

# DESCRIPTION AND ECOLOGY OF THREE *STENONEMA* MAYFLY NYMPHS

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## INTRODUCTION

Mayflies of the genus *Stenonema* (Heptageniidae : Ephemeroptera) are common inhabitants of streams in the Eastern United States, and are often the dominant mayflies in samples collected from natural and artificial substrates in water quality surveys.

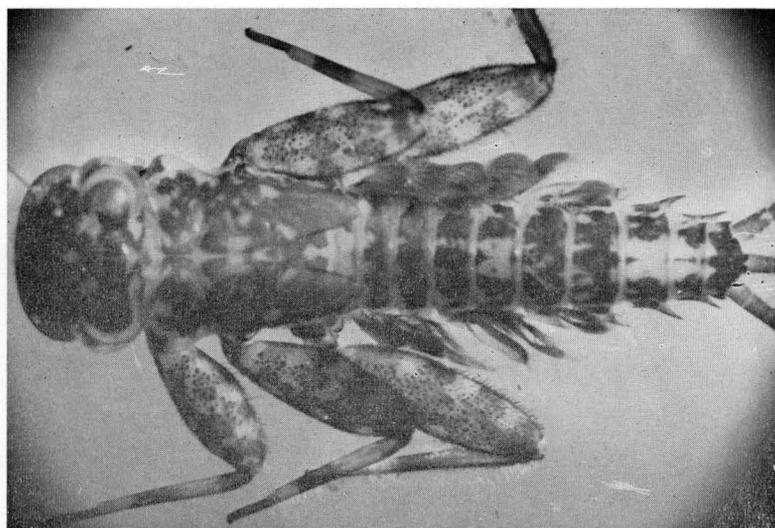
Fourteen species, some of which show preference for organically enriched water, have been collected from streams in the Ohio River Basin. GAUFIN (1958), in a study of the Mad River, Ohio, listed three *Stenonema* as facultative (*S. ares*, *S. heterotarsale*, and *S. pulchellum*) and three others (*S. interpunctatum*, *S. tripunctatum*, and *S. rubromaculatum*) as intolerant to pollution. However, the use of *Stenonema* as indicator organisms has been hampered by a lack of descriptive information on the nymphs. Thirteen of the 34 species and subspecies listed by EDMUNDS (1962) have not been described in the nymphal stage.

This paper presents three previously undescribed nymphs, *S. scitulum*, *S. terminatum* and *S. integrum* collected and reared by the author. The adults were compared to previously identified specimens from the Illinois Natural History Survey Museum (INHS).

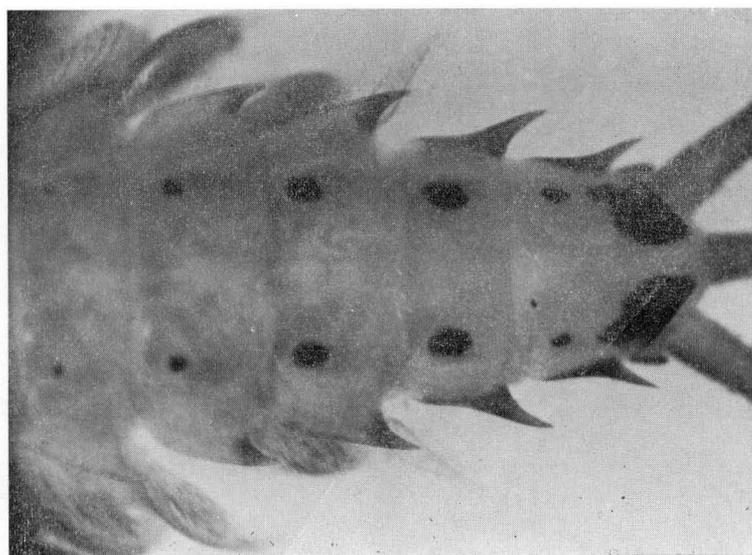
The genus *Stenonema* was erected by TRAVER (1923a) to include species formerly placed in *Heptagenia* and *Ecdyonurus*. The adults of 35 species were described and keyed by TRAVER (1935) but, although a key to the nymphs was presented, no nymphs were described. Important contributions to the knowledge of the taxonomy and ecology of *Stenonema* mayflies prior to 1933 included : SAY (1823, 1839), WALKER (1853), HAGEN (1861, 1863), WALSH (1862, 1863), EATON (1871), NEEDHAM (1901, 1905, 1908), BANKS (1910, 1914), CLEMENS (1913), CLEMENS and LEONARD (1924), McDUNNOUGH (1924, 1925 a & b, 1926, 1930, 1933), IDE (1930) and SPIETH (1933). More recent studies by DAGGY (1945), SPIETH (1947), BERNER (1950), BURKS (1953) and LEONARD and LEONARD (1962) have added to our knowledge of this genus. BURKS' key is widely used for identification of *Stenonema* throughout North America. KOSS (1968) constructed keys to the females of several species of *Stenonema* based on egg morphology.

