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HEPTAGENIIDAE (EPHEMEROPTERA) OF WISCONSIN¹R. Wills Flowers² and William L. Hilsenhoff³

Heptageniidae are one of the most abundant and widespread components of Wisconsin's aquatic insect fauna. In almost any stream with a firm substrate and free of gross pollution, the flattened nymphs can be found hiding in crevasses and under rocks, or clinging to submerged wood. Adults and nymphs are easily distinguished from mayflies of other families, nymphs by their dorsoventrally flattened head and dorsal eyes, and adults by their 5-segmented tarsi and complete wing venation. This paper presents our knowledge to date of Heptageniidae in Wisconsin.

Early studies of Heptageniidae and other mayflies are summarized by Burks (1953). The original classification of Heptageniidae was based on the adult male, particularly length ratios of fore tarsal segments. Traver (1933a, b, 1935) redefined the genera on nymphal characters. She erected the genus *Stenonema* for a larger group of American species that had been placed in *Heptagenia* and in the European genus *Eclyonurus*. Although the great diversity of nymphal forms in this family was known for some time, Traver seems to have been the first to recognize its taxonomic value and her classification is, with some modification, still in use today.

More recently Daggy (1945), Burks (1953), Leonard and Leonard (1962), Lewis (1974a), and Edmonds and Jensen (1974) described additional species of this family. The genus *Stenonema* has been revised by Lewis (1974b), and a new genus, *Stenacron*, was erected by Jensen (1974).

Although Heptageniidae in states adjacent to Wisconsin have been studied in some detail (Daggy, 1941, Minnesota; Burks, 1953, Illinois; Leonard and Leonard, 1962, Michigan), similar studies in Wisconsin are lacking. Only a preliminary survey of Wisconsin's mayfly nymphs (Kreuger, 1969) and a study of the Pine-Popple River fauna (Hilsenhoff and Walton, 1972) have been carried out. In these studies, mayflies were identified using existing literature, especially Burks (1953), which has become the standard reference work on midwestern mayflies.

During a study of the biology and ecology of Wisconsin Heptageniidae, we encountered numerous difficulties in identifying specimens using existing keys, and a study of their taxonomy was initiated. Nymphs collected from Wisconsin during the studies mentioned above were reexamined, as were specimens from the Illinois Natural History Survey and the University of Minnesota. In addition, we sampled numerous streams during the open water months of 1972 and 1973, obtaining many additional specimens. A rearing program was undertaken to correlate adults and nymphs. Specimens, along with detailed records of collecting sites, are retained in the University of Wisconsin Collection.

In Wisconsin, 22 species belonging to seven genera have been found, and they are separated by the following keys to adult males and mature nymphs. Female adults can be keyed as far as the couplets using genitalia. Young nymphs, especially those of *Stenonema*, are often difficult to identify since their color patterns change as they grow. *Anepeorus simplex* (Walsh), *Pseudiron centralis* McDunnough, *Heptagenia aphrodite* McDunnough, *H. inconspicua* McDunnough, *H. maculipennis* Walsh, *H. persimplex* McDunnough, *Stenonema ithaca* (Clemens and Leonard), and *S. luteum* (Clemens) have not been collected, but could occur in Wisconsin, especially in large rivers in the southern and western parts of the state.

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KEY TO WISCONSIN HEPTAGENIIDAE—ADULTS

- 1, Vein R₄₊₅ of hind wing unbranched (Fig. 1A) *Arthroplea bipunctata*
 1', Vein R₄₊₅ forked at or near center of wing 2
 2, First segment of fore tarsus as long as or longer than second *Epeorus vitrea*
 2', First segment of fore tarsus shorter than second 3
 3, Crossveins in stigma area of fore wing anastomosed (Fig. 1B) *Rhithrogena* 4
 3', Stigmatic crossveins not anastomosed 7
 4, *Rhithrogena*—wing length < 10 mm; veins light colored, scarcely distinguishable from the membrane. *R. pellucida*
 4', Wing length > 10 mm; veins dark colored, contrasting with the wing membrane . 5
 5, Penes with outcurving tips (Figs. 1C, D) 6
 5', Penes not outcurved at tips (Fig. 1E) *R. impersonata*
 6, Penes distinctly narrowed apically (Fig. 1C) *R. jejuna*
 6', Penes not narrowed apically (Fig. 1D) *R. undulata*
 7, Penes with a cluster of spines on outer margin (Fig. 1G); 2 or 3 crossveins below bulla of forewing connected by a black dash (Fig. 1F) . . *Stenacron interpunctatum*
 7', Penes lacking spines on outer lateral margin 8
 8, Penes distinctly L-shaped (Fig. 1H) *Stenonema* 9
 8', Penes not distinctly L-shaped (Figs. 1, I-M) *Heptagenia* 16
 9, *Stenonema*—posterior margin of abdominal terga 2-8 with three transverse black dashes *S. tripunctatum*
 9', Posterior margin of abdominal terga marked otherwise. 10
 10, Posterior margin of abdominal terga with 2 black dashes *S. terminatum*
 10', Posterior margin of abdominal terga marked otherwise 11
 11, Abdominal terga 2-7 with posterior ¼ to ½ shaded with brown *S. fuscum*
 11', Abdominal terga 1-7 with a narrow black stripe at posterior edge 12
 12, With black dots or dashes on abdominal spiracles 13
 12', Abdominal spiracles unmarked *S. exiguum*
 13, Spiracular marks in the form of oblique black dashes *S. infegrum*
 13', Spiracular marks in the form of dots 14
 14, Posterior black line on abdominal terga 2-8 short, often reduced to a dash on meson; mesonotum pale yellowish-tan *S. mediopunctatum*
 14', Posterior black line on terga 2-8 longer, extending almost to spiracular dots; mesonotum dark brown or reddish-brown. 15
 15, Penis lobes with subterminal spine smaller than apical spine; cross-veins not crowded in bulla region; mesoscutellum entirely white *S. pulchellum*
 15', Penis lobes with subterminal spine about the same size as apical spine; only tip of mesoscutellum white *S. rubrum*
 16, *Heptagenia*—large species, wing length 9 mm or greater 17
 16', Small species, wing length 8 mm or less 19
 17, Dorsum of abdomen pale with narrow dark streaks on the posterior edge of each segment; genitalia as in Fig. 1I *H. diabasia*
 17', Dorsum of abdomen with more extensive dark markings 18
 18, Abdominal terga with wide reddish-brown median dorsal stripe; genitalia as in Fig. 1J *H. flavescens*
 18', Terga with wide reddish-brown stripe on posterior margin; no distinct median stripe; genitalia as in Fig. 1K *H. pulla*
 19, Abdominal terga brown, no pale median spots; genitalia as in Fig. 1L . . *H. lucidipennis*
 19', Abdominal terga brown laterally, pale median spots on tergites 4-8; genitalia as in Fig. 1M *H. hebe*

KEY TO WISCONSIN HEPTAGENIIDAE—NYMPHS

- 1, Two caudal filaments 2
 1', Three caudal filaments 3
 2, Tubercles on head, thorax, and along the meson of abdomen (Fig. 2) . *Spinadis* sp.

