer (UWO).

Biological Information: Lillie and Hilsenhoff (1992) found larvae of *L. propinquus* abundant in the lower Wisconsin River, on a variety of substrates in shorelines and shallows. Likewise, I have found it as the dominant baetid at a number of sites. Bergman and Hilsenhoff (1978a), however, considered it uncommon overall in Wisconsin. It can be associated with plants, logs, and rubble, particularly in stream backwaters (Bergman and Hilsenhoff 1978a; Burian and Gibbs 1991).



Figure 92. *Labiobaetis propinquus*, larva.

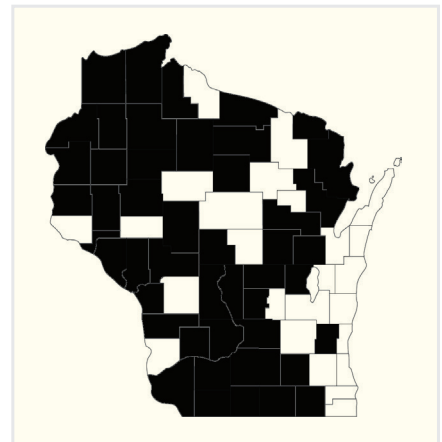


Figure 93. Wisconsin records of *Labiobaetis propinquus*.

Neocloeon

Comments: The two recognized species of North American *Neocloeon* most recently were included in *Centroptilum*. Kluge (2011) and Jacobus and Wiersema (2014) reassigned all of the North American species of *Centroptilum* to *Neocloeon* and

Anafroptilum. *Centroptilum* is now restricted to Old World species.

Determination: Identification of *Neocloeon* larvae is **Slightly Difficult** for the genus and **Difficult** for the species within the genus. Larvae of the two North American species lack metathoracic wingpads, unlike almost

all *Anafroptilum*. In *Neocloeon*, the third segment of the maxillary palpi is long, sharply tipped, and weakly separated from the second segment. In contrast to most Wisconsin species of *Anafroptilum*, the abdominal terga of *Neocloeon* have spines along the lateral margin that are sufficiently robust to also suggest *Procloeon*.

Key to the Species of *Neocloeon*

1. Each femur of fresh specimens with a dark band extending from dorsal margin at two-thirds length (Fig. 94a); gill tracheation interrupted by a white band at two-thirds length (Fig. 94b); males never present *N. triangulifer*
- Each femur unbanded or with an indistinctly shaded band extending from dorsal margin at two-thirds length; gill tracheation uninterrupted in distal half of gills; males usually present in populations *N. alamance*

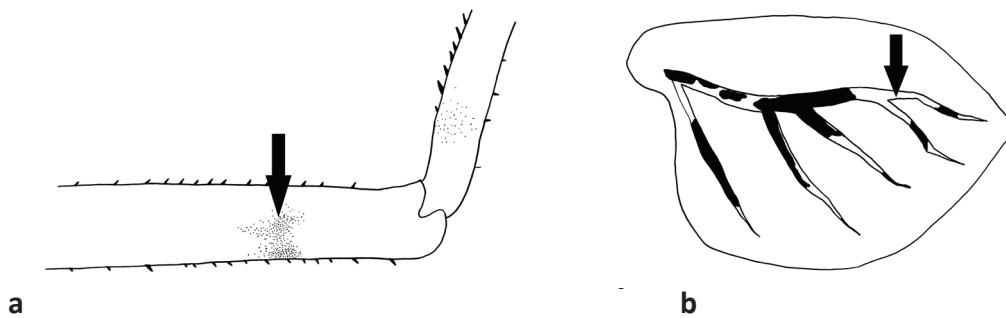


Figure 94. *Neocloeon* (Baetidae). **a**, *N. triangulifer*, hind femur (posterior); **b**, *N. triangulifer*, gill.

Neocloeon alamance Traver, 1932 (Fig. 95)

Taxonomic History: *Centroptilum alamance* (Traver), 1932 (comb.); *Cloeon alamance* (Traver), 1932 (comb.); *Neocloeon alamance* Traver, 1932 (orig., curr. comb. Jacobus and Wiersema 2014).

Larval Description: Traver (1932a); Funk et al. (2006), as *Centroptilum alamance*.

Larval Habitus: Traver (1932a, 1932b, 1935).

Determination: Identification of *N. alamance* larvae is **Difficult**. Faded specimens can be particularly hard to identify, as no structural characters separate *N. alamance* from *N. triangulifer* (Jacobus and Wiersema 2014).

Previous Wisconsin Records: Hilsenhoff et al. (1972); Randolph and McCafferty (1998), as *Centroptilum alamance*.

Status: Published records of *N. alamance* are only from Florence and Forest Counties in northeastern Wisconsin. There are unverified reports from the Wisconsin Department of Natural Resources that this species also occurs in several other far northern counties of the state.

Biological Information: In contrast to *N. triangulifer*, parthenogenesis is not obligatory and males of *N. alamance* may be present within a given population. There are no previously published details regarding the habitat associations of this species.

