

DISTRIBUTIONAL AND CLASSIFICATORY SUPPLEMENT TO THE BURROWING MAYFLIES (EPHEMEROPTERA: EPHEMEROIDEA) OF THE UNITED STATES¹

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ABSTRACT: The extant Ephemeroidea species of the United States are updated with respect to higher classification, species taxonomy, and state records. Distribution maps are provided for all 23 currently recognized species. Forty three new state records for 14 species were published since 1975. An additional 19, mostly expected, new state records are given here for 11 of the species. Species ranges are now apparent from the distributional data. *Ephemera compar* Hagen and *Pentagenia robusta* McDunnough are assumed to be extinct, and the genus *Dolania* is excluded from the Ephemeroidea.

The last review of the Ephemeroidea in North America was given by McCafferty (1975). Since then, the group has been further restricted and its higher classification modified, the family Potamanthidae has been completely revised, certain species have been synonymized, others have been shown to be extinct, and several new geographic records of species have been reported. The purpose of this paper is to update the status of Ephemeroidea since the 1975 work with respect to both classification and distribution in the United States, and to provide additional new state records that allow a more complete representation of specific ranges.

Thirty species were listed for North America north of Mexico by McCafferty (1975). No indication of family classification was given primarily because family limits were undergoing evaluation. Edmunds *et al.* (1976), however, did provide a traditional familial classification of these species. A revised phylogenetic classification of the genera of Ephemeroidea of the world was presented by McCafferty (1991), wherein the former family Euthyplociidae was incorporated into the Polymitarciidae and the former family Palingeniidae was incorporated into the family Ephemeridae. Furthermore, the family Behningiidae (represented in North America only by the genus *Dolania*) was removed from the Ephemeroidea and placed in a separate superfamily. As a result, *Dolania* is not treated in this supplement. The revised higher classification of Ephemeroidea with respect to the North American fauna is given in Table 1. The family and subfamily classification is based on phylogenetic relationships (see McCafferty 1979, 1991)

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Pentagenia robusta McDunnough and *Ephemera compar* Hagen were treated by McCafferty (1975) and traditionally have been listed with extant species of mayflies (e.g., Edmunds *et al.* 1976). It has become apparent in recent years, however, that these species are in all likelihood extinct. Their status has been discussed by Edmunds and McCafferty (1984) and McCafferty *et al.* (1990). Extensive work on benthos of large rivers in the Midwest by numerous workers in recent years has not yielded *P. robusta*, which is still known only from original material described from the Ohio River by McDunnough (1926). Also, extensive on going work in Colorado (e.g., see McCafferty *et al.* 1993) has not yielded *E. compar*, which is still known only from original material described from Colorado by Hagen (1875). These species therefore are excluded from the present work, which is restricted to extant species.

Opportunities for corroborating and adding to state records of burrowing mayflies have been ample over the past 20 years, a period which has seen a strong emphasis on benthic macroinvertebrate research in the United States. Thus, it is assumed that, based on the data summarized herein, relatively complete pictures of species ranges are now represented. A few states within ranges of certain species still do not indicate a presence of the respective species, but this is generally because these states have yet to be adequately documented with published mayfly records. Below, any recent revisionary or distributional data related to species from Table 1 and supplemental to McCafferty (1975) is discussed. In addition, conterminous United States distribution maps are presented for each of the species, and include all state records. **Circles within states indicate valid records known at the time of the McCafferty (1975) treatment; squares indicate records published between then and the present, and triangles indicate new state records reported herein.** Most specimens on which new records are based are at the Purdue Entomological Research Collection; some are at the National Museum of Natural History. North Carolina specimens are held by the North Carolina Division of Environmental Management (Raleigh) and some Missouri specimens are at the University of Missouri.

