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Life Histories of Stenonema vicarium (Walker) and S. tripunctatum (Banks) in a West Virginia Stream (Ephemeroptera: Heptageniidae)[1]

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ABSTRACT: Life history studies of the mayflies, *Stenonema vicarium* (Walker) and *S. tripunctatum* (Banks), were made in Beech Fork of Twelvepole Creek, Wayne Co., West Virginia, between November 1970 and October 1971. The nymphs of both species are herbivorous and feed primarily on allochthonous detritus mixed with mineral particles and to a lesser extent on diatoms (primarily *Navicula* spp., *Synedra* sp. and *Pinnularia* sp.) and filamentous algae, mainly *Spirogyra* sp. Frequency distributions show that nymphs of both species required 1 year to complete their life cycle. Small nymphs of both species were collected in June. The nymphs attained their greatest growth rate from September through November (57.1 and 60.0%, *S. vicarium* and *S. tripunctatum*, respectively). Emergence of *S. tripunctatum* started in late April and peaked in May. In *S. vicarium*, emergence started in early May and peaked in late May. The chi-square test, at the 0.05 confidence level, shows a significant difference from the 1:1 sex ratio in nymphs of both species. Total egg counts range from 3058-4231 ($\bar{X}$ = 3528) and 1176-3271 ($\bar{X}$ = 2621) eggs per nymph in *S. vicarium* and *S. tripunctatum*, respectively.

INTRODUCTION

The life history and ecology of most species of aquatic insects are not known in detail. The ecology of each species represented in a stream community is necessary for the complete understanding of community dynamics. Few ecological studies have been reported of mayfly species of North America (Hunt, 1953; Fremling, 1960; Britt, 1962; Trost and Berner, 1963; Minshall, 1967). Brief ecological notes on *Stenonema tripunctatum* (Banks) and *S. vicarium* (Walker) have been reported by Clemens (1913, 1915), Needham *et al.* (1935), Cooke (1940), Spieth (1940, 1947) and Koss (1968). Other studies by Ide (1930, 1935a, 1935b), Traver (1933a, 1933b, 1935), Burks (1953), Trama (1972) and Lewis (1973) have been published on the

[1] Part of a thesis submitted by the first author to the Graduate School, Marshall University, in partial fulfillment of the requirements for the Master of Science degree, December 1971.

genus *Stenonema*. This project involves life history studies of *S. vicarium* and *S. tripunctatum* in Beech Fork of Twelvepole Creek, Wayne Co., W. Va.

DISTRIBUTION

Stenonema vicarium is common in the eastern states and Canada S to North Carolina, Kentucky and Illinois. The nymphs of *S. vicarium* are found on the underside of stones in riffle areas of streams. *Stenonema tripunctatum* occurs throughout the central states from Texas to New York and Minnesota and in central and eastern Canada. Nymphs of *S. tripunctatum* are found under stones in the shallow water of streams and lakes. The species are often sympatric (Spieth, 1947). For the first time, both species are reported from West Virginia.

MATERIALS AND METHODS

Three sampling stations were established on Beech Fork, which originates 23 km ESE of Wayne, W. Va., near the town of Nestlow and flows 45.9 km to enter Twelvepole Creek just above Lavalette, West Virginia (Olson, 1971). Station 1 was located 30 km above the mouth of Beech Fork in a riffle 3.9 m wide and 17.5 cm deep. Substrate consists of gravel and rubble. Station 2 was located 13.2 km above the mouth in a riffle 10.8 m wide and 10 cm deep. Substrate consists of rocks, gravel and sand. During July 1971, this station was destroyed by channelization of Beech Fork as a result of dam construction. Station 3 was located 2.5 km above the mouth in a riffle 5.9 m wide and 16 cm deep. The substrate consists of rocks, gravel and sand.

A 5-min sample of both species was collected monthly, between November 1970 and October 1971, from each station using a bottom dredge with 60 threads per inch. The substrate was vigorously disturbed and the dislodged debris collected by the net. Sufficient numbers of specimens of both species were difficult to collect each month from each station; therefore, data are presented for all stations combined.

Monthly water temperature measurements were obtained from instantaneous readings by a mercury thermometer near the bottom. Dissolved oxygen and *p*H were measured in the field each month with a Hach chemical kit, Model AL-36-WR. Water samples were brought to the laboratory for measurements of hardness (calcium and magnesium) and total alkalinity, using a Hach chemical kit, Model DR-EL.