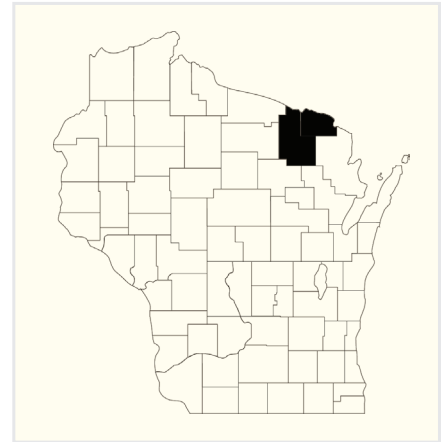


Figure 95. Wisconsin records of *Neocloeon alamance*.

Neocloeon triangulifer (McDunnough), 1931 (Figs. 96 and 97)

Taxonomic History: *Centroptilum* sp. 1 McCafferty and Davis, 1992 (syn.); *Centroptilum triangulifer* (McDunnough), 1931 (comb.); *Cloeon triangulifer* McDunnough, 1931 (orig.); *Neocloeon triangulifer* (McDunnough), 1931 (curr. comb., Jacobus and Wiersema 2014).

Larval Description: Funk et al. (2006), as *Centroptilum triangulifer*.

Determination: Identification of *N. triangulifer* larvae is **Difficult**. They are very similar to larvae of *N. alamance*. Though color differences traditionally have been used to separate the species, there are no known morphological differences (Jacobus and Wiersema 2014). Separation of the two species usually requires fresh, unfaded specimens. In most Wisconsin specimens I have examined, the anterior margin of the ninth abdominal sternum has a transverse, dark band. The band is much less well-defined

than similar marks found on larvae of *Procloeon viridoculare* (Fig. 111f), *P. fragile*, or *Pseudocentroptiloides*. The remaining sterna of these specimens are entirely white or have barely evident speckles in posterior half of each segment. Such specimens are consistent in having lateral spines on the third abdominal tergum and usually have at least one such spine on the second tergum. In much rarer specimens, the abdominal sterna are much more patterned throughout. They lack the transverse mark on the anterior margin of the ninth segment. Instead, they have well-defined submedial spots in the anterior quarter of each sternum and many speckles throughout each sternum. This pattern is suggestive of *Anafroptilum* sp. A, except for having more circular submedial spots on the sterna and, of course, lacking metathoracic wingpads. The pattern occurs in both immature and mature

(blackwing) larvae. Interestingly, all larvae of this form I have observed lack lateral spines on abdominal terga II and III. Such larvae have been found in both northern (Lincoln and Burnett Counties) and southern (Sauk) Wisconsin. Both of these forms tentatively identified as *N. triangulifer* have distinct bands near the distal ends of the femora in contrast to *N. alamance*. No other differences between these forms have been found, so it is not known whether they are separate species or simply variations of *N. triangulifer*.

Previous Wisconsin Records: McCafferty et al. (2004).

New County Records: LINCOLN: 1L, Devil Crk., upstream 20 m from Highland Dr., 45.13443°N 89.84708°W, X-6-2011, H. Yang (UWSP); MARATHON: 1L, Silver Crk., upstream 17 m from 72nd Ave., 45.07773°N 89.72725°W, X-5-2011,

H. Yang (UWSP); **ROCK:** 2L, Turtle Crk., Smith Rd., between Shopiere and Tiffany, VII-27-1999, THK and C. Hess (THK); **RUSK:** 2L, Chippewa R., Co. Rd. D, T33NR7W S33, VI-23-1998 (WiDNR); 1L, Hay Crk., Singer Rd., site "Chipr 7220", 45.479244°N 91.380158°W, Summer 2012, K. L. Schmude (UWS); **SAUK:** 1L, Otter Crk., Baxter's Hollow, Stone's Pocket Rd., VII-31-2007, THK (THK); **SAWYER:** 1L, Flambeau R., Hervas, T37N R4W S35, VI-19-1997 (WiDNR); 2L, Flambeau R., Oxbo Rd., 39NR3W S14, VI-18-1997 (WiDNR); **VILAS:** 1L,

Haymeadow Crk., X-17-1968 (UW); 1L, Wisconsin R., upstream 50 m from Co. Rd. K, 46.04779°N 89.26578°W, X-17-2011, H. Yang (THK).

Status: *Neocloeon triangulifer* is listed as a Species of Special Concern on the Wisconsin Department of Natural Resources Natural Heritage Working List (Anonymous 2014b). It is the most widely distributed and most commonly encountered member of the genus in the state.

Biological Information: The biology of *N. triangulifer* apparently is similar

to that of species of *Anafroptilum*. Burian and Gibbs (1991) described its habitat as emergent vegetation along the shoreline of second- to fourth-order streams. *Neocloeon triangulifer* is an obligatory parthenogenetic species that is very closely related to the sexually reproducing *N. alamance* (McCafferty et al. 2004). Funk et al. (2006) found both genetic and morphological differences between the two species, validating their status as separate species.



Figure 96. *Neocloeon triangulifer*, larva.

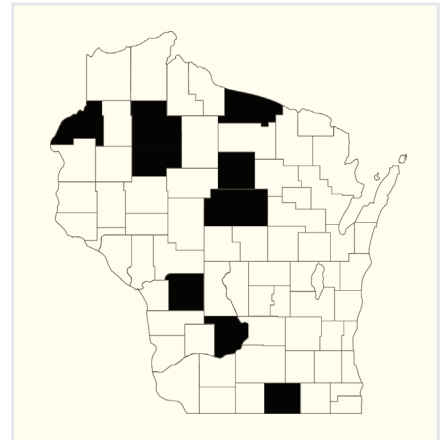


Figure 97. Wisconsin records of *Neocloeon triangulifer*.