No records of Ephemeroidea exist for Alaska (see McCafferty 1985) or Hawaii, although Bae and McCafferty (1991) reported an adult specimen of *Potamanthus formosus* Eaton from Hickam Field that was collected in 1954. It most likely was an adventive transported by military aircraft from Japan or Korea. There is no evidence that the species has become established in Hawaii.

SPECIES DATA

Tortopus incertus (Traver) (Fig. 1)

Lenat and Penrose (1987) showed this species to occur in North Carolina, thereby extending its known southeastern distribution pattern slightly northward.

Tortopus primus (McDunnough) (Fig. 1)

Tortopus is a primarily Neotropical genus, closely related to the also primarily Neotropical genus *Campsurus* (see McCafferty *et al.* 1992). Lugo-Ortiz and McCafferty (1994) found *T. primus* in Texas, and confirmed the presence of *Campsurus decoloratus* and *T. circumfluis* also from that state. McCafferty (1975) indicated questionable records of this species from Missouri and Arkansas. The Texas record would tend to support those records and suggests a general range in the central United States.

Ephoron album (Say) (Fig. 1)

This western and midwestern species overlaps with the distribution of its eastern sister species *E. leukon* in the upper midwestern United States, Missouri (see below), and Manitoba. Lake Erie populations reported on by Britt (1962) probably represent the easternmost range of the species. There is considerable evidence (McCafferty unpublished) that the two species have hybridized in at least one river in Indiana. Ward and Stanford (1990) reported the species from Colorado for the first time. A new state record is as follows: MISSOURI. Crawford Co., Meramac R. nr St. Hwy 8, VII-26-1992, B. Nichols.

Ephoron leukon Williamson (Fig. 1)

Lager *et al.* (1982) reported this eastern and midwestern species from Minnesota, Kondratieff and Harris (1986) reported it from Alabama, and Lugo-Ortiz and McCafferty (1994) reported it from Texas. The listing of this species in Virginia by Kondratieff and Voshell (1983) was not accompanied by substantiating data, but nevertheless it undoubtedly exists there. New state records are as follows: CONNECTICUT, Litchfield Co., Kent, VIII-22-1917 (adults). IOWA, Winneshiek Co., Iowa R. VII-5-1977, K. L. Johnson (larvae). MISSOURI, Newton Co., Shoal Cr. near Neosho, 1974, D. S. Sarai (larvae). PENNSYLVANIA, Center Co., Bald Eagle Cr., VIII-9-1977, G. A. Hoover (larvae and adults); Forrest Co., Allegheny R. at Tionesta, VIII-26-1976; G. A. Hoover (adults). Faulkner and Tarter (1977) reported this species, as a new state record, from West Virginia. It had, however, been known from that state previously.

Anthopotamus distinctus (Traver) (Fig. 2)

All North American species of the Potamanthidae belong to the genus *Anthopotamus* (McCafferty and Bae 1990); they were previously considered in the Old World genus *Potamanthus*. Kondratieff and Harris (1986) reported *A. distinctus* from Alabama; Bae and McCafferty (1991) reported it from Massachusetts, Vermont, and Virginia; and Burian and Gibbs (1991) reported it from Maine. The range map given by Bae and McCafferty (1991) should be extended somewhat southward.

Anthopotamus myops (Walsh) (Fig. 2)

Bae and McCafferty (1991) synonymized *Anthopotamus inequalis* (Needham) and *Anthopotamus rufous* (Argo) with *A. myops*, and thus Maryland and Missouri were automatically added to the distribution of *A. myops*. In addition, Bae and McCafferty (1991) gave records for Alabama, Georgia, Minnesota, Virginia, and West Virginia.