Size-frequency distributions, arranged in monthly 1-mm groups, were used to distinguish the size classes of both species. Body length (exclusive of caudal filaments) of the nymphs was measured. Head width was selected as a more reliable index of growth, since it changed little during preservation (Britt, 1953). All measurements of 1548 nymphs were made to the nearest 0.5 mm.

Foregut analyses were performed on nymphs of both species. Five nymphal foreguts of each species were excised each month and the contents were extruded on a glass slide containing Hoyer's mounting

medium. Each item was identified and counted in 10 separate fields (Whipple eyepiece) at 430 magnification.

Mature nymphs of both species were brought from the stream to the laboratory and reared through emergence. They were kept in 2- and 5-gal aerated aquaria with rocks and 7.5 cm of stream water. The water was kept at 26 C in a thermostatically controlled unit. Attempts were made to observe feeding of nymphs and longevity of adults.

Fecundity in both species was determined by counting eggs of mature nymphs under a dissecting binocular microscope. Since adults were scarce, and some of their eggs already oviposited, egg counts on mature nymphs were used to estimate reproductive potential. The diameters of 250 and 350 eggs, of *S. tripunctatus* and *S. vicarium,* respectively, were measured with an ocular micrometer to the nearest 0.01 mm.

The chi-square test was applied to data from 347 *S. tripunctatum* and 1140 *S. vicarium* nymphs, to determine a possible significant departure from the 1:1 sex ratio at the 0.05 level.

STREAM ENVIRONMENT

The waters in Beech Fork were usually high in dissolved oxygen, ranging from 6.1 to 11.3 mg/l with 8.6 mg/l as the yearly average. The average *p*H was 7.2 with a range of 6.8 to 7.5. Detailed water analyses were reported by Richardson (1971).

LIFE HISTORIES

NYMPH

Development of S. vicarium.—One size class was present in the nymphal population (Fig. 1). Recruitment of young nymphs started in June and continued into September. First instars (1.5 mm body length) were collected from June to September. Mature nymphs with dark wing-pads were present in April and May. The largest male and female nymphs collected in Beech Fork (20 April 1971) were 11.5 and 14.5 mm in body length, respectively. Generally, female nymphs were larger than the male nymphs.

The smallest mean head width, 1.4 mm, occurred in June and September. The nymphs grew slowly during the summer months. They attained their greatest growth rate, 57.1%, from September (17.5 C) through November (12.3 C). The largest monthly percentage of growth occurred from September to October (35.7%); the water temperature was 16 C. By the end of November, the nymphs had attained a mean head width of 2.2 mm. Growth was slower during the winter and spring months; the range of water temperature was 4.2 to 15.0 C. The largest mean head width, 2.7 mm, occurred in April. The largest head width recorded for the study period, 4.0 mm, was in January and March.

Development of S. tripunctatum.—One size class was represented in the nymphal population (Fig. 1). Although large numbers of

nymphs were not collected in summer, probably due to small size and concealment, hatching started in June and continued into autumn. The smallest nymphs collected during June were 2.0 mm in body length. In October, nymphs 3.0 mm in body length were collected.