## METHODS

The nymphs were collected in basket samplers (MASON, *et al.*, 1967) from the Ohio and Scioto Rivers and from natural substrates in small streams in the Ohio Basin and transferred to rearing tanks (MASON and LEWIS, 1970). Most of the adults were pinned to preserve color characters. The subimaginal skins, nymphal exuviae and nymphs were preserved in 70 % ethanol and numbered according to the pinned adults. The nymphs described in this paper and corresponding adults were deposited in the Illinois Natural History Survey Museum (INHS).



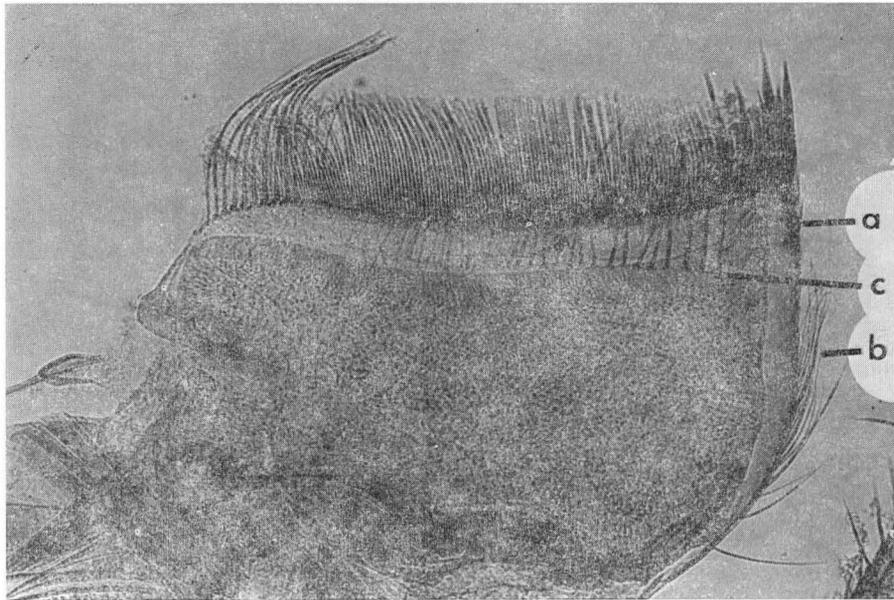
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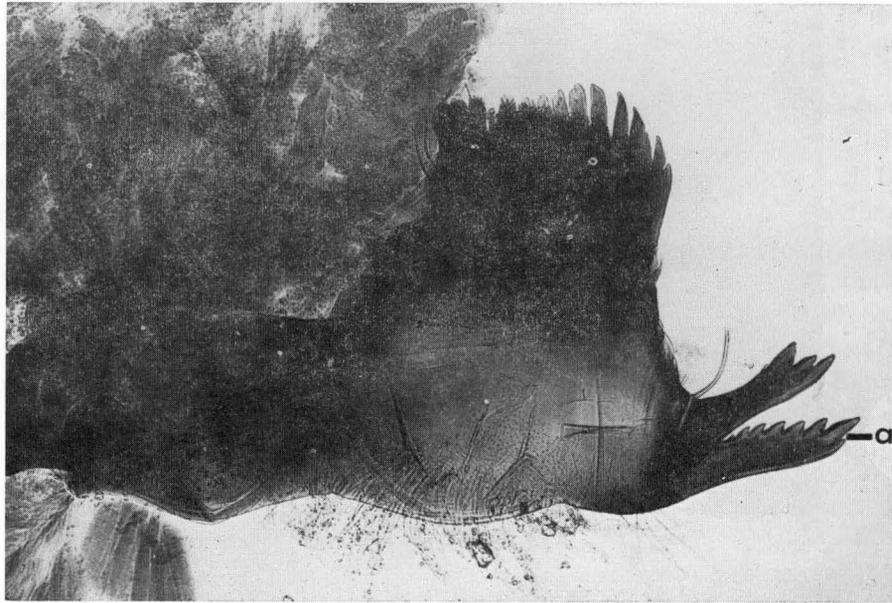
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PLATE I

Nymph of *Stenonema scitulum*. — a, dorsal view X10. — b, ventral view X30.