Anthopotamus neglectus (Traver) (Fig. 2)

This species was divided into two geographic subspecies by Bae and McCafferty (1991): *A. n. neglectus*, known only from the Northeast, and *A. n. disjunctus* Bae and McCafferty, from the southeastern and south central United States. Faulkner and Tarter (1977) added West Virginia to the known distribution, McCafferty and Provonsha (1978) reported the species from Arkansas, and this was later confirmed by Bae and McCafferty (1991). A previous report of this species in Arkansas by Koss (1970) remains tentative (see McCafferty 1975), although it may well be correct. Kondratieff and Harris (1986) reported *A. neglectus* from Alabama, and Bae and McCafferty (1991) reported it from Georgia and Oklahoma. Kondratieff and Voshell (1983) listed *A. neglectus* from Virginia. However, it is not known to which subspecies any Virginia or West Virginia populations would be assignable.

Anthopotamus verticis (Say) (Fig. 2)

Bae and McCafferty (1991) synonymized *Anthopotamus diaphanus* (Needham) and *Anthopotamus walkeri* (Ide) with *A. verticis*, and reported new state records for Iowa, Maryland, Minnesota, Pennsylvania, Virginia, and Wisconsin. McCafferty and Bae (1992) established types for this species, designating a lectotype for the junior synonym *Ephemera flaveola* Walsh, and a neotype from Indiana for the senior name, *Baetis verticis* Say. David Lenat (Pers. comm.), using the species keys of Bae and McCafferty (1991), confirmed that this species, along with *A. distinctus*, occurs in North Carolina (both species in the mountains, but only *A. verticis* in the Piedmont). The new state record is

based on numerous collections as follows: NORTH CAROLINA, Ashe, Burke, Caldwell, Henderson, Mitchell, Rutherford, Transylvania, Watauga, Wilkes, and Yancey Counties (where both *A. verticis* and *A. distinctus* occur) and Chatham, Durham, Harnett, Orange, Person, and Randolph Counties (where only *A. verticis* occurs).

Ephemera blanda Traver (Fig. 3)

Kondratieff and Voshell (1983) listed *E. blanda* for Virginia but gave no locale data. The record appears reasonable given this species' southeastern distribution pattern. A new state record is as follows: KENTUCKY, Jackson Co., War Fork of Station Camp Cr. at Turkey Foot Camp, V-4-1982, W. P. McCafferty and A. V. Provonsha (adults); and Pulaski Co., Fishing Cr. .5 mi S of St. Rd. 635 & 70 junction, V-4-1982, W. P. McCafferty and A. V. Provonsha (adults).

Ephemera guttulata Pictet (Fig. 3)

Cather and Harp (1975) reported this species from the Ozarks of Arkansas. This would appear to be the westernmost distribution of this species, which shows an old eastern mountainous distribution pattern, primarily in the Appalachians, but with isolates in the Ozark Plateau. Faulkner and Tarter (1977) predictably found this species in West Virginia, and Kondratieff and Voshell (1983) listed it for Virginia. The Alabama record by Kondratieff and Harris (1986) probably represents the southernmost distribution of *E. guttulata*. I have found it to be the most common burrowing mayfly in small and mid-sized streams in central and eastern Kentucky.

Ephemera simulans Walker (Fig. 3)

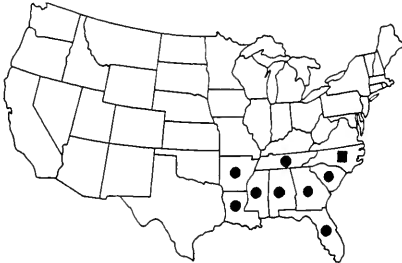
Faulkner and Tarter (1977) found this relatively widespread species in West Virginia, Liechti (1981) added it to the Kansas list of mayflies, and Unzicker and Carlson (1982) showed it to occur in North Carolina. Berner and Pescador (1988) indicated that the dubious record of this species in Florida could not be substantiated despite considerable collecting effort in the area where it had supposedly been collected. I have excluded Florida from the range map of this species. New state records are as follows: MISSOURI, Christian Co., James R. & adjacent spring, V-24-1972, W. B. Morton (adults); Greene Co., James R. 4 mi E Springfield, V-30-1972, B. A. Sassmann (adults); Taney Co., Swan Cr. Hwy. AA, V-23-1972, R. W. Baumann (adults). NORTH DAKOTA, Grand Forks Co., Turtle R. at Turtle R. St. Prk. 1.7 mi N Arvilla, V-12-1978 (larvae). OKLAHOMA, Ottawa Co., Five Mile Cr., 5.1 mi N & 1.25 mi E Peoria. VI-12-1984, P. Liechti (adults).



