

## The Life Cycles of Five Closely Related Mayfly Species (Ephemeroptera: Heptageniidae) Coexisting in a Small Southern Ontario Stream Pool

by

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ROWE, L. and M. BERRILL: The Life Cycles of Five Closely Related Mayfly Species (Ephemeroptera: Heptageniidae) Coexisting in a Small Southern Ontario Stream Pool. *Aquatic Insects*, Vol. 11 (1989), No. 2, pp. 73-80.

The life cycles of *Stenacron interpunctatum* (Say), *Stenonema femoratum* (Say), *S. luteum* (Clemens), *S. vicarium* (Walker) and *S. modestum* (Banks) are described in a small southern Ontario stream. All five species shared similar life cycles. With the exception of *S. femoratum* each species was univoltine. *S. femoratum* may be bivoltine, although its main cohort is temporally similar to the other species. Body size of mature nymphs decreased as the emergence period progressed and females were consistently larger than males. Although these species shared the same microhabitat, there was little evidence of temporal staggering of life cycles within this guild. For all species emergence peaked in early summer and growth peaked in early and late summer.

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### INTRODUCTION

Members of the closely related mayfly genera, *Stenonema* and *Stenacron* (Heptageniidae), are often the most abundant benthic insects in the streams of eastern North America (Bednarik & McCafferty, 1979). Species within these two genera are generalists, feeding primarily on detritus and diatoms (Shapas & Hilsenhoff, 1978; Kondratieff & Voshell, 1980). There appear to be no strong interspecific differences among the *Stenonema* and *Stenacron*, however, there is evidence indicating seasonal and developmental variation in feeding habits (Kondratieff & Voshell, 1980; Lamp & Britt, 1981). A univoltine winter life cycle is the most characteristic of this group, although bivoltine and multivoltine cycles do occur (for review see Clifford, 1982).

Closely related coexisting species often partition the resources of time, space or food (Schoener, 1974). For example, in guilds with shared habitat and food resources, time may be partitioned by the staggering of growth periods among species. This temporal staggering of life cycle events is common within assemblages of closely related stream insects (Brittain, 1982). In this study we compare the timing of life cycle events in an unusually species-rich assemblage of 5 closely related species (*Stenacron interpunctatum* (Say), *Stenonema femoratum* (Say), *S. luteum* (Clemens), *S. vicarium* (Walker) and *S. modestum* (Banks) coexisting in a small stream pool.

## METHODS

The study site was a 25 metre section of a pool zone situated directly upstream from a rock pile dam in Thompsons Creek, Peterborough County, Ontario. Thompsons Creek is a small hard water stream on limestone bedrock, flowing south through pasture from the Trent Canal. The width is 6 metres, with a depth of approximately 20-40 cm and a uniform substrate of angular, flat cobble. Stream temperature varies little from site to site within the reach ( $\pm 2^\circ\text{C}$ ). The benthic community is dominated in numbers by *Stenonema* and *Stenacron* mayflies and the crayfish *Orconectes rusticus* (Girard).

Quantitative samples (12.XII.84, 29.III.85, 29.IV.85, 1.VI.85, 3.VII.85, 1.VIII.85, 15.X.85) consisted of sampling four to seven sites at six metre intervals along each of two transects running parallel to the shore. At each site, three adjacent surber samples were taken by lifting rocks from the substrate and scraping them off into a surber sampler and then vigorously disturbing the sediment below. Qualitative samples (15.V.85, 20.VI.85, 12.VII.85, 20.VIII.85, 6.XI.86) were taken by shaking rocks from the substrate into a dip net. Samples of December and March were obtained with a 800  $\mu\text{m}$  mesh net, while all others were with 200  $\mu\text{m}$  mesh nets. Stream temperature was determined on all of these and occasional other dates.

Nymphs from each site were placed alive into water filled plastic containers and transported back to the laboratory for determination of species, size, development stage and sex. Species were identified using the keys of Bednarick & McCafferty (1979), and Needham et al. (1935). Body length was measured as the distance from the back of the head capsule to the tip of the tenth abdominal segment. Mature nymphs (final instar) were defined as those with swollen black wing pads, a sign of impending emergence (Clifford, 1970). Density of mature nymphs was used as an indicator of relative emergence density. On dates where quantitative samples were not obtained, density of mature nymphs was estimated as the product of estimated density of a species (Fig. 1a) and the known proportion of nymphs that were mature on that date. Each quantitative sampling removed a significant portion of the population (4%), animals were returned alive to the stream.