Paracloeodes

Comments: There are three species of *Paracloeodes* in North America (Anonymous 2014a). Only one of them is known from the Midwest.

Paracloeodes minutus (Daggy), 1945 (Figs. 98 and 99)

Taxonomic History: *Paracloeodes abditus* Day, 1955 (syn.); *Paracloeodes minutus* (Daggy), 1945 (curr. comb., Edmunds et al. 1976); *Pseudocloeon minutum* Daggy, 1945 (orig.).

Larval Description: Daggy (1945), as *Pseudocloeon minutum*.

Larval Habitus: Lillie (1995).

Determination: Identification of *Paracloeodes minutus* larvae is **Fairly Easy**. Misidentification most likely is as a very small *Procloeon*, *Anafroptilum*, *Neocloeon*, *Pseudocentropiloides*, or *Apobaetis*. Careful use of the key is recommended. Larvae of *Paracloeodes minutus*, in addition to the characters used in the key, usually have a distinctive, dark ring around a pale area on the second abdominal tergum.

Previous Wisconsin Records: Lillie and Hilsenhoff (1992); Lillie (1995).

New County Records: **ASHLAND:** Marengo R., Government Rd., IX-9-2009, K. L. Schmude (UWS); **EAU CLAIRE:** 10L (including blackwing), Eau Claire R., adjacent to Co. Rd. Q,

The remaining species are from South America (Kluge 2014).

Determination: Identification of *Paracloeodes* larvae in Wisconsin is **Fairly Easy**.

44.819648°N 91.363869°W, IX-29-2009, M. Hazuga (THK); **GRANT:** 2L, Wisconsin R., Woodman, 3–4 ft. sand, moderate flow, VI-20-1986, R. A. Lillie (UW); **IOWA:** 1L, Wisconsin R., Co. Rd. C, 2.2 mi. NNE. of Spring Green, 43°8'41"N 90°3'13"W, VIII-8-2011, THK, E. Wolf, and C. Brown (THK); **MARINETTE:** 1L, Pike R., 45.496827°N 87.982493°W, VIII-12-2009 (THK); **ROCK:** 22L, Turtle Crk., Shopiere, VII-13-1999, THK (THK); **SAUK:** 1L, Wisconsin R., St. Rd. 130/133 bridge, 43°9'55"N 90°11'34"W, VII-26-2011, THK (THK); **WAUPACA:** 3L, Little Wolf R., Bridge Road, upstream along bridge riprap, 44.4946065°N 88.8999065°W, IX-20-2012, J. Riebe (UWSP).

Status: *Paracloeodes minutus* is listed as a Species of Special Concern on the Wisconsin Department of Natural Resources Natural Heritage Working List (Anonymous 2014b). Lillie (1995) recommended that it be considered for conservation efforts. Randolph and McCafferty (1998) believed, rather, that

the species was uncommonly collected because of size, not because of its rarity.

Biological Information: The very small larvae of *P. minutus* are not easily collected, though a significant amount of biological information is available for the species. They mostly occur in warm-water streams (Edmunds et al. 1976). Mature larvae can occur in large numbers in extremely shallow, silted pools and puddles of water along shorelines and floodwaters (Edmunds et al. 1976; Lillie and Hilsenhoff 1992; McCafferty et al. 2003a). Apparently, larvae occupy sandbars in deeper water during most of their development and only migrate to shallows when mature. In southeastern Nebraska streams and rivers, I have observed large numbers of mature *P. minutus* larvae in extremely shallow water and isolated puddles along the shoreline. Despite the larvae being excellent swimmers, a shallow pan could be used to scoop up large numbers of individuals in a short time.



Figure 98. *Paracloeodes minutus*, larva.

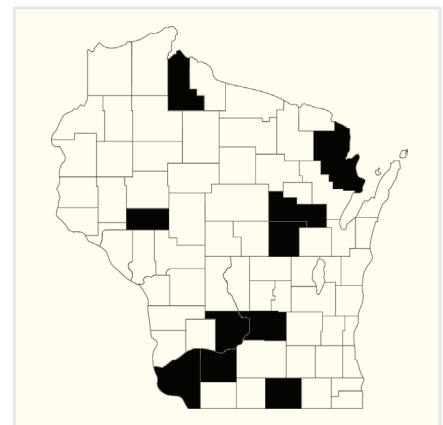


Figure 99. Wisconsin records of *Paracloeodes minutus*.

Plauditus

Comments: The species currently placed in *Plauditus* have been the subject of numerous taxonomic changes and historically have been placed in various combinations in a number of genera, including *Acentrella*, *Barbaetis*, *Baetis*, *Cloeon*, and *Pseudocloeon*. Because of the difficulty of identifying *Plauditus* larvae, the number of species

unknown as larvae, and the number of very recently described species, there likely are many misidentified specimens in various collections (Wiersema 1999a). There are ten recognized species, all from North America (Kluge 2014), with only four known from Wisconsin.