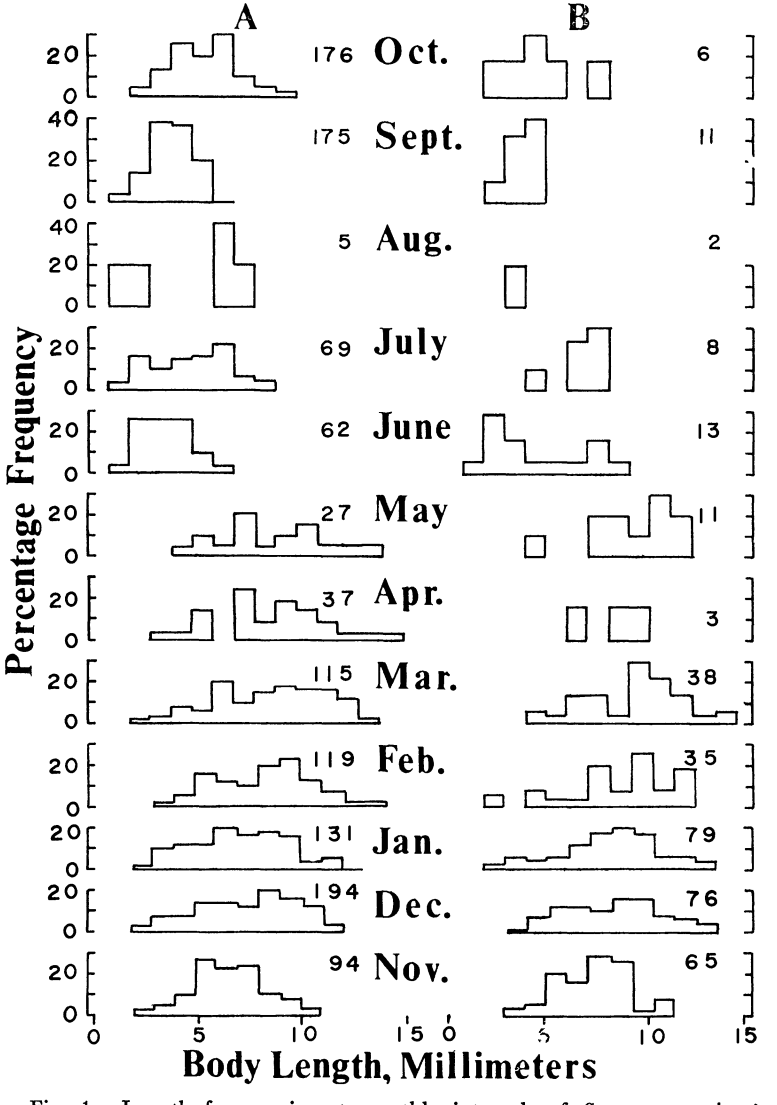

Fig. 1.—Length frequencies at monthly intervals of *Stenonema vicarium* (A) and *S. tripunctatum* (B) nymphs in Beech Fork, Wayne Co., W. Va. The number of nymphs collected is given beside each month

Mature nymphs, 14 mm in body length, appeared in March and May. They were probably present in April but only three specimens were collected. The largest male and female nymphs collected in Beech Fork (23 March 1971) measured 11.5 and 14.0 mm in body length, respectively.

Little growth in head width occurred during the summer months. The smallest mean head width, 1.0 mm, was recorded in August. As in *S. vicarium,* the nymphs of *S. tripunctatum* attained their greatest growth rate (60%) during autumn. During that time they grew from a mean head width of 1.5 mm to 2.4 mm. The largest percentage of growth (41.2%) occurred from October to November. Growth rate was slow during the winter and spring months. During the study period, the largest head width, 4.0 mm, was measured in December, January and March.

Coleman and Hynes (1970) noted that the nymphs of *S. vicarium* in the Speed River, Wellington Co., Ontario, grew steadily throughout the year. Maxwell and Benson (1963) reported that the heptageniid nymphs of *Epeorus pleuralis* (Banks) and *E. fragilis* (Morgan), Roaring Creek, Preston Co., W. Va., grew steadily during the winter months; the most spectacular growth occurred during the lowest temperature. Clemens (1913) and Spieth (1947) stated that *Stenonema* probably completed its life cycle in a year. Ide (1935a) stated that some *Stenonema* spp. in the southern range probably require 2 years to complete their life cycle. Nymphal specimens of *S. vicarium* and *S. tripunctatum* in Beech Fork, W. Va., required 1 year to complete the life cycle.

Emergence of S. vicarium *and* S. tripunctatum.—Based on exuviae in the stream, emergence in *S. vicarium* started in early May and reached a peak in late May; the water temperature in May was 16.7 C. In *S. tripunctatum,* emergence started in late April and reached a peak during May; the water temperature in April was 15.0 C. No exuviae of either species were observed clinging to stones or vegetation above the waterline. Ecdysis was observed in the laboratory and it was similar in both species. While the nymph was on the water surface, the skin split down the thorax on the dorsal side, and the subimago wriggled out of the skin. After the wings had dried, the subimago flew to a nearby object. Clemens (1913) reported that the first bred specimens of *S. tripunctatum* emerged on 31 May. Prior to emergence, the nymphs seemed to migrate into quieter waters.

Food habits.—Foregut analyses indicated that the nymphs of both species were herbivorous and fed primarily on allochthonous detritus mixed with mineral particles. Diatoms and filamentous algae were less abundant.

In *S. vicarium,* detritus was about 20 times more abundant than mineral particles on a monthly basis. Generally, diatoms were more abundant than filamentous algae. They were present every month and most abundant in March. An average of five diatoms per field were

counted at this time, while 173 pieces of detritus per field were recorded. *Navicula* spp., *Synedra* sp. and *Pinnularia* sp. were the most abundant diatoms throughout the year.