To test for temporal segregation of species by body size, we regressed mean body weight of each species on a given date against each other species on that date. Therefore, ten regressions were calculated (representing each species pair), with twelve points in each regression (representing the twelve sampling dates). We would expect high correlation coefficients for species pairs that shared temporally similar growth periods. Before undertaking this test the relationship between length and dry weight was determined, so that our length data could be converted to dry weights. The curve was not significantly different between these closely related species, therefore the data were combined. The relationship is best described by the power function  $\text{Wt}(\text{mg}) = 0.0249 * \text{Length}^{2.73}$ ,  $r = 0.98$ ,  $\text{DOF} = 83$ .

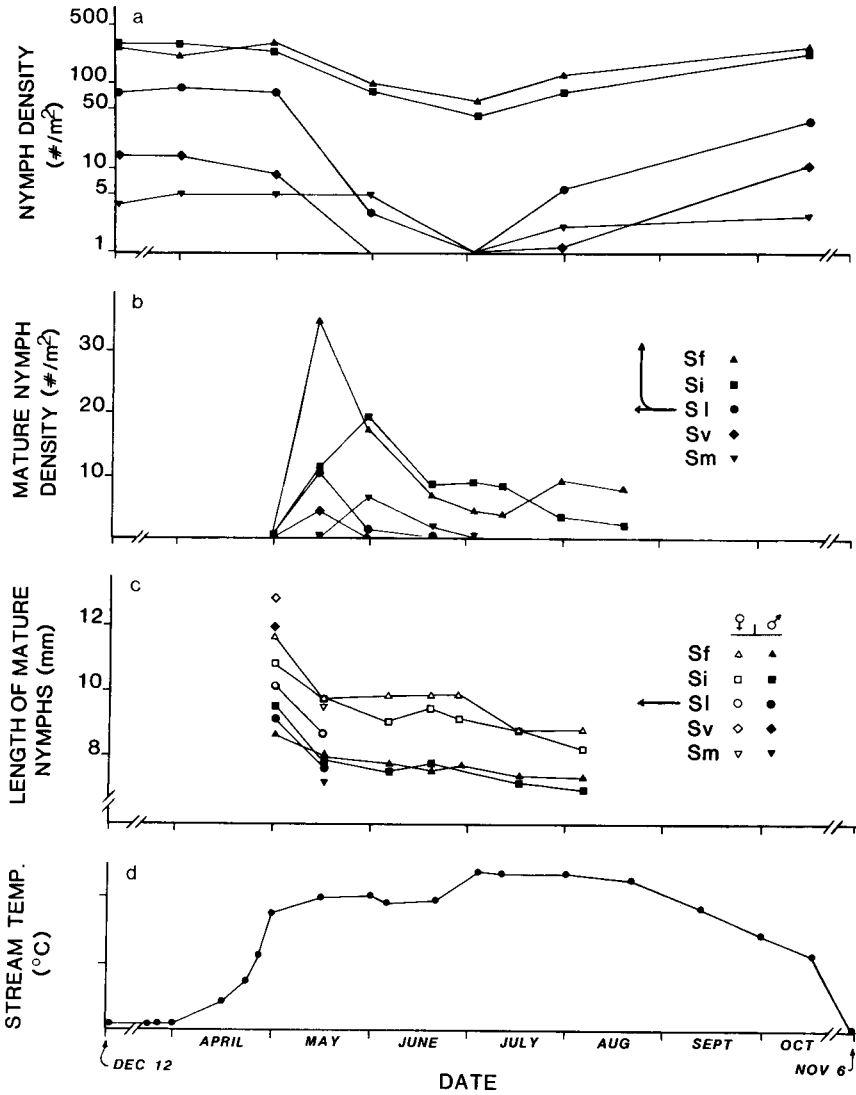
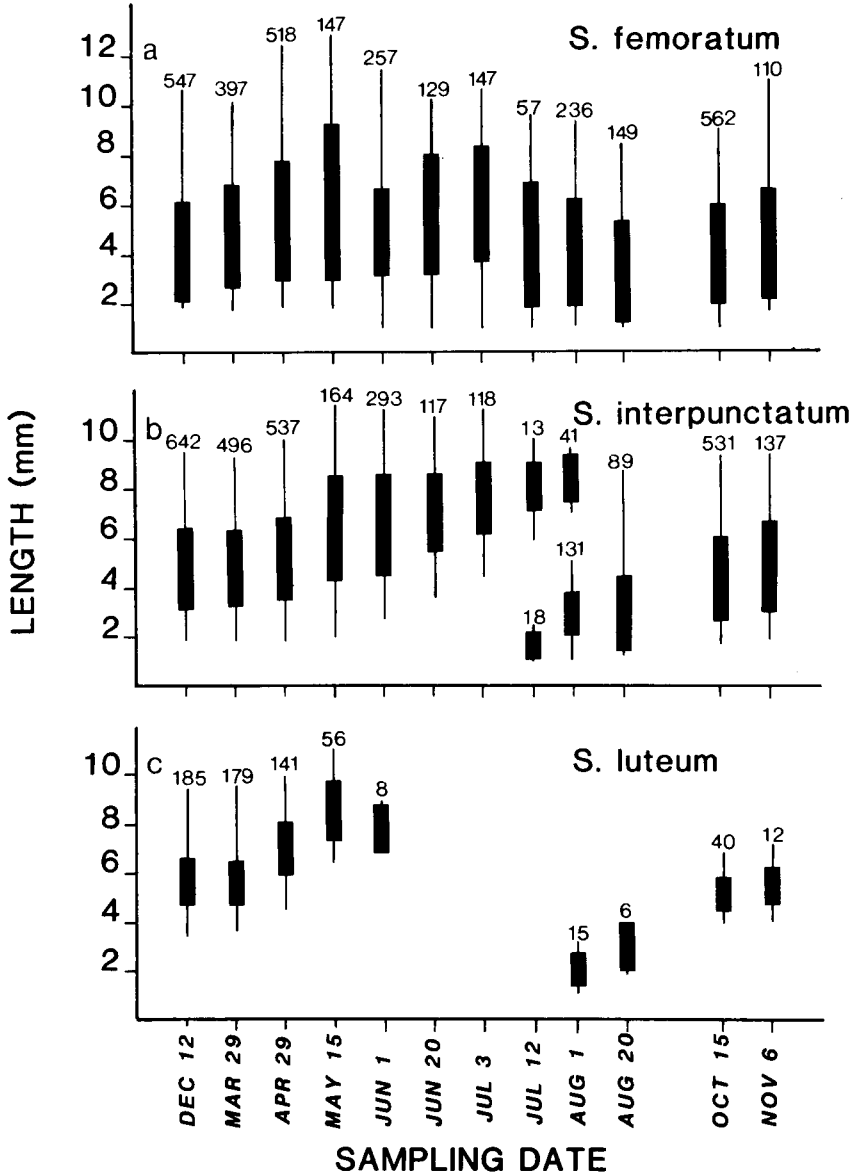