Determination: Identification of *Plauditus* larvae is **Fairly Easy** for

identification of the genus, and **Moderately Easy to Problematic** for the species within the genus.

Larval Keys: Traver (1935) and Burks (1953), both as *Pseudocloeon*; Hilsenhoff (1982), as *Baetis* and *Pseudocloeon*.

Key to the Species of *Plauditus* (*P. ellioti* and *P. veteris* not keyed)

1. Antennae of mature larvae equal to or shorter than one and a half times the length of head capsule (Fig. 100a); labial palpus with broadened third segment (Fig. 100b); protarsal claw with dorsal margin relatively straight, with a gently curved tip (Fig. 100c); tergum and sternum of either V or VII darkened in contrast to other segments (Fig. 101); males and females similarly patterned **2**
 Antennae of mature larvae usually at least two times longer than length of head capsule; labial palpus with third segment appearing truncate but not broadened (Fig. 20m); protarsal claw with dorsal margin more distinctly curved from base to tip (Fig. 20j); terga and sterna variously colored, usually with all terga uniformly colored (females) or with three or more segments darker than others (males) **3**
2. Antennae distinctly longer (usually at least one and a half times) than head capsule; tergum and sternum V similar in darkness to other segments and often not as dark as VII; pro- and mesofemora each with a short and long, dark mark on anterior surface in fresh specimens (Fig. 100d); tergum and sternum IX usually not darkened; abdominal sterna usually with dark, medial mark in intersegmental spaces (similar to *P. punctiventris*) ***P. gloveri***
 Antennal length subequal to length of head capsule (Fig. 100a); tergum and sternum V usually darker than IV, VI, and VII (Fig. 101); pro- and mesofemora not marked as above, each usually with a dark crossband near base in fresh specimens; tergum and sternum IX sometimes slightly darker than other segments; abdominal sterna without a dark, medial mark in each intersegmental space ***P. cestus***
3. At least some abdominal sterna with a median dark spot or dash along posterior margins, sometimes extending into the intersegmental membranes (Fig. 100e) ***P. punctiventris* / *P. virilis***
 Abdominal sterna with pairs of submedian spots or streaks, but without median posterior spots; a series of unfaded specimens recommended **4**
4. Each caudal filament without a dark band at midlength ***P. cingulatus***
 Each caudal filament with a dark band at midlength; male larva with terga V–VII strikingly darker than other segments (Fig. 105); female larva with terga uniformly colored (Fig. 106) ***P. dubius***

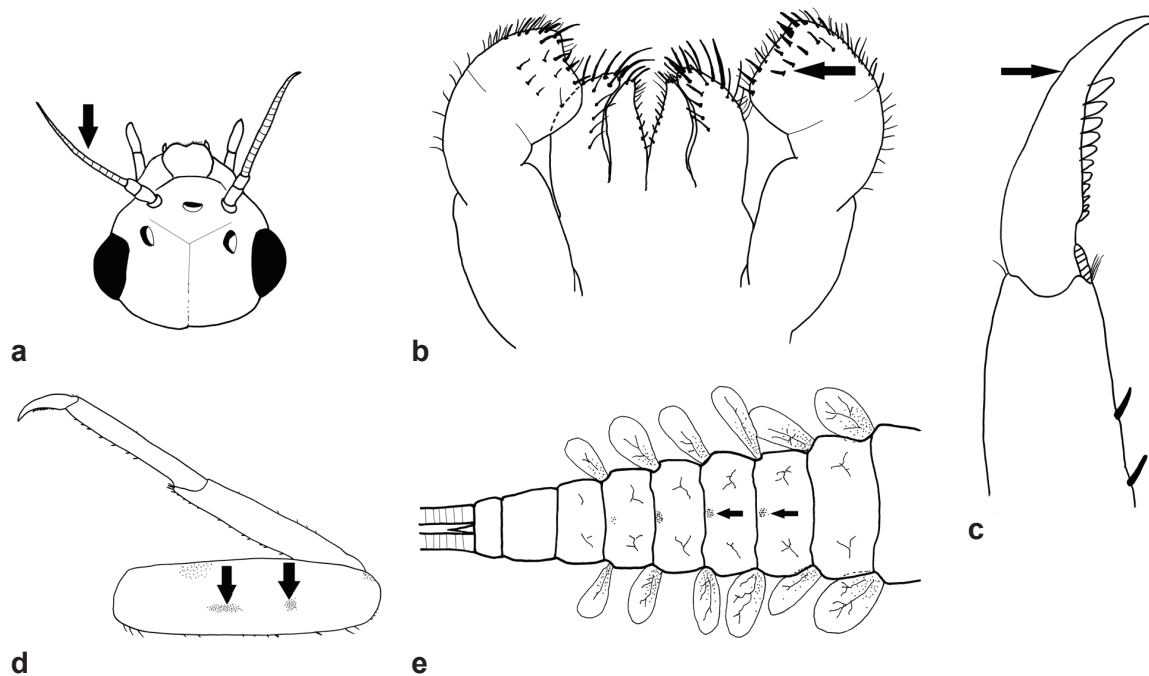


Figure 100. *Plauditus* (Baetidae). **a**, *P. cestus*, head (anterior); **b**, *P. cestus*, labium (ventral); **c**, *P. cestus*, front claw; **d**, *P. gloveri*, front leg (anterior); **e**, *P. punctiventris*, abdominal sterna.