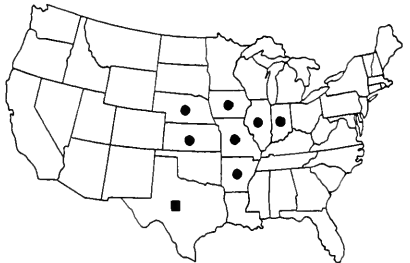
Campsurus decoloratus



Tortopus circumfluus



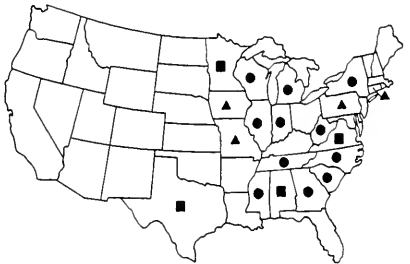
Tortopus incertus



Tortopus primus

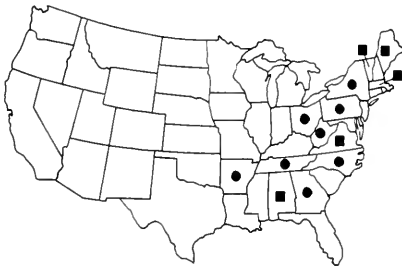


Ephoron album

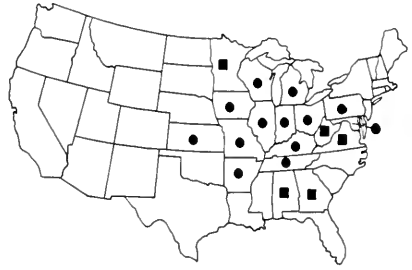


Ephoron leukon

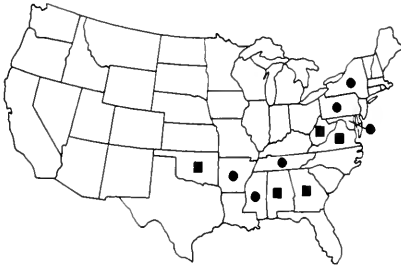
Fig. 1. United States distribution of extant species of *Campsurus*, *Tortopus*, and *Ephoron*.



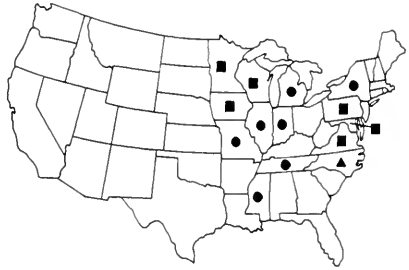
Anthopotamus distinctus



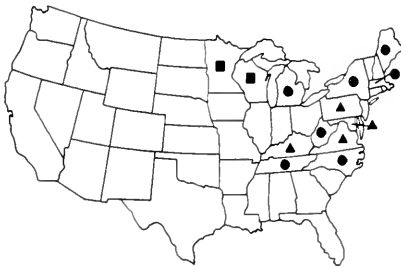
Anthopotamus myops



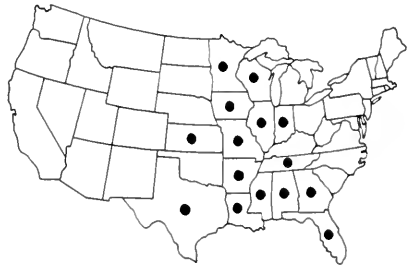
Anthopotamus neglectus



Anthopotamus verticis



Liobrancha recurvata



Pentagenia vittigera

Fig. 2. United States distribution of extant species of *Anthopotamus*, *Liobrancha* and *Pentagenia*.

