Life History of Potamanthus myops (Walsh) (Ephemeroptera: Potamanthidae) in a Central Michigan Stream

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ABSTRACT: The life history of *Potamanthus myops* (Potamanthidae) was investigated for 1 year in a 4th-order central Michigan stream. *Potamanthus myops* has a univoltine life cycle with emergence occurring from June until mid-August. Adults averaged 16 mm in length. Fecundity was high, averaging 4559 eggs per female (range 3297-6498), with females ovipositing over riffle sections from late afternoon until after dark. Eggs hatched in approximately 2 weeks with limited nymphal growth occurring through the summer and autumn. There was no significant growth during the winter months (October to March), with nymphs undergoing accelerated growth (0.99 to 4.7% dry wt/day) from April to June. A total of 3939 degree-days (base T = 0 C) were required for *P. myops* to develop from the egg stage until emergence 1 year later.

INTRODUCTION

Potamanthidae is a relatively uncommon mayfly family with most known species occurring in Asia (Edmunds *et al.*, 1976). The genus *Potamanthus* Pictet has a Holarctic distribution (Edmunds *et al.*, 1976), with eight species recognized in eastern North America (McCafferty, 1975). Potamanthidae are placed within the superfamily Ephemeroidea, known typically as the burrowing mayflies. Although members of most families within this superfamily burrow, Potamanthidae are considered clingers and sprawlers (Edmunds, 1984) on rock substrate in streams. Members of this family are in the collector-gatherer functional group (Merritt and Cummins, 1984), feeding on epilithic material.

Earlier studies on *Potamanthus myops* (Walsh) were taxonomic, yielding little life history information (Ide, 1935; McCafferty, 1975). More recently, studies by Lord (1975) and Meier and Bartholomae (1980) have dealt with the life history and ecology of *P. myops*. Munn (1982) found densities of *P. myops* nymphs to range from 4.6/m^2 during July to 68.0/m^2 by late August. Population biomass was highest in late June just prior to peak adult emergence with a mean of 67.6 mg/m^2, decreasing rapidly to 13.4 mg/m^2 by the end of July.

This paper presents the life history of *Potamanthus myops* in a central Michigan fourth-order stream (Strahler, 1957). Life history parameters investigated include emergence period of adults, fecundity and oviposition behavior of females, along with size distribution and growth rates of nymphs for 1 year.

DESCRIPTION OF STUDY AREA

The Chippewa River is a fourth-order hardwater stream located in Midland Co., Michigan. The area consists of mixed farmland and hardwood forest. The riparian zone consists of dense forest along the river's southern bank and low shrub vegetation on its northern bank. At this site the stream averaged 60 m in width during base flow and was shallow most of the year, with discharge rates varying from 5 m^3/sec in August to 18 m^3/sec in March. Water temperatures ranged from 1 C during winter when the river was ice-covered, to 31 C during midsummer. Dissolved oxygen during the day varied from 64% saturation (9.1 mg/1iter) in mid-winter to 120% saturation (11.2 mg/

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liter) during spring. The riffle substrate was classified based on the Wentworth (1922) scale and consisted of cobble, gravel and pebble, with pebble being the dominant material. Localized regions of sand occurred throughout the riffle. Aquatic plants were present throughout the stream during the warmer seasons, with *Potamogeton pectinatus* L. and *Ceratophyllum demersum* L. the major vascular plants, while a species of *Cladophora* Kuetzing was the dominant filamentous alga.

MATERIALS AND METHODS

Sampling design. — Benthos samples were collected from a 5400 m^2 riffle using a systematic random sampling design. On each of nine sampling dates 28-34 samples were collected, with the study conducted from 30 October 1980 through 31 October 1981. Sampling intensity was greatest during spring and early summer, when nymphs undergo their most rapid growth. River conditions prohibited midwinter benthic sampling.

A 0.093 m^2 Surber sampler, fitted with a 0.5 mm mesh net, was used to collect all benthos samples. Samples were placed in 12.5% formalin and transported to the laboratory for processing.

Water temperature was monitored on a weekly basis, except during ice cover, using a Taylor maximum-minimum thermometer.