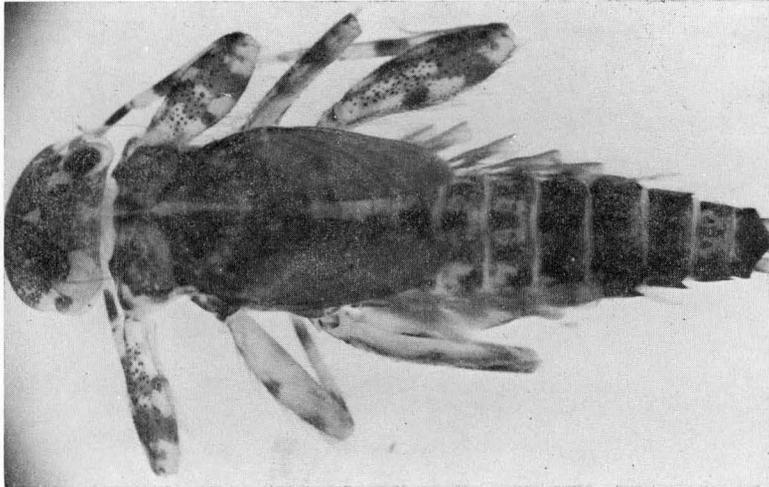
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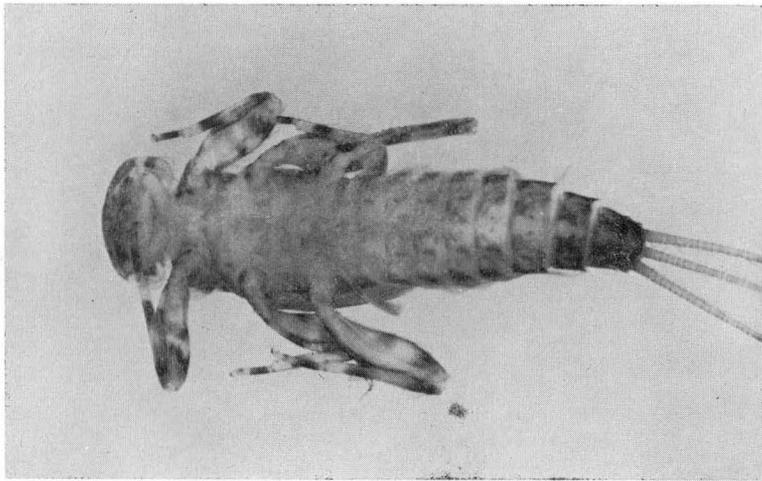
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PLATE II

Nymph of *Stenonema scitulum*. — a, dorsal view of right maxilla X150 (a = pectinate spines, b = setae on crown, c = lateral setae). — b, ventral view of left mandible X 100 (a = outer canine).



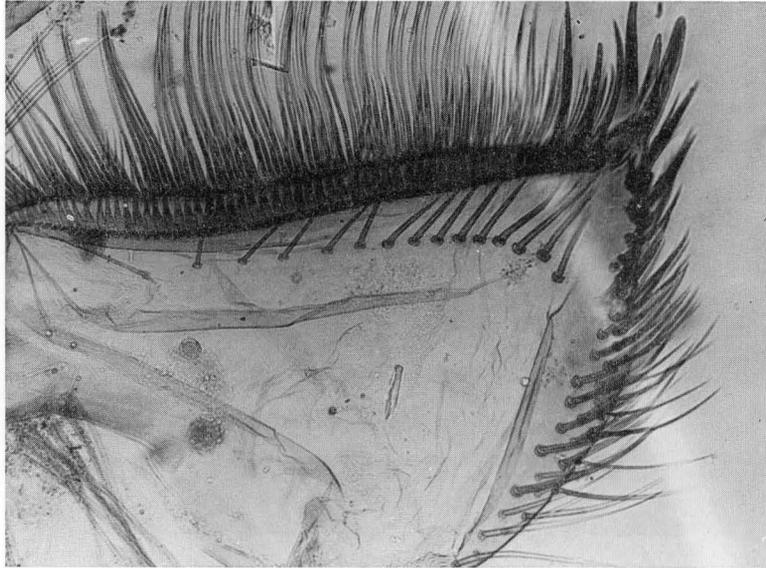
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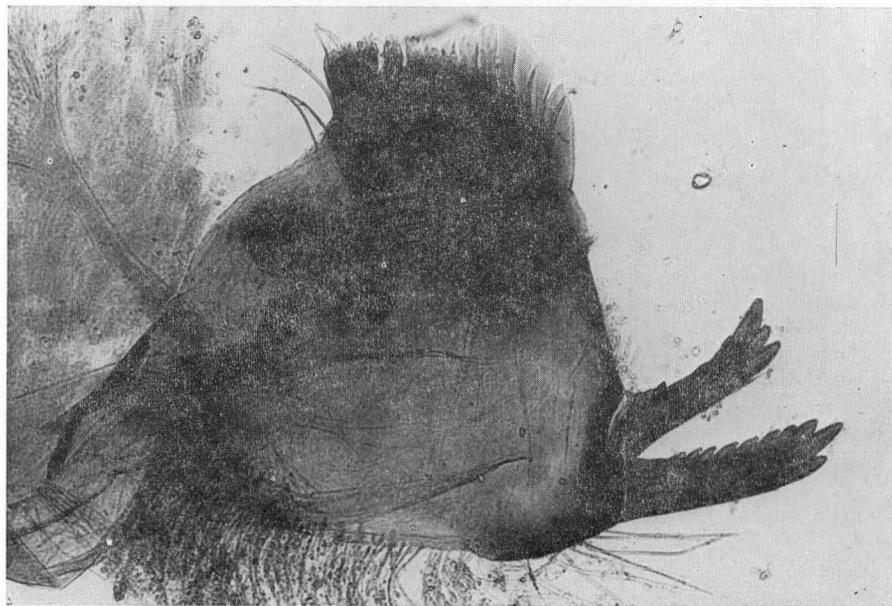
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PLATE III