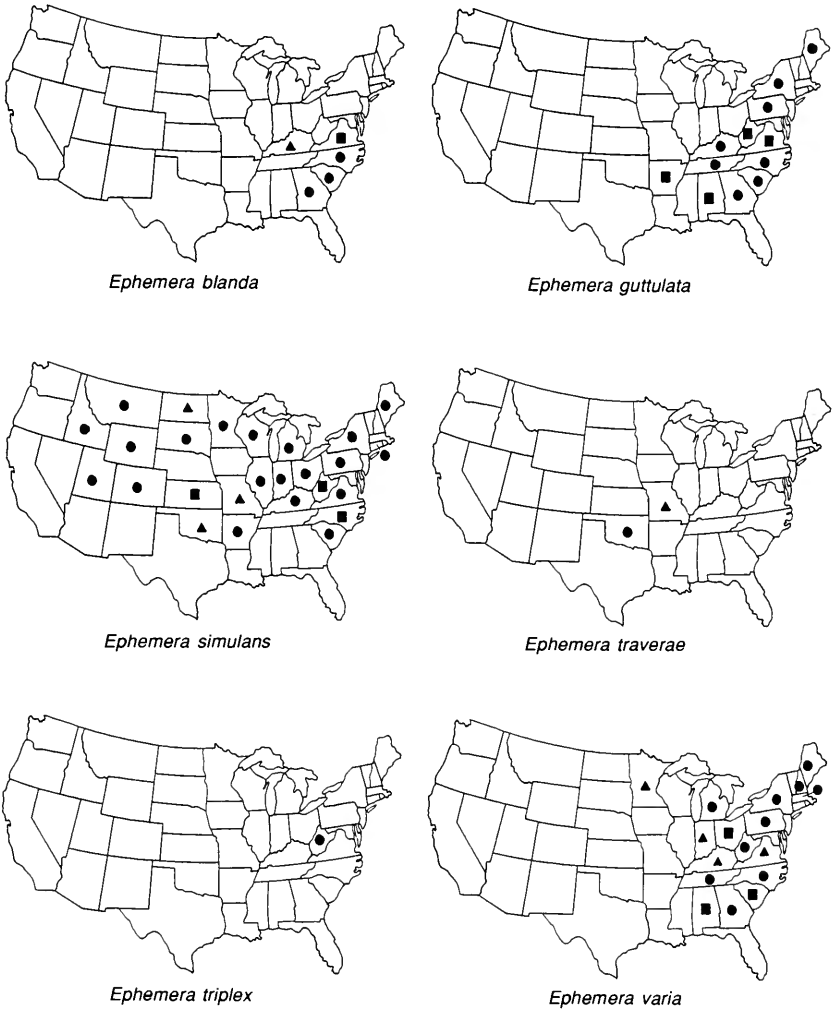


Fig. 3. United States distribution of extant species of *Ephemera*.