Eggs. — Egg size and number per female were determined by dissecting 10 newly emerged females. Eggs were filtered onto a .45 μm millipore filter with total counts determined at 20x magnification. Length and width measurements of 10 eggs were taken with a compound microscope at 100x.

Nymphs and adults. — Nymphs were measured from anterior of head to tip of last abdominal segment and divided into 1-mm size classes. Average weight of individuals in each group was determined after placing all members of each size class on filter paper to remove excess water and weighing them as a group to the nearest 0.1 mg with a Mettler H-30 balance.

To determine a conversion factor for estimating dry weights 10 nymphs were weighed, dried at 105 C for 24 hrs, and reweighed. An average percent difference in body weight was calculated and used to determine all dry weight values. This conversion factor was used to calculate relative growth rates (RGR) for the 1980-1981 cohort. The RGR equation is from Cummins (1975), with dry weight values expressed as mg/mg/day.

Information on emergence and oviposition of *Potamanthus myops* adults is based on 2 summers of field observations.

RESULTS AND DISCUSSION

Eggs. — *Potamanthus myops* females contained an average of 4559 eggs, with a range of 3297-6498 (Table 1). Egg number in mayflies varies within and between species, ranging from 44-148 eggs in *Dolania americana* Edmunds and Traver (Behningiidae) (Harvey *et al.*, 1980) to 2200-8000 in *Hexagenia* sp. Walsh (Ephemeridae) (Edmunds *et al.*, 1976), although higher numbers are known. It is well established that egg number in mayflies is correlated with body size (Newell and Minshall, 1978; Vannote and Sweeney, 1980). Thus, it is not surprising that the 16-mm-long *P. myops* females had such a high egg number.

TABLE 1. — Data on *P. myops* eggs collected from newly emerged females

	$\bar{X}$	SD	N	Range
Eggs/female	4,559	942	10	3,297-6,498
Egg length (mm)	0.26	.008	10	0.243-0.270
Egg width (mm)	0.12	.004	10	0.108-0.121

Eggs of *Potamanthus myops* were ovoid, averaging 0.26 mm long and 0.12 mm wide, approximating those reported by Smith (1935) for *Potamanthus rufous* Argo, a similar species, with an egg length and width of 0.22 and 0.10 mm, respectively. Eggs were a light cream color when first deposited in the water, but quickly turned to a dark brown. Polar tufts were located at each end of an egg, as previously described by Smith (1935). The polar tufts were extremely adhesive, permitting the eggs released into a stream to attach to any object.

Eggs developed in approximately 2 weeks or less, based on early instar nymphs (1-2 mm long) being collected 13 days after the first emergence of adults. Argo (1927) found eggs of *Potamanthus* sp. to hatch in 14 days under laboratory conditions. However, in our study *P. myops* eggs continued to hatch from mid-June until August, so development times may vary. Delayed or irregular hatching of some eggs may be an evolved strategy permitting insects to deal with unreliable or stressful environmental conditions (Hynes, 1970). For many aquatic insects the egg may serve as a resting stage (Hynes, 1970), with egg development sometimes taking as long as 11 months (Brittain, 1982). Much of this long development time may in actuality be a waiting period since eggs of some mayflies require a rapid rise in water temperature in spring to initiate development or hatching (Britt, 1962). At the other extreme Gray (1981) found that eggs of aquatic insects inhabiting desert streams develop extremely rapidly, *e.g.*, *Baetis quilleri* Dodds (Baetidae), which develops in 1-2 days.

Nymphs.—The 1980-1981 size class distribution of *Potamanthus myops* nymphs shows that this species has a univoltine life cycle (Fig. 1), which is common for mayflies from temperate regions. During October 1980, nymphs were in early instars, averaging 4.5 mm in length. This 1980-1981 cohort remained as early instars until March of 1981. Results from a t-test comparing mean nymphal length from October 1980 to March 1981 showed no significant difference in mean lengths, thus supporting the idea that some mayfly nymphs cease growing during the winter. Cessation of growth during the winter period has been observed in other aquatic insects (Thorup, 1963; Hynes, 1970; Wise, 1980).