Plauditus cestus (Provonsha & McCafferty), 1982 (Figs. 101 and 102)

Taxonomic History: *Barbaetis cestus* (Provonsha and McCafferty), 1982 (comb.); *Plauditus cestus* (Provonsha and McCafferty), 1982 (curr. comb., Lugo-Ortiz and McCafferty 1998a); *Pseudocloeon cestum* Provonsha and McCafferty, 1982 (orig.).

Larval Descriptions: Provonsha and McCafferty (1982), as *Pseudocloeon cestum*; Lugo-Ortiz and McCafferty (1998b); McCafferty and Jacobus (2001).

Larval Habitus: Provonsha and McCafferty (1982), as *Pseudocloeon cestum*.

Determination: Identification of *Plauditus cestus* larvae is **Moderately Easy** for fresh specimens. Though mature larvae of *Plauditus cestus* are quite small, the distinctive abdominal coloration usually is a reliable field mark. In male larvae of *P. dubius*, abdominal terga IV through VI usually are darker than other segments (Fig. 105). In *P. gloveri*, the only darkened

abdominal segment usually is VII. In most *P. cestus*, both the tergum and the sternum of the fifth abdominal segment contrast strongly with adjacent segments (Fig. 101). Structurally, *P. cestus* is most similar to *P. gloveri*. Intraspecific and interspecific variability of these two species was covered in detail by McCafferty and Jacobus (2001).

Previous Wisconsin Records: McCafferty and Jacobus (2001).

New County Record: ASHLAND: Marengo R., Government Rd., IX-9-2009, K. L. Schmude (UWS); **BURNETT:** 2L, St. Croix R., Nelson, SW. of Danbury, Summer 1996 (WiDNR); 1L, St. Croix R., Sand Rock Cliffs, 5 mi. NW. of Grantsburg, T38NR19W S7, Summer 1996 (WiDNR); **SHAWANO:** 6L in two vials, Mill Crk., Willow Crk. Rd., 44.75561°N 88.75651°W, VI-6-2000, K. L. Schmude, C. Brennan, and J. Denninger (UWS); **WAUPACA:** 2L, Wolf R., River Rd.,

44.65431°N 88.60595°W, VI-3-1999, K. L. Schmude, C. Brennan, and J. Tanck (UWS).

Status: *Plauditus cestus* is listed as a Species of Special Concern on the Wisconsin Department of Natural Resources Natural Heritage Working List (Anonymous 2014b). It is known only from scattered locations in the northern half of the state.

Biological Information: *Plauditus cestus* is a very small species occurring in clean streams and rivers with pea-sized gravel bottoms (Provonsha and McCafferty 1982; Webb et al. 2004). In Wisconsin, it is known from both small and large rivers. Because of their size, larvae are often overlooked if fine-meshed nets are not used (Lugo-Ortiz and McCafferty 1998b). Little is known regarding the phenology of this species in Wisconsin. All of the adults of *P. cestus* that I have examined from Wisconsin were taken in June.

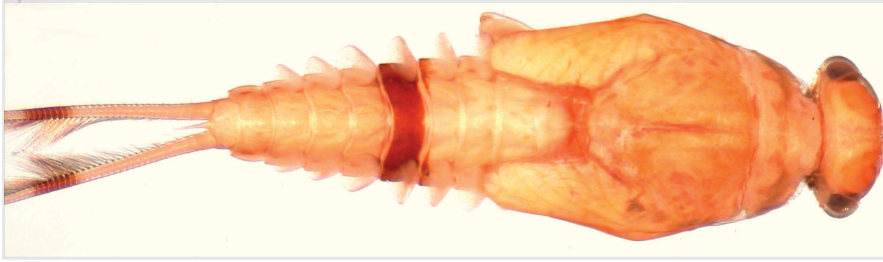


Figure 101. *Plauditus cestus*, larva.

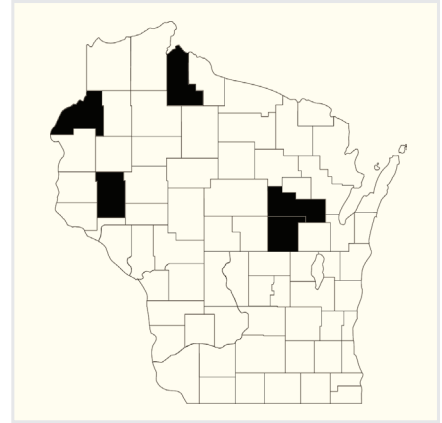


Figure 102. Wisconsin records of *Plauditus cestus*.

Plauditus cingulatus (McDunnough), 1931 (Figs. 103 and 104)

Taxonomic History: *Baetis cinctutus* McCafferty and Waltz, 1990 (syn.), *Plauditus cinctutus* (McCafferty and Waltz), 1990 (syn. comb.); *Plauditus cingulatus* (McDunnough), 1931 (curr. comb., McCafferty 1999); *Pseudocloeon cingulatum* McDunnough, 1931 (orig.). In 1925, McDunnough described *Baetis cingulatus*, which later was synonymized with *Baetis flavistriga*. In 1931, McDunnough applied the similar name *Pseudocloeon cingulatum*, which is the correct origin of *Plauditus cingulatus* (McDunnough 1931a).