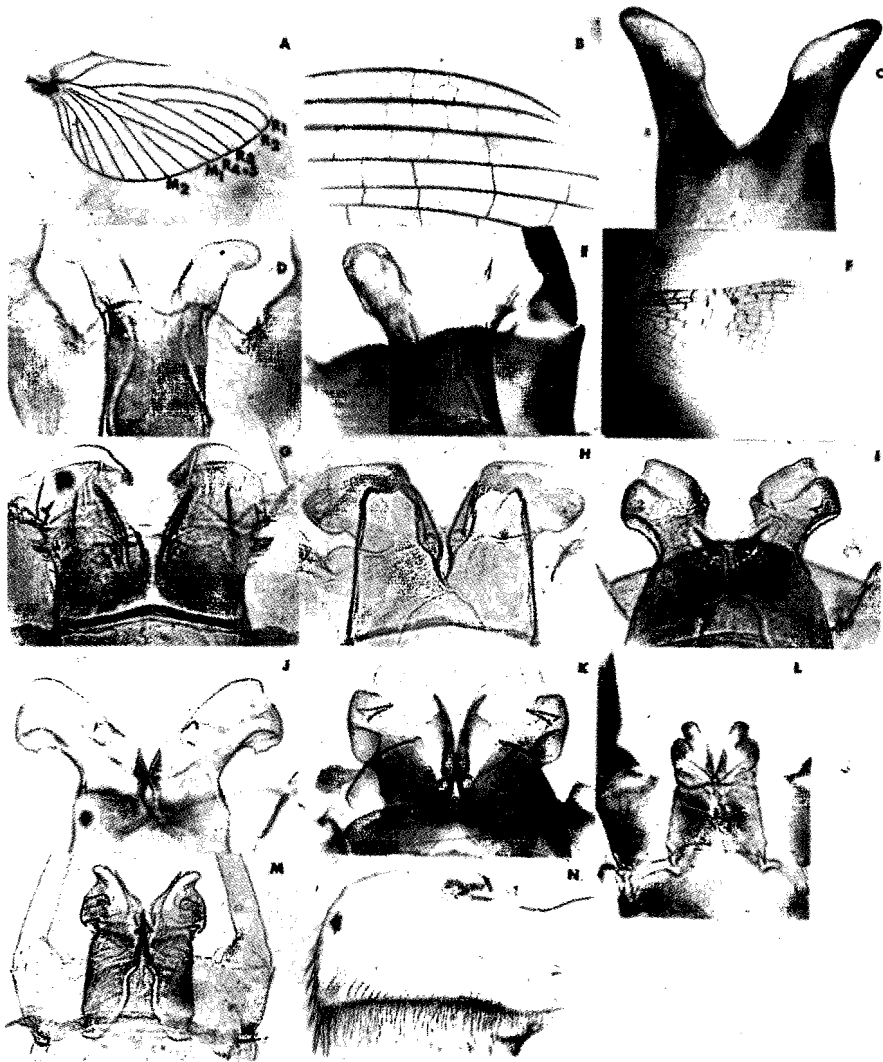


Fig. 1. A—Hindwing of *Arthroplea*; B—Forewing of *Rhithrogena*, showing anastomosed crossveins between costa and subcosta; Penes of *Rhithrogena*; C—*jejunata*; D—*undulata*; E—*impersonata*; F—Forewing of *Stenacron*; Penes of: G—*Stenacron interpunctatum*; H—*Stenonema fuscum*; I—*Heptagenia diabasia*; J—*H. flavescens*; K—*H. pulla*; L—*H. lucidipennis*; M—*H. hebe*; N—Maxilla of *Stenonema bipunctatum*.

- 2'. Lacking tubercles on dorsum *Epeorus vitrea*
- 3. Second segment of maxillary palpi elongated, recurved over dorsum of thorax *Arthroplea bipunctata*