Nymph of *Stenonema terminatum*. — a, dorsal view X 12. — b, ventral view X 10.



a



b

PLATE VI

Nymph of *Stenonema integrum*. — a, dorsal view of right maxilla X250. — b, ventral view of left mandible X100.

*Stenonema scitulum* TRAVER

The body of the mature nymph (Plate I) is 10-12 mm in length and the tails 11-13 mm. The ground color of the body and head is tan or light brown, freckled with pale dots. The anterior margin of the head is marked with a pair of lateral pale spots and occasionally a small median spot. A pair of pale spots is present lateral to each compound eye, separated by brown bands that extend from the lateral margin of the eye to the margin of the head. A pale spot is present near each ocellus and three pale spots are present along the rear margin of the head. The scape of the antenna is pale, the pedicel and basal segments of the flagellum tan, and the remaining segments are pale.

The maxillae (Plate IIa) have 3 pectinate spines and commonly 10-15 setae on the crown, and 30-35 lateral setae. The mandibles (Plate IIb) have 6 lateral teeth and sometimes an indication of a 7th, progressively smaller in size, on the inner margin of the outer canine.

The anterior margin of the pronotum is pale with large pale blotches extending inward one-half the width of the pronotum. Other pale spots on the pronotum, mesonotum and wing pads are variable in arrangement and size. The femora are brown with pale spots arranged in four irregular bands dorsally. The ventral surface is entirely pale. The tibiae are pale, each with a basal and a median light brown band. The tarsi are shaded with brown basally. The claws have two ventral denticles that may be seen under high magnification.

Abdominal terga 1 and 5 have a pair of median pale spots which often converge to form one large spot; submedian pale spots are usually present at the base of terga 3, 4, 6, and 7; and large, median pale spots of terga 8 and 9 usually converge to form somewhat of a broad "X" pattern. The three black marks present on the posterior margins of terga 2 to 8 of the adults are usually visible in the mature nymphs. The gills on segments 1 to 6 are rounded apically, and become progressively more rounded and smaller, posteriorly. The seventh gills have a single trachea and a fringe of long hairs.

Abdominal sterna 5-8 (sometimes 2-8) have a pair of submedian lateral brown spots on each segment, gradually increasing in size from anterior to posterior (Plate Ib). Sternum 9 has two pairs of small lateral brown spots and a very large brown spot at each posterolateral angle. Posterolateral angles of segments 3-9 are produced as spines. Caudal filaments are yellow at the base with alternating pairs of dark and light segments in the middle and a pical areas.

This nymph is very similar to *S. tripunctatum* and has in the past been confused with that species. Typical specimens of *S. tripunctatum* differ from *S. scitulum*, however, by having four pectinate spines and 3-10 setae on the crown of the maxillae and less than 30 lateral setae on the maxillae. The nymph of *S. femoratum*, another closely related species, differs from *S. scitulum* in having 2 pectinate spines on the crown of the maxillae, and the anterior margin of the head is emarginate. Intergrades between *S. scitulum*, *S. tripunctatum*, and *S. femoratum* are common in the Ohio River Valley, and SPIETH (1947) may have been correct in synonymizing them as *S. femoratum*.

Adult description : TRAVER (1935) page 330 & 331.