Larval Description: Leonard and Leonard (1962).

Determination: Identification of *P. cingulatus* larvae is **Moderately Easy** for unfaded, intact specimens, but **Moderately Difficult** for specimens with broken caudal filaments. Faded material of *P. cingulatus* may be inseparable from *P. dubius*.

Previous Wisconsin Records: Hilsenhoff et al. (1972), as *Baetis cingulatus*; Randolph and McCafferty (1998), as *B. cinctutus*.

New County Records: POLK: 1L, St. Croix R., Nevers Landing, near Wolf Creek, Summer 1996 (WiDNR).

Status: *Plauditus cingulatus* is listed as a Species of Special Concern on the Wisconsin Department of Natural Resources Natural Heritage Working List (Anonymous 2014b). It likely is the least common member of the genus in the state.

Biological Information: *Plauditus cingulatus* was reported from erosional reaches of first- to third-order streams (Burian and Gibbs 1991), though the St. Croix River record above suggests a tolerance of larger rivers.



Figure 103. *Plauditus cingulatus*, larva.

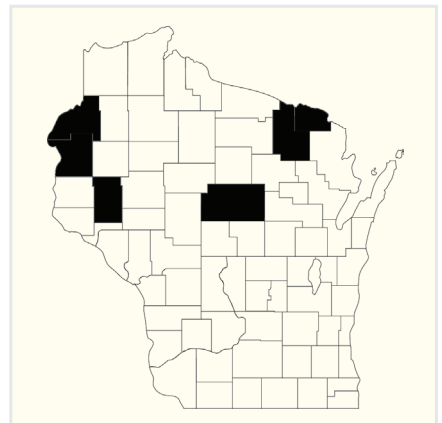


Figure 104. Wisconsin records of *Plauditus cingulatus*.

Plauditus dubius (Walsh), 1862 (Figs. 105–107)

Taxonomic History: *Baetis dubius* (Walsh), 1862 (comb.); *Cloe dubia* Walsh, 1862 (orig.); *Cloeon chlorops* McDunnough, 1923 (syn.); *Cloeon dubium* (Walsh), 1862 (comb.); *Plauditus dubius* (Walsh), 1862 (curr. comb., Lugo-Ortiz and McCafferty 1998a); *Pseudocloeon chlorops* (McDunnough), 1923 (syn.); *Pseudocloeon dubium* (Walsh), 1862 (comb.).

Larval Description: Clemens (1913, 1915c), as *Cloeon dubium*; Burks (1953), as *Pseudocloeon dubium*.

Larval Habitus: Clemens (1913), as *Cloeon dubium*.

Determination: Identification of *Plauditus dubius* larvae is **Moderately Easy**. Larvae are sexually dimorphic, with males (Fig. 105) having more contrasting abdominal terga. Females (Fig. 106) can be confused with *Acentrella turbida*. Faded specimens may be inseparable from *P. cingulatus* and *P. punctiventris*.

Previous Wisconsin Records: Hilsenhoff (1972), Shapas and Hilsenhoff (1976), and Hilsenhoff (1982), all as *Pseudocloeon dubium*; Randolph and McCafferty (1998), as *Baetis dubius*.

New County Records: **DUNN:** 1L, Chippewa R., 640th St. Landing, VII-9-2013, K. L. Schmude (UWS); **JACKSON:** 1L, Black R., River Rd. Canoe Launch, VII-11-2013, K. L. Schmude (UWS); **MARINETTE:** 2L, Menominee R., Co. Rd. Z, T36NR22E S20, VI-25-1996 (WiDNR); **PEPIN:** 2L, Chippewa R., Ella Boat Landing, VII-9-2013, K. L. Schmude (UWS); **POLK:** 1L, St. Croix R., Sunrise, VI-10-1996 (WiDNR); **ROCK:** 3L in two vials, Turtle Crk., Carver's Rock Rd., VI-1-2005 and VII-20-2007, THK (THK); Turtle Crk., Shopiere, VII-20-2007, THK (THK); 3L, Turtle Crk., Lathers Rd., 1 mi. WSW. of Shopiere, T2NR13E S9, THK, C. Brown, and E. Wolf (THK); 6L, Turtle Crk., Sweet Allyn Pk.

on Belding Rd. in Shopiere, T1NR13E S3, VI-6-2011, THK, C. Brown, and E. Wolf (THK); 2L, Yahara R., Murwin Pk. in Fulton, VII-7-2011, THK, E. Wolf, and C. Brown (THK); **RUSK:** 15L in three vials (including blackwing), N. Fork Chippewa R., Bruce, T34NR7W S5, VI-23-1998 (WiDNR); **SAWYER:** 30L in three vials, Chippewa R., Town Line Rd., T37NR7W S35, VI-23-1998 (WiDNR); **WASHBURN:** 6L, Namekagon R., Groat Landing, Brickman Rd., 7 mi. WSW. of Hayward, 45°59'45"N 91°38'6"W, VII-15-2011, THK (THK); 1L, Namekagon R., Co. Rd. K, T40NR12W S18, VI-24-1998 (WiDNR).