In *S. tripunctatum,* detritus was also about 20 times more abundant than mineral particles. Diatoms, primarily *Navicula* spp., were not as abundant as in *S. vicarium.* Filamentous algae, mainly *Spirogyra* sp., were most abundant during February. An average of four strands per field was present compared to an average of 153 pieces of detritus per field.

Spieth (1947) noted that the nymphs of *Stenonema* spp. fed by sweeping, scraping and tearing detritus, algae and diatoms from the substratum. Trama (1972) found that the nymphs of *S. pulchellum* (Walsh) were exclusively herbivorous and treated them as a true primary consumer.

Predation.—Previous studies on Beech Fork were helpful in designating certain predators of the nymphs of both species. The trout-perch, *Percopsis omiscomaycus* (Walbaum), occasionally fed on *S. vicarium* and *S. tripunctatum,* in summer, winter and spring, respectively (Watkins, 1973). Olson (1971) reported that *S. vicarium* and *S. tripunctatum* were the most important ephemeropterans used by fishes in Beech Fork.

Sex ratios.—The chi-square test indicated a significant difference from the 1:1 sex ratio at the 0.05 confidence level in both species. The sex ratio of *S. vicarium* nymphs was based on a random sample of 489 males and 651 females, a ratio of about 75 males to 100 females. The sex ratio of *S. tripunctatum* nymphs was based on a random sample of 119 males and 228 females, a ratio of about 52 males to 100 females.

Minshall (1967) found the sex ratio of 171 mayfly nymphs of *Epeorus pleuralis* was 1:1. Hunt (1953) suggested that a sex ratio in favor of the females might be better for *Hexagenia limbata* (Serville) because the males of this species apparently mated more than once. Cooke (1940) reported that on several occasions, after having mated, or having attempted to mate, the males of *S. vicarium* were seen returning to the swarm possibly for more mating. Therefore, a sex ratio in favor of the females of *S. vicarium* in Beech Fork would be beneficial to the species.

SUBIMAGO

Mature nymphs of both species were successfully reared to the subimago stage under laboratory conditions. Although the exact duration of the subimago stage was not determined, the period did not exceed 3 days in either species.

Clemens (1915) stated that the subimago stage for laboratory-reared specimens of *S. tripunctatum* usually lasted a day but, early in the season, it may last 3-4 days. In an earlier paper, Clemens (1913) reported that temperature and humidity seemed to play an important role in the duration of the subimago stage.

IMAGO

In the laboratory, only 10 subimagoes of both *S. tripunctatum* and *S. vicarium* emerged to the imago stage. The exact duration of the imago stage could not be determined but did not exceed 3 days under laboratory conditions. Although the mating flights of both species were not observed in the field, nymphal recruitment indicated they occurred throughout the summer.

Clemens (1913) reported that a swarm of 20 individuals (*S. tripunctatum*) was found between 2000 and 2050 hr on 11 June 1913 flying 10-20 ft high along shore. One female and several males were collected. They remained very abundant until 5 July. Cooke (1940) observed the mating flights of *S. vicarium* on 15 July 1938 near Darby Creek, 1 mile N of Clifton Heights, Pennsylvania. Coleman and Hynes (1970) reported that *S. vicarium* from the Speed River, Ontario, was on the wing from April until August.

EGG

Fecundity.—Egg counts of six mature nymphs of *S. vicarium* ranged from 3058 to 4231 eggs per nymph; the average was 3528. Egg counts of five mature nymphs of *S. tripunctatum* ranged from 1176 to 3271 eggs per nymph; the average was 2621. Estimated egg counts of 10 mature nymphs of *Epeorus pleuralis* ranged from 2053 to 6096 eggs per nymph; the average was 4260 (Minshall, 1964).

Size.—Mature eggs of both species were mostly ellipsoid and measured 0.072 by 0.095 mm; range was 0.054-0.095 mm by 0.072-0.108 mm. Koss (1968) noted that the eggs of *S. vicarium* were nearly spherical and lacked polar caps. Chorionic sculpturing and a sperm guide were usually absent; the micropylar canal was 8-15 μ long. However, the eggs of *S. tripunctatum* were ovoid and slightly tapered toward the poles. Polar caps were absent, but chorionic sculpturing and a sperm guide were present; the micropylar canal was 12-14 μ long. Needham *et al.* (1935) observed that the eggs of *S. vicarium* and *S. tripunctatum* were ellipsoid and measured 0.18 to 0.20 mm by 0.14 mm.

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