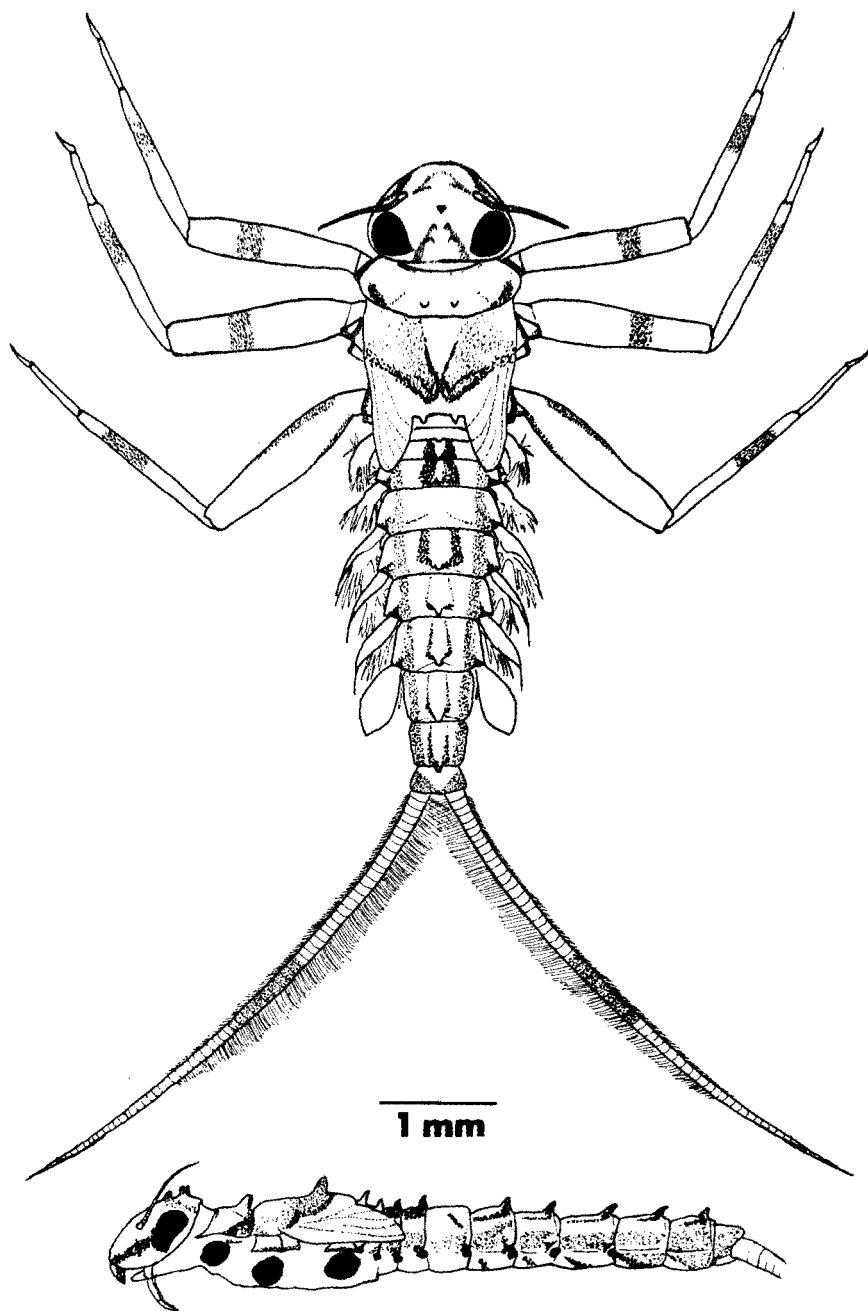


Fig. 2. *Spinadis* sp.: Above—Dorsal view; Below—Lateral view with legs and gills removed.

- 3'. Second segment of maxillary palpi not elongated or recurved over dorsum of thorax 4
- 4. Gills, especially first and seventh pairs, greatly expanded ventrally to form an adhesion disc *Rhithrogena* 5
- 4'. Gills not expanded ventrally, seventh pair may be reduced 8
- 5. *Rhithrogena*—gills 2-6 with fingerlike process on dorsal margin (Figs. 3B, C).... 6
- 5'. Gills with dorsal margin rounded (Fig. 3A) 7
- 6. Dorsal process of gills 2-6 longer than broad (Fig. 3C) *R. undulata*
- 6'. Dorsal process about as long as broad (Fig. 3B) *R. impersonata*
- 7. Profemur with dark band (Fig. 3G) *R. jejuna*
- 7'. Profemur without dark band, dark margins of femur constricting or even dividing pale center area (Fig. 3I) *R. pellucida*

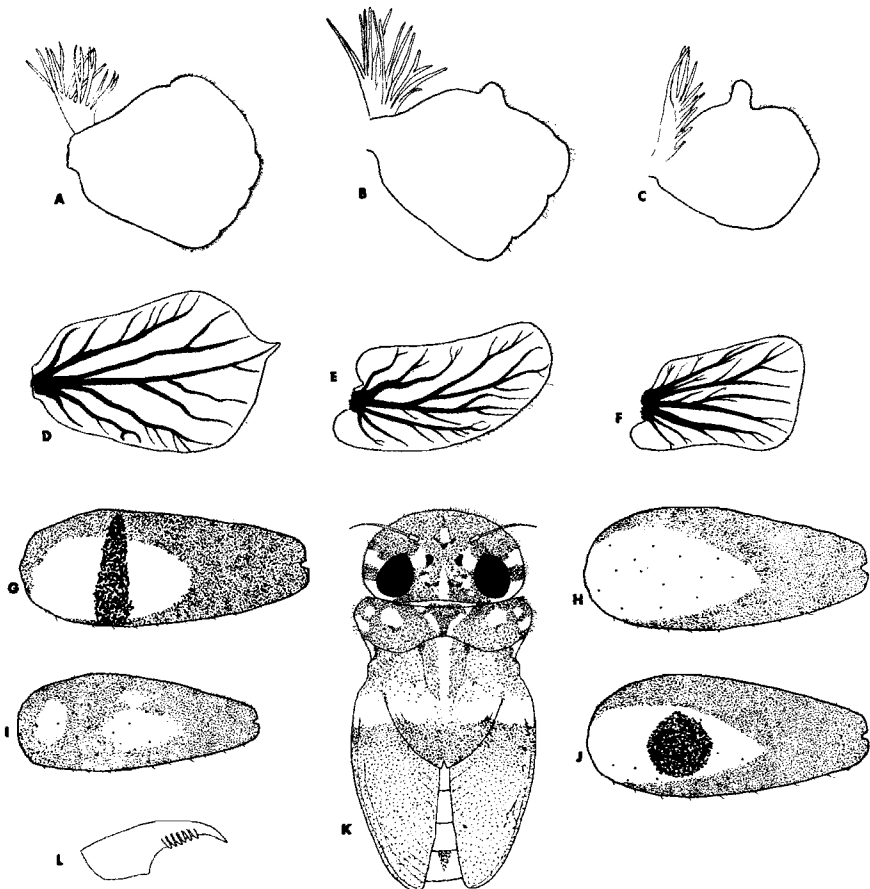


Fig. 3. Lateral view of third abdominal gill of: A—*Rithrogena jejuna*; B—*R. impersonata*; C—*R. undulata*; D—*Stenacron interpunctatum*; E—*Stenonema tripunctatum*; F—*S. fuscum*; left profemora of *Rhithrogena*: G—*jejuna*; H—*impersonata sanguinea*; I—*pellucida*; J—*impersonata*; K—*Stenonema exiguum*, dorsal view of head and thorax of nymph; L—tarsal claw of *Heptagenia hebe*.