The nymphal description is based on a specimen from Shayler Run, Union Township, Clermont County, Ohio, VI-30-1969 INHS No. 660024 and is deposited in the INHS Museum. A male reared from a stream near St. Leon, Indiana (INHS No. 660015) and a female reared from Shayler Run (INHS No. 660019) are also in the Museum. In addition, ten males, seven females and fifteen nymphs were examined from the following locations : Mountain Fork River, Hochatown, Oklahoma, V-6-1939 (K. WADDLE), 1 male; Creek E. of St. Leon, Indiana,

IV-29-1969 (P.A. LEWIS = PAL), 3 males (reared); Shayler Run, Union Township, Ohio, V-28-1968 (PAL), 1 male (reared), 2 nymphs; same location, XII-4-1969 (W. MASON), 1 nymph; Boiling Spring Creek, near Munfordville, Kentucky, VIII-15-1969 (PAL), 1 male (reared), 2 nymphs; Salmonie River, Pennville, Indiana, VIII-5-1969 (PAL), 1 nymph; Creek NE. of Liberty, Kentucky, VIII-15-1969 (PAL), 3 males (reared), 3 females (reared), 2 nymphs; Paint Lick Creek, Kirksville, Kentucky, VIII-15-1969 (PAL), 1 male (reared); Little Kentucky River, Carrollton, Kentucky, VIII;13-1969 (PAL), 1 nymph; Rough River, Axtel, Kentucky, VIII-13-1969 (PAL), 1 nymph; Sand Creek, near Reddington, Indiana, X-22-1965 (M. ANDERSON), 1 nymph; Embarras River, Charleston, Illinois, VIII-24-1967 (M. ANDERSON), 1 nymph; and Lake Johanna, St. Paul, Minnesota, IX-22-1936 (R. DAGGY), 1 nymph.

Table I

*Physical and Chemical Data for the Year 1969 for the Ohio River above Cincinnati, and at Anderson Ferry Ohio, the Scioto River at Lucasville, Ohio, and Shayler Run, Union Township, Ohio. Samples taken once a month*

		Ohio River Above Cincinnati	Ohio River Anderson Ferry	Scioto River Lucasville, O.	Shayler Run, O. Union Township
Dissolved Oxygen (mg/l)	Max.	14.0	13.5	11.2	13.1
	Mean	8.8	8.3	9.4	9.8
	Min.	4.0	4.2	4.4	6.2
Temperature (°C)	Max.	29	29	28	25
	Mean	15	15	13	11
	Min.	0	1	1	1
pH	Max.	8.0	8.1	8.0	8.2
	Mean	7.2	7.4	7.6	7.8
	Min.	6.7	7.2	6.8	7.5
Total Dissolved solids (mg/l)	Max.	456	445	600	700
	Mean	395	297	—	450
	Min.	98	135	417	195
Total Phosphorus (mg/l)	Max.	0.3	0.3	1.5	10+
	Mean	0.1*	0.2	0.4	1.5
	Min.	0.0	0.1	0.2	0.4
Flow (cfs)	Max.	288,000	288,000	89,500	13
	Mean	75,000	75,000	5103	3
	Min.	9000	9000	535	1

Ohio River and Scioto River data are from EPA Water Quality Records. Shayler Run data are from Newtown Fish Toxicology Laboratory, EPA, Newtown, Ohio.

\* This mean is not considered a representative value as the yearly mean from 1962 to 1968 was 0.02 mg/l.

Ecology : The nymphs are common in shallow alkaline streams. This is by far the most common *Stenonema* found in Shayler Run, a small headwater stream receiving effluent from a small sewage treatment plant about two miles above the collection site. The mean total dissolved solids (TDS) for 1969 was 450 mg/l. The maximum (700 mg/l) occurred September 23

(Table I). The yearly mean dissolved oxygen (DO) was 9.8 mg/l, and the minimum value was 6.2 mg/l. The total phosphorus (TP) concentration reached 10 mg/l during periods of low flow with a mean value of 1.5 mg/l for 1969 (Table I). Experience has shown that the nymphs prefer slightly alkaline water, water temperatures below 25 °C, and can tolerate moderate amounts of organic pollution. The nymphs were often seen crawling about the bottom of the shallow pools, and did not inhabit riffle areas.