Potamanthus myops did show a significant increase in length by spring. By 8 May 1981 average nymph length had increased to 5.6 mm; growth continued throughout the spring (Fig. 1, Table 2). Nymphs collected on 31 May were more variable in length, with some nymphs approaching the typical pre-emergence size of 16 mm. Nymphs rapidly increased in mean size until 21 June, with some adults emerging by 10 June. Nymphs from the 1980-1981 cohort occurred in decreasing numbers until mid-August when they had completed emergence.

The relative growth rates (RGR) of the 1980-1981 cohort demonstrate how rapidly an insect can increase its weight (mg/mg/day) just prior to emergence (Table 3). *Potamanthus myops* nymphs increased 0.24% dry wt/day throughout the winter. During spring (March-May) growth rates increased to 0.99% dry wt/day, rising to 3.0% dry wt/day by late May. Highest growth rates of the 1980-1981 cohort occurred between 31 May and 21 June, with a 4.70% dry wt/day increase. From late June to the end of July the growth rates decreased since most nymphs had already achieved their emergence size.

The second cohort (1981-1982) first appeared in late June, showing only limited growth. By mid-August, when the last of the 1980-1981 cohort had emerged, the second cohort averaged 4.3 mm in length, remaining as early instars until the next spring (Fig. 1). It should be noted that although *Potamanthus myops* are approximately 1 mm in length when they hatch (Argo, 1927), it is likely that the 0.5 mm mesh net used in sampling may not have retained all first instars; thereby, creating some error in the length and weight measurements.

Growth rates of *Potamanthus myops* are similar to other mayfly species. Humpesch (1979) found the mean growth rate to vary from 0.82-2.97%/day for *Baetis alpinus* Pictet and 0.96 to 3.33 %/day for *B. lutheri* Muller-Liebenau (Ephemeroptera). Humpesch

(1979) and Markarian (1979) found a correlation between growth rates and water temperature (expressed as degree days). We determined that *P. myops* required 3939 degree days from egg to adult (number of days times mean weekly water temperature), which is high when compared to other mayflies. Univoltine mayflies require between 1300 and