- 8. Seventh pair of gills much reduced, lanceolate 13
- 8'. Seventh pair of gills not reduced, plate-like *Heptagenia* 9
- 9. *Heptagenia*—seventh pair of gills biramous, containing plate and tuft elements; claws not pectinate 10
- 9'. Seventh pair of gills uniramous, only plate element present; claws pectinate (Fig. 3L) 12
- 10. Venter of abdomen with dark markings on posterior edge of ninth sternum only *H. flavescens*
- 10'. Dark markings present on lateral margins of ninth sternum and usually present on anterior sterna 11
- 11. Abdominal terga 4 and 8 with a pair of pale submedian streaks *H. diabasia*
- 11. Abdominal terga 4 and 8 with pale median spot *H. pulla*
- 12. Base of caudal filaments unicolorous, white or nearly so *H. lucidipennis*
- 12. Base of caudal filaments distinctly darkened at articulations *H. hebe*
- 13. Gills of abdominal segments 1-6 pointed at apex (Fig. 3D) *Stenacron interpunctatum*
- 13. Gills of abdominal segments 1-6 rounded or truncate at apex *Stemonema* 14

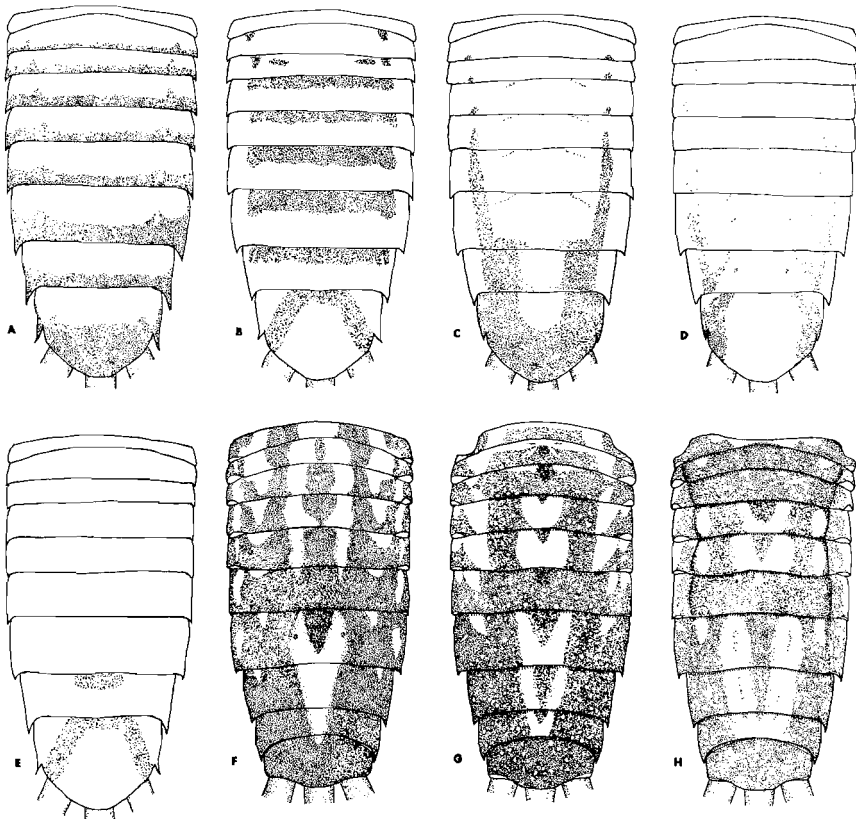


Fig. 4. Abdomens of *Stenonema* nymphs: A—*fuscum* (ventral); B—*mediopunctatum* (ventral); C—*bipunctatum* (ventral); D—*terminatum* (ventral); E—*rubrum* (ventral); F—*integrum* (dorsal); G—*bipunctatum* (dorsal); H—*terminatum*, young nymph, (dorsal).

- 14. *Stenonema*—gills on abdominal segments 1-6 rounded (Fig. 3E) . . . *S. tripunctatum*
- 14. Gills on abdominal segments 1-6 truncate (Fig. 3F) 15
- 15. Abdominal sterna 3-8 with dark transverse bands 16
- 15. Abdominal sterna marked otherwise 17
- 16. Dark bands at posterior edge of abdominal sterna (Fig. 4A) *S. fuscum*
- 16. Dark bands at anterior edge of abdominal sterna (Fig. 4B) *S. mediopunctatum*
- 17. Thoracic nota with pale transverse band at base of dark wing pads (Fig. 3K)
 *S. exiguum*
- 17. Nota without pale transverse band 18
- 18. Abdominal terga 7, 8, 9 with median pale V-shaped mark (Fig. 4F) *S. integrum*
- 18. Abdomen marked otherwise 19
- 19. Abdominal sternum 8 with median brown spot; sternum 9 with a U-shaped mark (Fig. 4E) *S. rubrum*
- 19. Abdomen not marked as above 20
- 20. Sterna of abdomen white, except for posteriolateral angles of sternum 9 and sometimes lateral margins of sterna 7 and 8 *S. pulchellum*
- 20. Sterna with more extensive dark markings 21
- 21. Sternum 9 with posterior half dark brown (Fig. 4C) *S. bipunctatum*
- 21. Sternum 9 with lateral edges dark brown (Fig. 4D) *S. terminatum*

A discussion of each species follows, with notes on identification, biology, and synonymy. The synonymy includes the original name, all species synonyms, and the current name. Generic synonyms appear in Needham *et al.* (1953). Table 1 summarizes the life cycles and ecology, and known distribution is shown in Figures 5 and 6.

Table 1. Summary of life cycles and ecology of the species of Heptageniidae known to occur in Wisconsin.

Species	Seasonal Occurrence		Abundance	Occurrence of Nymphs	
	Nymphs	Adults		Preferred Habitat	Substrate
<i>Arthroplea bipunctata</i>	April-May	mid-late May	Uncommon	Vernal ponds near large streams	Sedges
<i>Epeorus vitrea</i>	Sept.-July	June-early July	Fairly common	Rocky streams of all sizes	Gravel to large rocks
<i>Heptagenia diabasia</i>	Year around	late May-Sept.	Common	Sand-bottomed streams	Debris or rocks
<i>H. flavescens</i>	Year around	June	Rare	Medium to large streams	Rocks and debris in deep water
<i>H. hebe</i>	Year around	June-Sept.	Abundant	All types of streams, moderate current	Rocks
<i>H. lucidipennis</i>	June-July	June-July	Common	Medium streams	Rocks
<i>H. pulla</i>	Year around	June	Uncommon	Streams and large lakes	Gravel to large rocks