*Stenonema terminatum* (WALSH)

The body of the mature nymph (Plate III) is 9-10 mm in length and the tails 11-12 mm. The head anterior to the eyes and on the vertex between the eyes is dark brown with numerous freckle-like dots, some of which converge to form irregular pale spots. The area lateral to the compound eyes is pale or divided into two large white spots by a brown band. A large pale spot surrounds each ocellus (the middle one shaped like an arrowhead), and there is a pale spot on the vertex at the posterior margin of the head. The pedicel and basal segments of each antennal flagellum are dark, the remainder pale. The maxillae have four strongly pectinate spines on the crown, no crown setae, and 15-25 lateral setae (Plate IVa). The inner margin of the outer canine of each mandible has 6 teeth, and sometimes a minute 7th (Plate IVb).

The thorax is brown, with many small pale spots mostly clustered in the mid-central region. The lateral margins of the pronotum are mostly pale. The femora are pale, have a hairy anterior margin, three irregular brown bands, scattered dark brown dots on the dorsal surface, and a narrow band of reddish-brown present near the apex. The ventral surfaces of the legs are pale except for reddish brown shading near the apices. Each tibia has a basal and a median brown band. The basal half of each tarsus is also brown. The claws lack ventral denticles.

Abdominal terga 1 and 2 are mostly pale, tergum 9 has a large pale median spot, and the remaining terga are mostly brown with pale dots. Terga 3-5 usually have a pair of submedian and lateral pale dashes. The apex of tergum 10 is deep brown or black. The gills on segments 1-6 are truncate at the apices. The seventh gills lack tracheae and are fringed with long hairs.

The extent of the ventral markings (Plate III b) is variable. Typically there are paired, submedian, posteriorly-diverging dashes on sterna 2-9, sometimes faint or absent on the anterior sterna. There is dark brown shading around the margin of sternum 9, and often on sternum 8, leaving the middle area pale. The shading becomes fainter or absent on the more anterior segments. The posterolateral angles of segments 8-9 are produced as spines, those on segment 8 being the longest. Caudal filaments are pale near the base, usually becoming banded alternately light and dark beyond the middle.

The adults of this species are difficult to separate from *S. ares*, *S. bipunctatum*, and *S. integrum*; however, the nymphs can be distinguished by the presence of 4 pectinate spines on the crown of the maxillae (the other species have 3 spines on the crown of the maxillae) and the dorsal color patterns. It is further separated from *S. integrum* by the absence of setae on the crown of the maxillae and from *S. bipunctatum* in lacking pectinations on the claws.

Adult description : WALSH (1862) page 376.

The nymphal description is based on a specimen from the Scioto River, Portsmouth, Ohio, V-6-1970 (INHS No. 670217). A male imago (INHS No. 670218) and a female imago (INHS No. 670239) were reared from nymphs collected in the Scioto River at Portsmouth, Ohio, V-5-1970. Seven males and 14 females were also reared from the same collection and 25 nymphs

were preserved in ethanol. Nymphs of what appear to be this species have been examined from the following locations : Great Miami River, Cincinnati, Ohio, VII-23-1968 (PAL); Ohio River, Madison, Indiana, VIII-25-1969 (PAL); White River, Petersburg, Indiana, VIII-25-1969 (PAL); White River, Petersburg, Indiana, IV-18-1967 (M. ANDERSON); and Ohio River, below Cincinnati (Anderson Ferry), Ohio, VIII-20-1969 (PAL). A male from the Rock River, Rockford, Illinois, IX-4-1940 (B.D. BURKS) was also examined.

Ecology : The nymphs of *Stenonema terminatum* inhabit medium-sized rivers where there is a moderate current. They seem to prefer coarse sand and gravel substrates, but have been found clinging to the undersides of rocks up to four inches in diameter. It is the only species of *Stenonema* collected in large numbers by basket sampler from the Scioto River at Portsmouth, Ohio. In this reach of river the 1969 yearly mean pH was 7.6. The DO averaged 9.4 mg/l, with a low of 4.4 mg/l on November 6. The TDS ranged from a maximum of 600 mg/l on November 6 to a minimum of 417 mg/l on February 12. The average TP for the water year 1969 was 0.4 mg/l, with a maximum of 1.5 mg/l recorded on November 6.

*Stenonema integrum* (McDUNNOUGH)

The body of the mature nymph (Plate V) is 7 to 8 mm in length, and the tails 10-14 mm. The head is dark brown, sprinkled with pale dots; a small median spot and two larger lateral spots occur on the anterior margin. The lateral margin of the head is pale, with a brown band connecting the compound eyes and lateral margin. Pale areas are present near each ocellus. A cuneiform pale streak begins near the posterior margin of the head, widens across the pronotum, and tapers off near the middle of the mesonotum. The antennae are entirely pale. The maxillae have 2 or 3 pectinate spines and about 50 setae on the crown (Plate VIa) and 15-20 lateral setae. The inner margins of the outer canine of both mandibles have 8 teeth (Plate VIIb).