Fig. 1. Seasonal fluctuations in a) total nymph density, b) mature nymph density, c) mature nymph size and d) stream temperature (*Stenacron interpunctatum*—Si, *Stenonema femoratum*—Sf, *S. luteum*—Sl, *S. vicarium*—Sv and *S. modestum*—Sm).

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## RESULTS

Total community density before emergence ( $675\text{ m}^{-2}$ ), was dominated by *S. femoratum* (55%) and *Stenacron interpunctatum* (41%) nymphs, while *S. luteum*, *S. vicarium* and *S. modestum* made up only 12%, 1.3% and 0.6% of the community density (Fig. 1a). Populations declined as emergence began in May and June, reaching a low of  $111\text{ m}^{-2}$  by July 1, and then began increasing as recruitment of new individuals occurred.



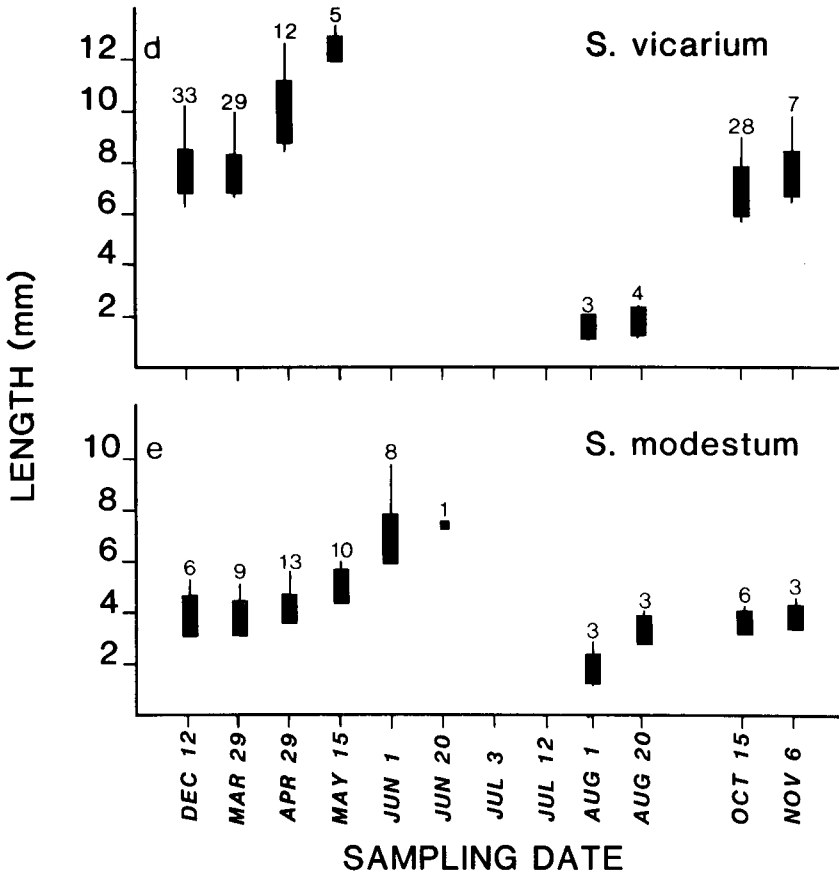


Fig. 2. Seasonal progression in length a) *Stenonema femoratum*, *Stenacron interpunctatum*, *Stenonema luteum*, b) and *S. vicarium* and *S. modestum*. Thin bars enclose range, thick bars enclose the standard deviation about the mean size and above each bar is the sample size for that date.

Unlike the other four species, *S. femoratum* (Say) appears to be bivoltine with a large winter cohort overlapping a smaller summer cohort (Fig. 2a). This is suggested by the occurrence of many small nymphs (< 2.0 mm) in the April 29 sample and a bimodal distribution of emergence. The occurrence of mature nymphs and a decline in population density suggests that emergence began after April 29 and peaked by mid-May. Emergence continued at a decreasing rate until late July and then increased to a secondary peak in mid-August (Fig. 1b). The timing of recruitment is difficult to determine. Small nymphs (< 2.0 mm) were present from late April (before emergence occurred) to mid-October, however, very small nymphs (1.0 mm) appeared in samples on June 1. These very small nymphs may have overwintered in the egg or as early instars, perhaps

as stragglers of the August emergence period the year before. Growth of nymphs occurred from spring to fall, but was greatest in spring (late April and May).

*Stenacron interpunctatum* had a univoltine winter cycle with a long emergence period (Fig. 2b). The occurrence of mature nymphs and a decline in population density indicate that emergence began in mid-May, peaked by June 1 and continued at a decreasing rate until the end of August (fig. 1a and 1b). Nymphs of the new cohort (mean size = 1.9mm) first appeared in our samples on July 15 and continued to appear until Oct. 15. Growth occurred from spring to fall but peaked in early May.

The remaining three species, *S. vicarium* (Walker), *S. luteum* (Clemens) and *S. modestum* (Banks) all had univoltine winter cycles with more easily defined cohorts (Fig. 2c, 2d and 2e). However, they differ in their periods of peak growth and emergence. Like *S. femoratum*, *S. vicarium* grows rapidly in the cool temperatures of April through early May and mid-August through early October, while rapid growth of *S. modestum* occurs in the warmer periods of late May and early August. As a result, emergence of *S. vicarium* occurred in mid-May while in *S. modestum* it occurred in mid-June. Growth and emergence periods of *S. luteum* were intermediate of these (Fig. 1b).