Table 1. Continued

Species	Seasonal Occurrence		Abundance	Occurrence of Nymphs	
	Nymphs	Adults		Preferred Habitat	Substrate
<i>Rhithrogena impersonata</i>	Year around	June-July	Uncommon	Small streams	Shallow gravel riffles
<i>R. jejuna</i>	Year around	May-June	Uncommon	Medium streams	Shallow gravel riffles
<i>R. pellucida</i>	June-Aug.	June-Aug.	Uncommon	Small to large streams	Shallow gravel riffles
<i>R. undulata</i>	Year around	June	Uncommon	Small to large streams	Shallow gravel riffles
<i>Spinadis</i> sp.	(?)	June?	Very rare	Very large rivers, deep water	Rocks (?)
<i>Stenacron interpunctatum</i>	Year around	June-Aug.	Abundant	Small to large streams, also lakes	Rocks, debris
<i>Stenonema bipunctatum</i>	Sept.-July	June	Uncommon	Large streams	Rocks
<i>S. exiguum</i>	Year around	June-Aug.	Common	Medium to large streams	Rocks and debris
<i>S. fuscum</i>	Year around	June-July	Abundant	Small to large streams	Rocks
<i>S. integrum</i>	Year around	June	Rare	Large streams	Rocks in deep water
<i>S. medio-punctatum</i>	Year around	June-July	Uncommon	Medium to large streams	Rocks
<i>S. pulchellum</i>	Year around (?)	June	Rare	Medium to large streams	Rocks
<i>S. rubrum</i>	Year around	June-July	Fairly common	All types	Rocks
<i>S. terminatum</i>	Year around	May-June	Common	Medium to large streams	Debris or rocks
<i>S. tripunctatum</i>	July-May	May-Aug.	Fairly common	Lakes	Rocks

Arthroplea bipunctata (McDunnough)

Synonymy.—*Cinygma bipunctata* McDunnough (1924c:76); *Arthroplea bipunctata* Ide (1930:42).

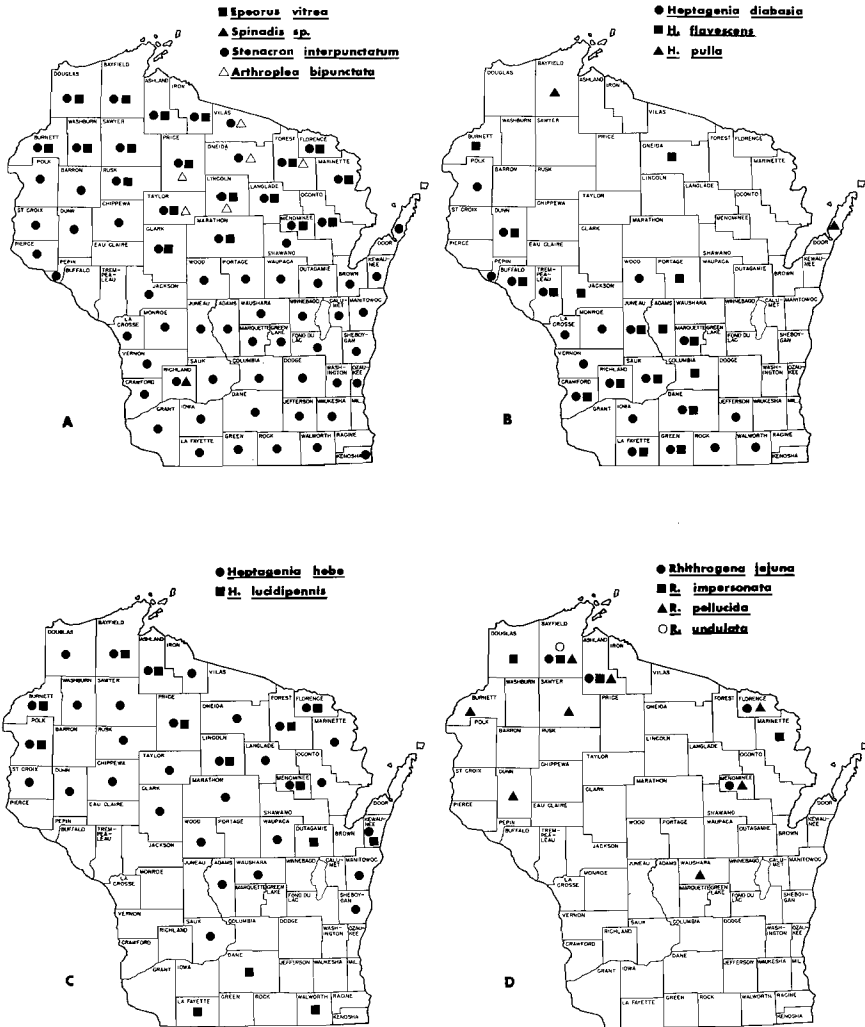


Fig. 5. Distribution of *Arthroplea*, *Epeorus*, *Heptagenia*, *Rhithrogena*, *Spinadis*, and *Stenacron* in Wisconsin. Marks represent county records.

Adult description.—McDunnough (1924).

Nymphal description.—Burks (1953, Fig. 395).

Arthroplea bipunctata is unique among Wisconsin Heptageniidae in its preference for living in temporary ponds. Froelich (1964) studied feeding behavior of European species and described how nymphs use their long palpi to sweep food from surrounding water. The body is much less flattened than that of other Heptageniidae nymphs.

Epeorus vitrea (Walker)

Synonymy.—*Palingenia vitrea* Walker (1853:555); *Epeorus humeralis* Morgan (1911:105); *Iron vitrea* Speith (1940:330); *Epeorus vitrea* Burks (1953:195).

Adult and nymphal descriptions.—Leonard and Leonard (1962).

Absence of a median caudal filament readily separates nymphs from other Heptageniids, except *Spinadis*. They can be distinguished from *Spinadis* by large platelike gills and a lack of dorsal tubercles. The gills are held against the substrate to form an incomplete adhesive disc, but are not as enlarged as those of *Rhithrogena* nymphs. The long first protarsal segment distinguishes adults.

Genus HEPTAGENIA Walsh

Five species have been found in Wisconsin. Nymphs and adult males are easily identified by characters given in the key, but female adults are difficult to separate from *Stenonema*. Association with adult males, and in some cases structures of the chorion of the eggs (Koss, 1968), are the only reliable means for identifying females.

Heptagenia is widespread in Wisconsin, but does not seem quite as tolerant of slow, organically enriched water as *Stenonema* or *Stenacron*.

Heptagenia diabasia Burks

Synonymy.—*Heptagenia diabasia* Burks (1946:610).

Adult and nymphal descriptions.—Burks (1935).