In addition to the median pale stripe, the pronotum has irregular pale streaks extending inward from the lateral margins, and a pair of pale stripes midway between the anteromedian line and the lateral margins. Pronotal protuberances are present on either side of the dorsal mid-line. The mesonotum and wing pads are mostly brown with pale streaks. The mesonotum between the wing pads ends in two blunt knobs. The femora are mostly pale with three irregular transverse brown bands. The tibiae have dark brown bands basally and just beyond the middle. The basal half of the tarsi are brown. The apical half and most of the claws are pale. The claws lack ventral denticles.

The terga are typically dark brown dorsally with submedian pale streaks on anterior portions of terga 2-7. The middle of segment 1 is mostly pale. A conspicuous pale «V-shaped» median patch (with the vertex on tergum 9 or 10) extends across terga 7 and 8. Terga 4 and 5 often have pale submedian patches. Pale lateral markings are present on terga 2-8, usually concealed under the purplish-gray truncate gills. The seventh gills are without tracheae and are fringed with long hairs.

The sterna are entirely pale except for sternum 9 (Plate V b), which sometimes has lateral dark bands that may coalesce anteriorly to form a dark inverted "U-shaped" mark. Posterolateral angles of segments 7-9 are produced into very small spines. The tails are pale, and ringed with brown beyond the middle, with an alternating pattern of three brown segments separated by one pale segment.

This nymph is similar to DAGGY's (1945) *S. wabasha* except that sterna 2-8 of *S. wabasha*

have paired dark submedian dots and lateral brown streaks. As BURKS (1953) suggested, *S. wabasha* is doubtless a synonym of *S. integrum*. The maxillae of *S. integrum* have 2 or 3 pectinate spines and about 50 setae on the crown, and there are 8 teeth on the inner margin of the outer canine of each mandible. The related species, *S. ares* and *S. bipunctatum*, have no setae on the crown of the maxillae, and have 5 or 6 teeth on the inner margin of the outer canine of the mandibles. The nymph described by LEONARD and LEONARD (1962) as *S. integrum* is probably a new species as they suggest.

Adult description : MCDUNNOUGH (1924) page 9.

The nymphal description is based on a specimen collected from the Ohio River, Cincinnati, Ohio, X-2-1968 (INHS No. 670247). Also an adult female was reared from a nymph collected in the same location VIII-26-1969 (INHS No. 670074) and is in the INHS Museum. Seventeen other specimens were examined from the following locations : Little Miami River, Loveland, Ohio, X-20-1968 (PAL), 1 female (reared); Wabash River, New Harmony, Indiana, V-15-1963 (M. ANDERSON), 1 nymph; same location, VII-15-1966 (M. ANDERSON), 1 nymph; Ohio River, Cincinnati, Ohio, X-2-1968 (PAL), 1 nymph; Ohio River, Louisville, Kentucky, VII-6-1966 (W. MASON), 1 nymph; Ohio River, Anderson Ferry (Cincinnati), Ohio, VIII-26-1969 (PAL), 1 male (reared), 4 females (reared), 1 nymph; Ohio River, Madison, Indiana, VII-14-1969 (PAL), 3 nymphs; White River, Newberry, Indiana, X-14-1965 (M. ANDERSON), 1 nymph; Mississippi River, Poplar Bluff, Illinois, VI-20-1943 (FRISON), 1 male (INHS No. 670206).

Ecology : The nymphs of *Stenonema integrum* are common in large rivers with organic enrichment. It was the only *Stenonema* collected in 1967 and 1968 from basket samples at Anderson Ferry, Ohio River, immediately below the city of Cincinnati, and was abundant at Miami Fort, Ohio (17 miles downstream from Anderson Ferry). Both of these stations are subject to organic wastes. Other macroinvertebrates indicative of organic pollution were collected in the samples including : *Dina* (leech), *Dero* (worm), *Physa* (snail) *Einfeldia* gr. (midge), *Psychoda* (Sewage fly), and Turbellaria. *Stenonema interpunctatum* was the common mayfly collected in the cleaner water area above Cincinnati during comparable sampling periods. The chemical and physical data presented in Table I for Anderson Ferry was taken from monthly readings and that from Miami Fort is from continuous daily monitoring. The Ohio River Valley Water Sanitation Commission monitor at Miami Fort recorded a low DO reading of 1.8 ppm in October, 1969, and the average for September was 3.6 ppm (ORSANCO, 1968, 1969). During September, 1968, the DO at Miami Fort remained below 4.0 ppm, and reached a low of 0.5 ppm. The emergence of this species from the Ohio River at Cincinnati covers a short period near the last of August or first of September.