Mature males of each species were consistently smaller than females and the size of mature nymphs was dependent upon both species and season (Fig. 1c). Nymphs of species that matured and grew during the cool spring temperatures were generally large, relative to those growing and maturing in the warmer temperatures of early summer. This is best illustrated by a comparison of the early maturing *S. vicarium* and the late maturing *S. modestum*. Furthermore, those species with prolonged emergence periods declined in size over the season (e.g. *S. femoratum* and *Stenacron interpunctatum*.)

An analysis of the relationship between the mean body-size, of the five species at the different sampling dates indicates that some temporal segregation of species occurred (Fig. 3). In particular, the seasonal progression in body-size of *S. modestum* differs from all other species, (Fig. 2e and 3). However, while *Stenacron interpunctatum* overlaps only with *S. femoratum*, *S. femoratum*, *S. luteum* and *S. vicarium* all overlap with each other.

## DISCUSSION

Despite the second emergence peak of *S. femoratum* and the prolonged emergence and recruitment of both *S. femoratum* and *Stenacron interpunctatum*, all five species share similar life cycles; having one main univoltine winter cohort that grew and developed primarily in fall and spring. Growth periods coincided with warming and cooling trends in water temperature. Following the spring period of rapid growth, emergence peaked in May/June and offspring of these cohorts appeared in our samples in mid-summer. These general life cycle

	S.f	S.l	S.v	S.m
S.i	.62*	.02	.02	.36
S.m	.12	.21	.04	
S.v	.69*	.88*		
S.l	.66*			

Fig. 3. Correlation coefficients for the linear equations of mean body weights of each species regressed against each other species on each date over the season (*S. femoratum* —Sf, *S. interpunctatum* —Si, *S. luteum* —Sl, *S. vicarium* —Sv and *S. modestum* —Sm. For each regression  $n = 12$  and significant ( $p < 0.05$ ) correlations are marked by an asterisk.

characteristics are consistent with earlier reports of conspecific populations in other localities (Flowers & Hilsenhoff, 1978; McCafferty & Huff, 1978; Richardson & Tarter, 1976; Coleman & Hynes, 1970; Kondratieff & Voshell, 1980).

However, it is apparent that the life cycles of populations within these two genera vary from single univoltine winter cycles to bivoltine populations and even multivoltine (Clifford, 1982). Species within this group may potentially have any one of these life cycle variations given an appropriate environment and our results suggest that these are species specific in a given microhabitat.

The decline in size at emergence with increasing temperatures observed in this study, is consistent with other studies of this group (Ide, 1935; McCafferty & Pereira, 1984) and appears to be general within the hemimetabolous insects (Vannote & Sweeney, 1980). A negative relationship between growth rate and development rates results in development increasing relative to growth during the warm summer period, leading to decreased size at emergence.

There is little evidence for the expected temporal segregation of growth periods within this guild. Due to the tendency of *S. modestum* to restrict its growth to warmer periods, it is distinct from the other four species. Nonetheless, there is a high degree of temporal overlap in the growth periods and emergence of the four remaining species. It is particularly intriguing that the two numerically dominant species, *S. femoratum* and *Stenacron interpunctatum* share such temporally similar life cycles.

Coexisting species, that share similar feeding habits, may partition space rather than time. For example, Lamp & Britt (1981) noted that *Stenacron interpunctatum* tended to be found in reaches of slower currents than *Stenonema*

*pulchellum*. However, the mayfly community in Thompson's Ck. is restricted to a single pool zone; if the five species are partitioning space, it is occurring on a very small scale. We conclude that although limited temporal segregation occurs and species may utilize different microhabitats, the five co-existing mayfly species in Thompson's Ck. have remarkably similar life cycles. This community, particularly the dominant *S. femoratum* and *Stenacron interpunctatum*, should prove suitable for field manipulations designed to illuminate the mechanisms of this coexistence.

#### ACKNOWLEDGEMENTS

This research was undertaken within the Watershed Ecosystems Program at Trent University with the support of a grant to M.B. from the Natural Sciences and Engineering Research Council of Canada. We thank Lois Hollett for many long hours measuring nymphs, Dave Lasenby for advice throughout the project and G. G. E. Scudder for support of the senior author during the preparation of this manuscript. Critical reviews of an earlier draft by D. Lasenby, W. P. McCafferty and J. Richardson improved the manuscript.

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