Closely related to *elegantula* of western United States, nymphs (Fig. 383 in Burks, 1953) can be recognized by their dorsal color pattern and dark submarginal stripes on the abdominal venter.

Heptagenia flavescens (Walsh)

Synonymy.—*Palingenia flavescens* Walsh (1862:373); *Heptagenia flavescens* Walsh (1863:197).

Adult and nymphal descriptions.—Burks (1953).

Nymphs somewhat resemble *diabasia*, but pale markings on the abdominal terga are more extensive (Fig. 384 in Burks, 1953) and submarginal black bars on the abdominal venter are missing. Adults are recognized by the dorsal abdominal stripe.

Heptagenia hebe McDunnough

Synonymy.—*Heptagenia hebe* McDunnough (1924b:122).

Adult and nymphal descriptions.—Burks (1953).

One of two small species of *Heptagenia* in Wisconsin, it is abundant throughout its range. At first glance, nymphs might be mistaken for small *Stenonema*, but the proportionally large head and the gill structure are distinctive.

Heptagenia lucidipennis (Clemens)

Synonymy.—*Ecdyurus lucidipennis* Clemens (1913:329); *Heptagenia lucidipennis* McDunnough (1924a:118).

Adult and nymphal descriptions.—Burks (1953).

Like *hebe*, this is a small mayfly. Nymphs have been confused with *hebe*, but characters in the key provide for reliable separation. Adult *lucidipennis* can be recognized by their brown bodies.

A "summer" mayfly, small nymphs first appear in late spring, followed by rapid development until emergence in late June. Most other Wisconsin Heptageniidae are

"winter" species; nymphs appear in autumn, develop slowly through the winter, and emerge the following spring.

Heptagenia pulla (Clemens)

Synonymy.—*Ecdyurus grandis* Clemens (1913:147) (Nomen nudum); *Ecdyurus pullus* Clemens (1913:330); *Heptagenia pulla* McDunnough (1924b:120).

Adult and nymphal descriptions.—Burks (1953).

Nymphs closely resemble *diabasia*, but their ranges do not overlap in Wisconsin. They have been found only in Lake Superior at 50 m (Selgeby, 1973), northern Lake Michigan, and tributary streams thereof. On the Door County shore of Green Bay they are found on rocks near shore, where they grow to an unusually large size.

Genus RHITHROGENA Eaton

Nymphs have gills expanded to form an adhesive disc (Fig. 390 in Burks, 1953). We have found large numbers only in clean, swift water with a substrate of small rounded stones less than three inches in diameter. On these smooth stones the disc can be used to best advantage. Nymphs are active, and when disturbed, move quickly to cover. Adult *Rhithrogena*, except for *pellucida*, can be separated only by male genitalia. Like *Epeorus*, this genus is predominantly western.

Rhithrogena impersonata (McDunnough)

Synonymy.—*Heptagenia impersonata* McDunnough (1925:191); *Rhithrogena impersonata* McDunnough (1926:195); *Rhithrogena sanguinea* Ide (1954:349).

Adult description.—Needham *et al.* (1935).

Nymphal description.—Ide (1954).

Nymphs can be recognized by a low rounded process dorsally on the gills (Fig. 3B), and by a dark, round or horizontally elongate dark spot on the femora (Fig. 3J).

The form *sanguinea* was originally described as a separate species. Typical nymphs differ from *impersonata* in having bright red gills, light reddish-brown body color, and in lacking the dark spot on the femora (Fig. 3H). However, we have found many nymphs that combine *impersonata* and *sanguinea* characters; a dark body color and rust colored gills. All *sanguinea* forms have pale, rusty gills when young; the bright red color appears as nymphs near maturity. The length of spines on the outer edge of the male genitalia has been used to separate adults of the two forms. Although we have been able to rear only eight males of the two forms, we have found this character variable. *Sanguinea* lives in the same riffles and emerges at the same time as *impersonata*. In view of these conditions, we do not feel that *sanguinea* merits species status.

Rhithrogena jejuna Eaton

Synonymy.—*Baetis fusca* Walker (1953:568); *Rhithrogena jejuna* Eaton (1885:252).

Adult description.—Needham *et al.* (1935).

Nymphal description.—length of body, 10 mm, tails, 6.5 mm. Head dark greenish-brown, pale line from outer corner of eye to lateral margin. Antennae greenish-brown at base, growing pale toward apex. Maxillae with eight pectinate spines on crown and 31-32 lateral setae. Pronotum greenish-brown with a pale spot at each anterior corner. Mesonotum and wingpads greenish-brown; pale line on midline of notum. Femora with greenish-brown margins and pale center; a dark brown vertical bar or triangular spot in center of the pale area (Fig. 3G). Tibia dark greenish-brown, pale at tip. Tarsus greenish-brown, pale at apical and basal ends. Claws with a single basal tooth. Dorsum of abdomen dark greenish-brown, ninth and tenth terga occasionally paler; venter

greenish-yellow often darker along midline. Gills translucent white, first and seventh pairs expanded and meeting under the body, dorsal margins lacking projections. Tails greenish-brown.

The lack of a process on the dorsal gill margin (Fig. 3A) and vertical femoral spots distinguish nymphs from those of other *Rhithrogena*.

Rhithrogena pellucida Daggy

Synonymy.—*Rhithrogena pellucida* Daggy (1945:383).

Adult and nymphal descriptions.—Daggy (1945).

The light spot on the tip of the nymph's abdomen, given by Daggy as a distinguishing characteristic, is useful for living specimens, but in alcohol the contrast diminishes, and specimens of *jejuna* show a similar light area. Thus, femoral patterns are more useful in identifying preserved material. Adults of both sexes of *pellucida* can be identified by the colorless wing veins.

Rhithrogena undulata (Banks)

Synonymy.—*Epeorus undulatus* Banks (1924:425); *Rhithrogena undulata* McDonnough (1926:195).

Adult description.—Needham *et al.* (1935).

Nymphal description.—Edmunds (1952).

Nymphs resemble *impersonata*, but can be recognized by narrow, dorsal thumb-like projections on the gills. *R. undulata* appears to be confined to sandstone streams of northern Bayfield County, which often carry heavy loads of red clay silt and differ geologically from southern parts of the county where other *Rhithrogena* are found.

Genus **SPINADIS** Edmunds and Jensen

Spinadis sp.