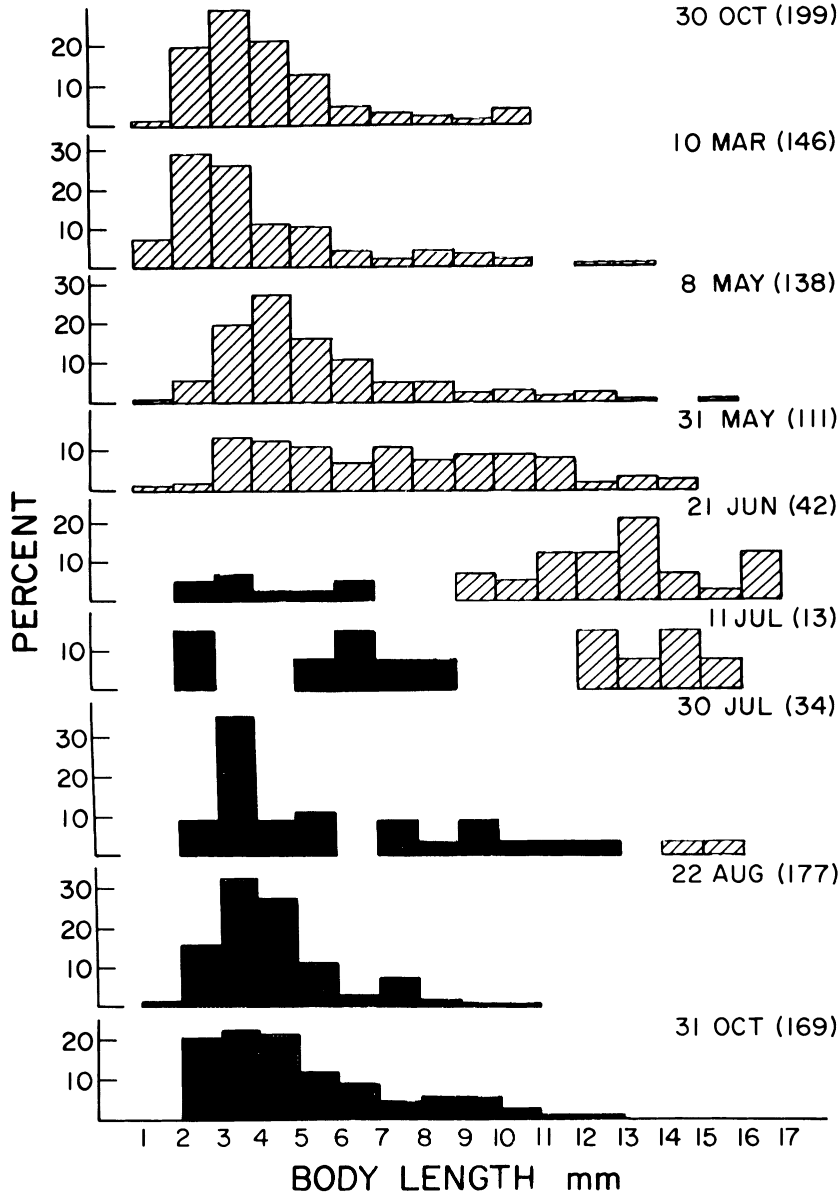

Fig. 1.—Body length frequency of *Potamanthus myops* collected from 1980-1981. Values in parenthesis are the number of individuals collected on that date. Diagonal bars are the 1980 cohort, while the darkly shaded bars are the 1981 cohort

3800 degree days for development (Cummins, 1974), depending on an individual species physiological requirements.

It should be noted that other variables besides temperature can influence aquatic insect growth. Ward and Cummins (1979) found food quality to significantly affect the growth rate of *Paratendipes albimanus* (Meigen) (Diptera: Chironomidae). Sweeney (1984) states that temperature, nutrition and photoperiod must be considered when one investigates factors which influence life histories of aquatic insects.

Adults. — Emergence. *Potamanthus myops* adults emerged from early June through mid-August, which agrees with the findings of Lord (1975) in a southern Michigan population. Under both laboratory and field conditions, mature nymphs were observed floating on the water surface when emergence took place. In a laboratory study Lord (1975) found that nymphs required approximately 15 sec from the time the nymphs reached the water surface to complete emergence.

It was difficult to determine where subimagos went upon emergence since they flew upward and eventually out of sight. Emergence of subimagos occurred only at dusk and after dark. Under laboratory conditions the subimago and imago stages lasted for 24 hrs each, although these times are known to be temperature dependent (Minshall, 1967).

Oviposition. —Mating activity was never observed during the course of this study, whereas oviposition behavior was noted on two occasions; both occurred between 1400 and 1600 hrs. In each case a single female was observed flying downstream over a riffle, then back again. During the downstream flight the female remained 2-3 m above the water surface, occasionally dropping to the water surface and floating downstream over the riffle. When the female approached the end of the riffle, it took flight again, returning to the upper part of the riffle to repeat the cycle.

After dark, numerous adults were observed flying 2-3 m above the water surface

TABLE 2. — Summary of changes in mean length over time for cohort I (1980-1981). NS = nonsignificance, * = significance at P < .01

Period	Days	$\bar{X}$ length (mm)	Sig.	N
30 Oct.-10 March	131	4.5 to 4.3	NS	199-146
10 March- 8 May	59	4.3 5.6	*	146-138
8 May-31 May	23	5.6 7.5	*	138-111
31 May-21 June	21	7.5 13.1	*	111- 33

Samples after 21 June were not used since the number of nymphs were too low to run a statistical test

TABLE 3. — Relative growth rates (RGR) calculated from the 1980-1981 cohort. Mean temperature and ranges are given for same period

		RGR		Temperature (C)	
Period	Days	mg/mg/day	Min	Mean	Max
30 Oct.-10 March	131	0.0024	−1.0	2.0	5.0
10 March- 8 May	59	0.0099	0.0	8.5	18.0
8 May-31 May	23	0.0300	15.0	18.3	21.0
31 May-21 June	21	0.4700	17.0	22.7	27.0
21 June-11 July	20	0.0100	18.0	24.5	31.0
11 July-30 July	19	0.1900	19.0	23.5	28.0

over the center of the stream. On a single night 12 adults were collected, which included seven spent females, one partially spent female, three unspent females and one male. Although oviposition behavior can occur during the daylight hours, the greater share of oviposition behavior for this species appears to occur after dark.

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