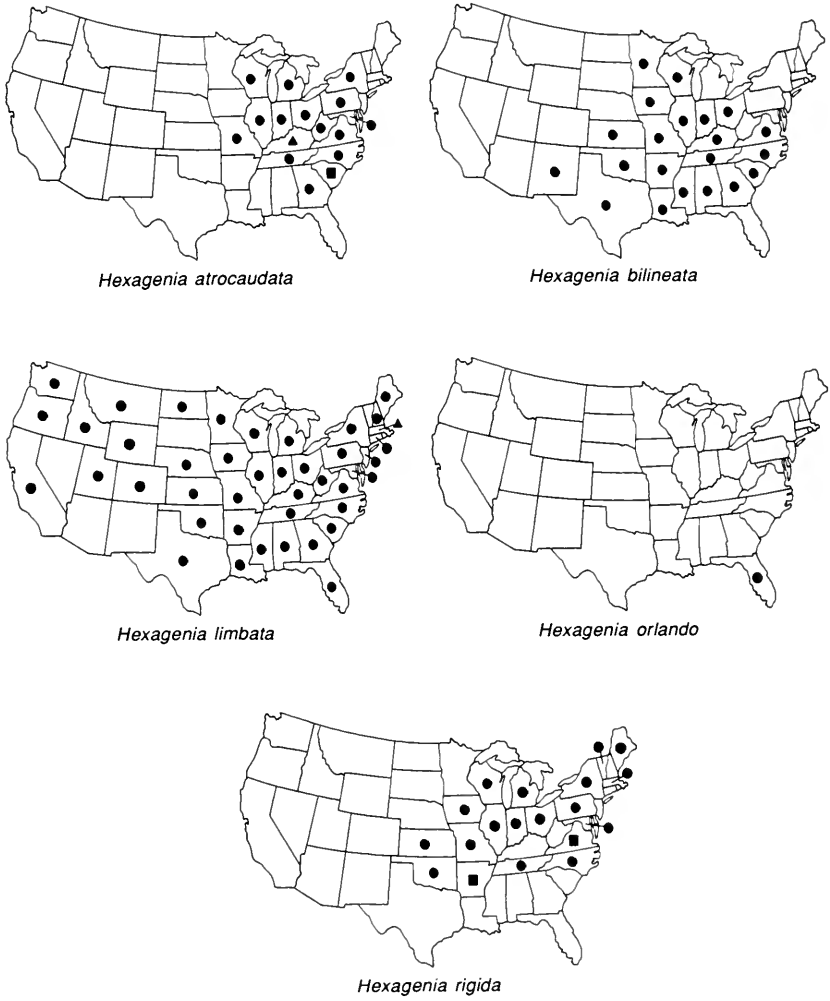


Fig. 4. United States distribution of extant species of *Hexagenia*.

Ephemera traverae Spieth (Fig. 3)

This species was previously known only from Oklahoma. A new state record follows: MISSOURI: Greene Co., Pearson Cr, 3.2 mi E Springfield, V-25-1977, VI-11,15-1977, N. R. Witte.

Ephemera varia Eaton (Fig. 3)

This species was reported from Ohio by Hall (1985), from Alabama by Kondratieff and Harris (1986), and from South Carolina by Unzicker and Carlson (1982). The Virginia record given by Kondratieff and Voshell (1983) is substantiated with new data below. New records are as follows: INDIANA, Owen Co., Rattlesnake Cr., VI-24-1980 (adults). KENTUCKY, Jackson Co., War Fork of Station Camp Cr., VI-7-1973, W. P. McCafferty, A. V. Provonsha, K. Black (larvae). MINNESOTA, Sand Lake, VI-20-1930, J. B. Fisher (adults). VIRGINIA, Prince William Forest Park, VII-4-1973, O. S. Flint, Jr. (adults).

Hexagenia atrocaudata McDunnough (Fig. 4)

Unzicker and Carlson (1982) expectedly reported this species from South Carolina. A new state record is as follows: KENTUCKY, Boyd Co., East Fork of Little Sandy R. off KY 3, 0.9 mi N jct KY 3 and KY 966, VI-1-1978 (larvae); Fleming Co., Fox Cr. at Big Run Road bridge, 0.2 km NW Big Run Road-KY 1013 jct., X-7-1983.

Hexagenia limbata (Serville) (Fig. 4)

McCafferty (1984) synonymized *Hexagenia munda* with this species and thereby expanded the state distribution of *H. limbata* to include Connecticut, Florida, Maryland, New Hampshire, New Jersey, Pennsylvania, and South Carolina. A new state record is as follows: MASSACHUSETTS, Whately, Mill R., X-30-1938 (larvae); Otter R., XI-19-1938 (larvae); N. Amherst, Pulpit Hill, IV-1952, J. R. Traver (larvae); Puffer's Pond, Amherst, R. W. Koss, X-7-1964 (larvae). McCafferty and Pereira (1984) experimentally demonstrated that color and size variants of *H. limbata* (and *H. munda*) sometimes regarded as subspecies were clinal ecophenotypes determined to a large degree by developmental temperature regime. This is the most widespread and variable North American burrowing mayfly species; it is distributed from coast to coast and is well represented in Canada and Mexico.