Only four nymphs of this unusual animal (Fig. 2) have been collected, all from the Wisconsin River in June 1973 after the water had been unusually high all winter. Gut contents of one specimen contained chironomid head capsules, indicating that this mayfly is predaceous. Edmunds (pers. comm.) has examined two specimens and has concluded that they belong to the newly erected genus *Spinadis* Edmunds and Jensen (1974), and are closely related to *S. wallacei* from the Altamaha River of Georgia and the White River of Indiana. We suspect that the Wisconsin *Spinadis* is a different species, but lack of adult material precludes any definite conclusions.

Genus **STENACRON** Jensen

This genus was recently erected (Jensen, 1974) for *Stenonema* species formerly known as the *interpunctatum* group. A single very common and highly variable species, *Stenacron interpunctatum*, occurs in Wisconsin. Many forms have been described as separate species, notably *heterotarsale*, *canadense* and *frontale*, but Spieth (1947) found numerous intermediate forms and concluded that they are at best subspecies. We have not attempted to differentiate subspecies since their taxonomy is still unsettled.

Stenacron interpunctatum (Say)

Synonymy.—*Baetis interpunctata* Say (1839:41); *Stenonema interpunctatum* Traver (1933:175); *Baetis canadensis* Walker (1853:569); *Ecdyonurus heterotarsale* (McDunnough (1933:42); *Stenonema affine* Traver (1933a:184); *Stenonema conjunctum* Traver (1935:309); *Stenonema ohioense* Traver (1935:322); *Stenonema proximum* Traver (1935:325); *Heptagenia frontalis* Banks (1910:199); *Stenonema majus* Traver (1935:320); *Stenonema areion* Burks (1953:163); *Stenacron interpunctatum* Jensen (1974:225).

Adult and nymphal descriptions.—Spieth (1947).

Nymphs can be recognized at any size by their pointed gills. A black dash below the bulla of the fore wing separates adults from *Heptagenia* and *Stenonema*.

Genus *STENONEMA* Traver

This is the largest genus of Heptageniidae in the eastern United States, reaching its greatest diversity in the Appalachian Mountains (Berner, 1950). To date, we have found nine species in Wisconsin.

Burks (1953) regards species of *Stenonema* as the most difficult Ephemeroptera to identify, because male genitalia, in contrast to other heptageniids, are very similar in most species. The penes are membranous L-shaped organs that carry only a few small spines and can easily be distorted when mounted. Color patterns of adults, although somewhat variable, are used to separate most species.

Wisconsin *Stenonema* can be reliably identified from adult males and mature nymphs, since many of the confusing forms do not occur in Wisconsin. The taxonomic treatment used in this paper is based in part on Lewis (1974b).

Stenonema bipunctatum (McDunnough)

Synonymy.—*Ecdyonurus bipunctatus* McDunnough (1926:191); *Stenonema bipunctatum* Traver (1935:306).

Adult description.—Burks (1953).

Nymphal description.—Lewis (1974b).

Insufficient adult males have been obtained for inclusion in the adult key. Adult females have paired black dashes on the abdomen. Nymphs resemble *terminatum*, but can be distinguished by the dark posterior half of the ninth sternum (Fig. 4C). The crown of the maxilla has setae that vary greatly in number, some individuals having only a single seta on one maxilla (Fig. 1N). Young nymphs have more extensive pale markings than mature nymphs and they also have a row of dark spots down the mid-line of the abdominal terga (Fig. 4G). As nymphs mature, these spots become less prominent due to darkening of surrounding areas.

Stenonema exiguum Traver

Synonymy.—*Stenonema exiguum* Traver (1933a:201); *Stenonema alabamiae* Traver (1937:79).

Adult description.—Traver (1933a).

Nymphal description.—Daggy (1945).

Mature nymphs are easily recognized by markings on the thoracic nota (Fig. 3K), but small nymphs lack this feature. Very small nymphs are dark brown above and pale beneath. As they grow, pale markings on the seventh abdominal tergum appear, followed by the other markings in successive moults. The distinctive thoracic pattern is not visible until the wingpads have achieved about half their length. The abdominal venter remains unmarked except for the lateral margins of the ninth sternum (see *Stenonema rubrum*).

Lewis (1974a) described *Stenonema quinquespinum* from Ohio and designated as paratypes an adult male and nymph from the Clam River in Burnett County, Wisconsin. We are unable to distinguish the nymph from those of *exiguum*. The discal spine on the genitalia of the adult is smaller than figured for the holotype, and a nymphal exuviae associated with this adult is probably that of *bipunctatum*. A series of reared specimens is needed to determine the status of *quinquespinum* and its relationship to *exiguum* and *bipunctatum* in Wisconsin.

Stenonema fuscum (Clemens)

Synonymy.—*Heptagenia fusca* Clemens (1913:254); *Ecdyonurus rivulicolus* McDunnough (1933:40); *Stenonema fuscum* Traver (1933a:174).