Biological Information: Burian and Gibbs (1991) described the habitat of *Plauditus dubius* as erosional and transitional reaches of second- and third-order streams. In Wisconsin, though, the species also is known from a number of medium to large rivers, including the St. Croix, Chippewa, and Menominee Rivers.

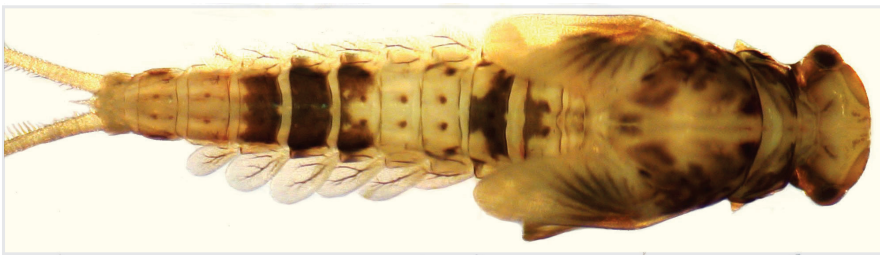


Figure 105. *Plauditus dubius*, male larva.

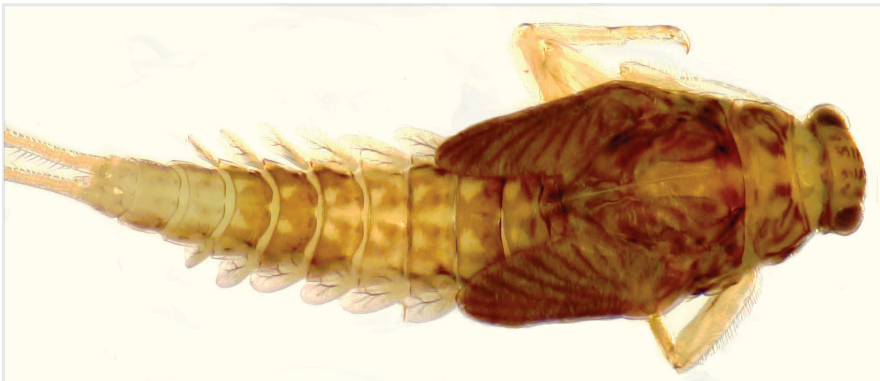


Figure 106. *Plauditus dubius*, female larva.

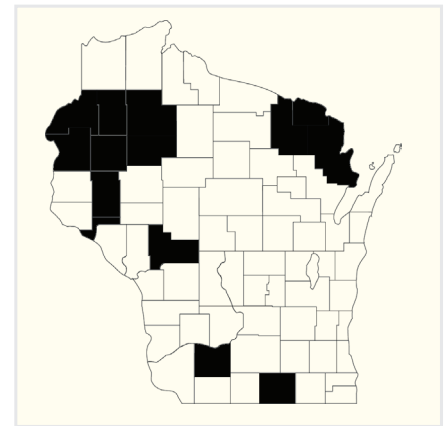


Figure 107. Wisconsin records of *Plauditus dubius*.

Plauditus elliotti (Daggy), 1945

Taxonomic History: *Baetis elliotti* (Daggy), 1945 (comb.); *Plauditus elliotti* (Daggy), 1945 (curr. comb., Lugo-Ortiz and McCafferty 1998a); *Pseudocloeon elliotti* Daggy, 1945 (orig.); *Pseudocloeon ida* Daggy, 1945 (syn.).

Determination: Identification of *Plauditus elliotti* larvae is **Problematic**. The species has not been formally described as larvae.

Previous Wisconsin Records: None. *Plauditus elliotti* was originally described by Daggy (1945) based upon

adults collected from the Mississippi River in Fridley, Minnesota (north of Minneapolis).

Biological Information: No accounts of the biology of this species have been published.

Plauditus gloveri McCafferty & Waltz, 1998 (Fig. 108)

Larval Descriptions: McCafferty and Waltz (1998); McCafferty and Jacobus (2001).

Larval Habitus: McCafferty and Waltz (1998).

Determination: Identification of *P. gloveri* larvae is **Fairly Easy**. Faded specimens may be difficult to separate from other species in the genus. Adults of *P. gloveri* have not been formally described.

Previous Wisconsin Records: None. Closest records of *P. gloveri* are from south-central Indiana (Jacobus and McCafferty 2006). Since the species has a fairly widespread distribution, from the southeastern United States to Manitoba (McCafferty and Waltz 1998; Jacobus and McCafferty 2001; McCafferty and Jacobus 2001; McCafferty et al. 2004; Webb et al. 2004; Jacobus and McCafferty 2006),

the absence of records from Wisconsin and neighboring states likely is because of being overlooked. It is expected in Wisconsin.

Biological Information: No accounts of the biology of this species have been published.



Figure 108. *Plauditus gloveri*, larva.

Plauditus punctiventris (McDunnough), 1923 (Figs. 109 and 110)

Taxonomic History: *Baetis punctiventris* (McDunnough), 1923 (comb.); *Baetis* sp. 1 McCafferty and Davis, 1992 (syn.); *Cloeon punctiventris* McDunnough, 1923 (orig.); *Plauditus punctiventris* (McDunnough), 1923 (curr. comb., Lugo-Ortiz and McCafferty 1998a); *Pseudocloeon myrsum* Burks, 1953 (syn.); *Pseudocloeon punctiventris* (McDunnough), 1923 (comb.).