## RÉSUMÉ

### *Description et écologie de trois larves de Stenonema*

Les larves d'éphémères de la famille des Heptageniidae : *Stenonema scitulum* TRAVER, *S. terminatum* (WALSH) et *S. integrum* (MCDUNNOUGH) provenant toutes du Mid-West des États-Unis, sont décrites à partir de spécimens qui ont été suivis jusqu'au stade adulte. La larve de *Stenonema scitulum*, confondue auparavant avec *S. tripunctatum*, est caractérisée par trois épines pectinées et par 3 à 20 setules sur la couronne des maxilles. *S. scitulum* est commun dans les rivières peu profondes avec une forte teneur en minéraux et peut tolérer un enrichissement modéré en matières organiques. La larve de *Stenonema terminatum* a quatre épines pectinées

sur la couronne des maxilles et 15 à 25 setules latérales; on ne trouve pas des alignements de poils sur les griffes. D'autres espèces avec quatre setules sur la couronne des maxilles différent de *S. terminatum* par le fait que setules et épines sont mêlées ensemble sur la couronne de leurs maxilles et qu'elles présentent des alignements de poils sur leurs griffes. On trouve ces nymphes surtout sur des substrats de gravier et de sable. Les larves de *Stenonema integrum* sont caractérisées par un pâle dessin en forme de V sur les tergites 7 à 9, en général par trois épines pectinées et 50 setules sur la couronne des maxilles, et par 8 dents sur le bord interne des canines externes. Les larves sont abondantes dans les grandes rivières riches en matière organique. Dans la plupart des cas la structure des parties buccales se révèle un meilleur critère que les variations de couleur pour la différenciation des espèces.

#### ZUSAMMENFASSUNG

##### *Beschreibung und Ökologie von drei Stenonema Eintagsfliegen Nymphen*

Eintagsfliegen Nymphen von der Familie Heptageniidae, *Stenonema scitulum* TRAVER, *S. terminatum* (WALSH), und *S. integrum* (MCDUNNOUGH), alle vom Mittelwesten der Vereinigten Staaten, deren Exemplare zu Erwachsenen aufgezogen wurden, sind beschrieben. Die Nymphe von *Stenonema scitulum* TRAVER, die vorher mit *S. tripunctatum* verwechselt wurde, ist durch drei pectinate Dornen und 3 bis 20 Borsten an den Kronen von den Maxillen charakterisiert. *S. scitulum* kommt vor in seichten Strömen mit hartem Wasser, und kann leichte organische Bereicherung vertragen. Die Nymphe *Stenonema terminatum* (WALSH) hat vier pectinate Dornen an den Kronen der Maxillen und 15 bis 25 seitliche Borsten, es fehlt Pectination in den Klauen. Andere Arten mit vier Borsten an den Kronen der Maxillen sind verschieden von *S. terminatum* weil sie Borsten und Dornen an den Kronen der Maxillen vermischen haben oder Pectination an den Klauen aufweisen. Diese Nymphen kommen meistens in Kies- und Sand-Substraten vor. Die Nymphen von *Stenonema integrum* (MCDUNNOUGH) sind durch einen bleichen V-förmigen Fleck an den Tergien 7 bis 9, gewöhnlich drei pectinate Dornen und 50 Borsten an den Kronen der Maxillen, und 8 Zähne am inneren Rand der äusseren Caninen charakterisiert. Diese Nymphe ist häufig in grossen Flüssen, welche reich an organischem Material sind. In den meisten Fällen sind die Strukturen der Mundteile zuverlässiger als die Farbmerkmale in der Bestimmung der Arten.

#### DISCUSSION

H. SCHOONBEE : Where did you take BOD [*Biological Oxygen Demand*, ed.] measurements ?

P. LEWIS : BOD measurements were taken at some places, but I didn't indicate BOD here. I am sure we can find BOD readings for most of these locations.

H. SCHOONBEE : Do you have an idea what the BOD values were at all locations ?

P. LEWIS : I can only tell you that the BOD below Cincinnati is higher than above Cincinnati.

H. SCHOONBEE : I also saw that the phosphates there were very high. It would be interesting to know what the nitrogen values were for the corresponding localities.

P. LEWIS : I cannot tell you. I am sure all of you are aware that we need more information on the ecology and the ecological requirements of these species, as well as on the conditions in which they live.

H. SCHOONBEE : Did you find that the various species differed in respect to the current speed ?

P. LEWIS : Yes, I found that *S. interpunctatum* does not occur in swift water; whereas, *S. pulchellum* is found in the swifter water. There certainly is a preference based on current in many species.

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