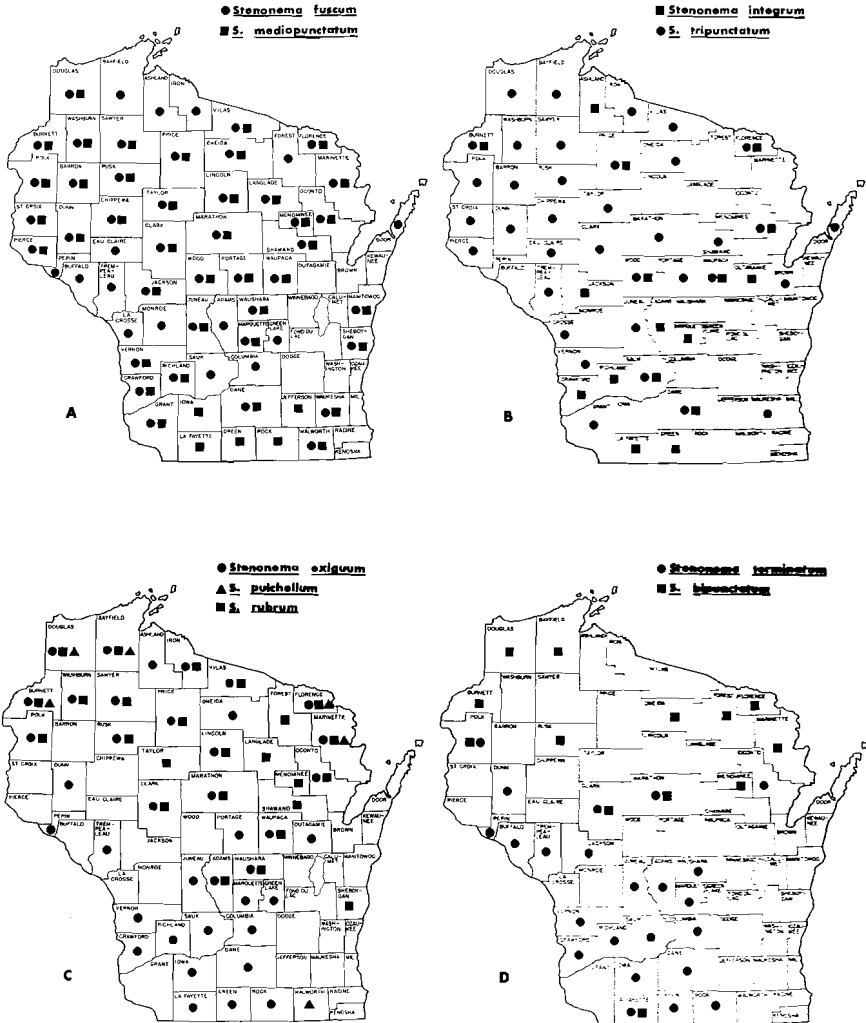


Fig. 6. Distribution of *Stenonema* in Wisconsin. Marks represent county records.

Adult and nymphal descriptions.—Burks (1953).

Dark bands on the abdominal venter are present even on very small nymphs, making this one of the more readily identifiable *Stenonema*. Markings on the ninth sternum range from a complete band (Fig. 4A) to two lateral dots. Although nymphs marked as in Fig. 4A will key to *Stenonema vicarium* in Burks (1953), Lewis (pers. comm.) has found that on the basis of adult characters, *vicarium* does not occur west of the Appalachian Mountains. Banded Wisconsin nymphs are the subspecies *rivulicolum*, thought by Burks to be a form of *vicarium*, but now considered by Lewis to be a subspecies of *fuscum*.

Stenonema integrum (McDunnough)

Synonymy.—*Heptagenia integer* McDunnough (1924:9); *Stenonema bellum* Traver (1933a:202); *Stenonema integrum* Traver (1933a:175); *Stenonema wabasha* Daggy (1945:378); *Stenonema metriotes* Burks (1953:174).

Adult description.—Burks (1953).

Nymphal descriptions.—Daggy (1945), Lewis (1971).

Nymphs are easily recognized by the pale spearhead mark on the abdominal venter, which is present (although sometimes reduced) in all specimens we have seen. They are identical to nymphs Daggy (1945) described as *wabasha*, which was synonymized with *integrum* by Burks (1953), and are much darker than nymphs of *integrum* described by Lewis (1971).

Stenonema mediopunctatum (McDunnough)

Synonymy.—*Ecdyonurus mediopunctatus* McDunnough (1926:191); *Stenonema mediopunctatum* Traver (1935:321).

Adult and nymphal descriptions.—Lewis (1974b).

The striped abdominal venter and U-shaped mark on the ninth sternum separate nymphs from other *Stenonema*. These markings are present, although often very faint, in the youngest nymphs we have collected.

Stenonema pulchellum (Walsh)

Synonymy.—*Palingenia pulchella* Walsh (1862:375); *Stenonema pulchellum* Traver (1933a:175).

Adult and nymphal descriptions.—Burks (1953).

Found only in northwestern and southeastern Wisconsin, these mayflies appear to be rare. We have collected only mature nymphs and they resemble *rubrum*, to which *pulchellum* is closely related, differing only in markings on the abdominal venter. Adult characters in the key are from Burks (1953) and Lewis (1974b).

Stenonema rubrum (McDunnough)

Synonymy.—*Heptagenia flavescens-nec* Walsh Clemens (1913:252); *Ecdyonurus ruber* McDunnough (1926:192); *Stenonema rubrum* Traver (1933a:190); *Stenonema varium* Traver (1933a:192).

Adult and nymphal descriptions.—Burks (1953).

Larger nymphs are easily recognized by the U-shaped mark on the ninth sternum and the single median dot on the eighth sternum. Very small nymphs lack these marks and are very difficult to distinguish from young *exiguum*. In general, *rubrum* nymphs are lighter, and markings on the femora tend to form alternating light and dark bands, rather than random patterns as in *exiguum*. These characters are not foolproof and only rearing or continual sampling will positively identify many populations. Fortunately, *rubrum* nymphs acquire their distinguishing marks while still relatively small.

Stenonema terminatum (Walsh)

Synonymy.—*Palingenia terminata* Walsh (1862:375); *Stenonema terminatum* Traver (1933a:175).

Adult description.—Burks (1953).

Nymphal description.—Lewis (1971).

Nymphs have only recently been described. Young nymphs, unlike most other *Stenonema* species, have more extensive pale markings than mature specimens (Fig. 4F, compare with Lewis, 1971, Plate III). Young specimens have pectinate claws; however, the pectines become reduced as the nymphs mature, and are completely lacking in the last nymphal instar. Reared adults have two black dashes on the abdominal terga. Young nymphs and adults of Wisconsin *terminatum* will key to *bipunctatum* in Burks (1953).

Stenonema tripunctatum (Banks)

Synonymy.—*Heptagenia tripunctata* Banks (1910:199); *Stenonema femoratum tripunctatum* (Banks) Spieth 1947:99; *Stenonema tripunctatum* Burks (1953:168).

Adult and nymphal descriptions.—Burks (1953).

Spieth (1947) considered this a subspecies of *Stenonema femoratum*, but Lewis (1974b) believes that both *femoratum* and *tripunctatum* are good species.

Nymphs can be recognized by their rounded gills and a pair of round brown dots on abdominal sterna 2-8.

The only Wisconsin *Stenonema* that occurs regularly in lakes, we encountered it most often in lentic waters; in streams it occurs in areas of slower current. On the Door County shore of Green Bay, it lives on rocks near shore where it grows to unusually large size. In Lake Superior it has been found at 32 m (Selgeby, 1974). This species is bivoltine in the Little Suamico River, adults emerging in May and again in late August. Clemens (1913) found *tripunctatum* to be single-brooded in Georgian Bay; however, Pleskot (1951) showed that variations in climate can have drastic effects on life cycles of Heptageniidae.

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