Larval Descriptions: Burks (1953), as *Pseudocloeon myrsum* and *P. punctiventris*.

Determination: Identification of *Plauditus punctiventris* larvae is **Difficult**, even for fresh specimens. Larvae are easily confused with other species, including *P. dubius*, *P. gloveri*, *P. virilis*, and *Iswaeon anoka*. Larvae of *I. anoka* can have a dark spot centrally located on each abdominal sternum (Fig. 20h), rather than between segments, and always have more robust tibiae (Fig. 20g) than *Plauditus*. Many collections have specimens of *I. anoka* misidentified as *P. punctiventris*, to which it formerly was a junior synonym. In *P. punctiventris*, each abdominal sternum has a dark medial spot along the posterior margin of the segment that usually bleeds into the intersegmental membrane (Fig. 100e). Most *P. gloveri* are similarly patterned (McCafferty and Waltz 1998; McCafferty and Jacobus 2001) but have thinner claws, among other characters.

I am not aware of reliable characters to separate larvae of *P. punctiventris* from *P. virilis*, and I have not examined confirmed, reared specimens of *P. virilis*. Specimens in the Purdue Entomological Research Collection labeled as *P. virilis* (Bartholomew Co., IN, IV-19-2005) have a ventral spot along the posterior margin of each sternum (and intersegmental membrane) as in *P. punctiventris*. Ide (1937) made no mention of these marks in his description of *P. virilis*, so I am unsure of the identity of the Indiana specimens. Larvae of *P. punctiventris*, *P. virilis*, and *P. dubius* are sexually dimorphic, with males having more contrasting abdominal terga than females (as in Fig. 109). Structural characters to separate these three species as larvae are lacking.

Previous Wisconsin records:

Hilsenhoff et al. (1972), as *Pseudocloeon punctiventris*; Shapas and Hilsenhoff (1972), as *P. punctiventris*; Hilsenhoff (1982), as *P. punctiventris*; Randolph and McCafferty (1998), as *Baetis punctiventris*. All Midwest records of this species prior to McCafferty et al. (2005) should be considered with some skepticism. The former synonymy with *Iswaeon anoka* (as *Pseudocloeon*) and the similarity between *Plauditus punctiventris* and *I. anoka* make it clear that all records of *P. punctiventris* should be

revalidated. Many of the specimens in the University of Wisconsin collection previously identified as *P. punctiventris* are now corrected to *I. anoka*. The confirmed and new county records of *P. punctiventris* listed below do not eliminate the possibility that some could actually be *P. virilis*.

Confirmed County Records:

BARRON: Bear Crk. (UWS); **BURNETT:** St. Croix R. (WiDNR); **CLARK:** Cunningham Crk. (UWS); **POLK:** St. Croix R. (THK); **PRICE:** S. Fork Flambeau R. (WiDNR); **ROCK:** Marsh Crk. (UWS), Turtle Crk. (THK); **RUSK:** N. Fork Chippewa R. (WiDNR); **WASHBURN:** Bean Brk. (THK).

New County Records: **MARINETTE:** 2L, Menominee R., Mine Rd., T27NR21E S25, VI-24-1997, R. A. Lillie (WiDNR).

Biological Information: Burian and Gibbs (1991) described the habitat of *P. punctiventris* as second- and third-order streams. Field work is needed to clarify the habitat and tolerance of this species independent of *Iswaeon anoka*. Taxonomic work, likely including a molecular component, is needed to determine if *P. punctiventris* as it currently is defined represents one variable species or a species complex potentially including species known to date only as adults.

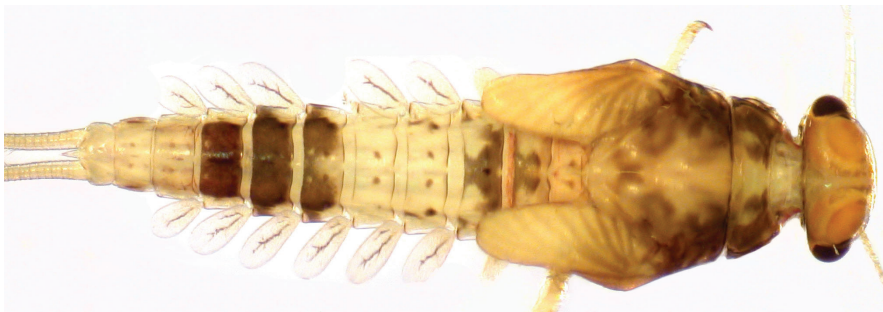


Figure 109. *Plauditus punctiventris*, larva.

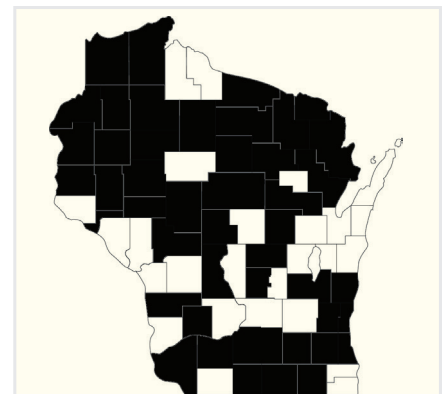


Figure 110. Wisconsin records of *Plauditus punctiventris*.



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