Hexagenia orlando Traver (Fig. 4)

This species was not treated by McCafferty (1975) because it was considered a synonym of *Hexagenia munda* at that time. Berner and

considered a synonym of *Hexagenia munda* at that time. Berner and Pescador (1988) presented evidence that *H. orlando* is a valid species restricted to sandbottomed lakes of the central Florida highlands.

***Hexagenia rigida* McDunnough (Fig. 4)**

Cather and Harp (1975) reported this species from Arkansas. Kondratieff and Voshell (1983) listed this species for Virginia but gave no locale data. Both Arkansas and Virginia are within the expected range of this species.

***Litobrancha recurvata* (Morgan) (Fig. 2)**

Lager *et al.* (1982) reported this species from Minnesota, and Hilsenhoff (1981) listed this species in Wisconsin but gave no substantiating data. It probably occurs in Wisconsin since it is known from Minnesota and I have collected it from the Upper Peninsula of Michigan directly north of Wisconsin. New state records are as follows: KENTUCKY, Letcher Co., Bad Branch, from falls to St. Rd. 932, IX-28-1991, G. A. Schuster (larvae). MARYLAND, Beaver pond on Kelley Stream .5 mi from Clayton Lake road, VI-5-1978, S. Strnad (lar-

Table 1. Classification of the extant Ephemeroidea of North America north of Mexico.

Family Polymitarcyidae

Subfamily Campsurinae

Genus *Campsurus* Eaton

Campsurus decoloratus (Hagen), 1861

Genus *Tortopus* Needham & Murphy

Tortopus circumfluus Ulmer, 1942

Tortopus incertus (Traver), 1935

Tortopus primus (McDunnough), 1924

Subfamily Polymitarcyinae

Genus *Ephoron* Williamson

Ephoron album (Say), 1824

Ephoron leukon Williamson, 1802

Family Potamanthidae

Genus *Anthopotamus* McCafferty & Bae

Anthopotamus distinctus (Traver), 1935

Anthopotamus myops (Walsh), 1863

Anthopotamus neglectus (Traver), 1935

Anthopotamus verticis (Say), 1839

Family Ephemeridae

Subfamily Ephemerinae

Genus *Ephemera* Linnaeus

Ephemera blanda Traver, 1932

Ephemera guttulata Pictet, 1843

Ephemera simulans Walker, 1853

Ephemera traverae Spieth, 1938

Ephemera triplex Traver, 1935

Ephemera varia Eaton, 1883

Subfamily Hexageniinae

Genus *Hexagenia* Walsh

Hexagenia atrocaudata

McDunnough, 1924

Hexagenia bilineata (Say), 1824

Hexagenia limbata (Serville), 1829

Hexagenia orlando Traver, 1931

Hexagenia rigida McDunnough, 1924

Genus *Litobrancha* McCafferty

Litobrancha recurvata (Morgan), 1913

Subfamily Pentageniinae

Genus *Pentagenia* Walsh

Pentagenia vittigera (Walsh), 1862

GINIA, Wythe Co., Barren Springs, VII-8-1978, I. Vance (adults). The Pennsylvania data reported above are incomplete, but there is no doubt that *L. recurvata* is common in Pennsylvania. For example, Caucci and Nastasi (1975), in their popular treatment of mayflies of importance to fly fishers, mentioned its importance on limestone streams of Pennsylvania, and a large sample of larvae evidently was taken from Fishing Creek at La Mar in 1973. Photographs of this material clearly indicate that specimens are *L. recurvata*.

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