Hydrobiologia 146: 71–75 (1987)

Ecology of *Potamanthus myops* (Walsh) (Ephemeroptera: Potamanthidae) in a Michigan stream (USA)

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Keywords: *Potamanthus myops*, Michigan, density, biomass, distribution, ecology

Abstract

The ecology of *Potamanthus myops* (Potamanthidae) was examined for a one year period in a central Michigan fourth order stream. Lowest nymphal densities (4.7 m^{-2}) occurred in mid-summer after adult emergence, while highest densities were found during late summer and fall (68.0 m^{-2} and 66.2 m^{-2}) after the new cohort had hatched. Biomass was the inverse of density with highest values, 67.7 mg m^{-2}, just prior to peak adult emergence in June and lowest in late summer (16 mg m^{-2}). Nymphs maintained a contagious spatial distribution with k values ranging between 0.19 and 1.40. *P. myops* nymphs fed mostly on detritus (96.8%), placing them in the collector-gatherer functional group. Nymphs were always found in erosional zones associated with rock substrate. Nymphs used their mandibular tusks for positioning themselves beneath rocks, while also appearing to use them for defensive purposes.

Introduction

Aquatic insects play a key role in lotic systems due to their intermediate position in the food chain converting carbon, derived from both allochthonous and autochthonous sources, into animal tissue. Few studies have investigated the ecology of mayflies within the family Potamanthidae, a monobasic group containing eight Nearctic species, all of which are located in the eastern United States (McCafferty, 1975). North American studies of *Potamanthus myops* (Walsh) have included life history (Lord, 1975; Bartholomae & Meier, 1977; Munn, 1982; Munn & King, 1986) and feeding behavior (Lord, 1975; Meier & Bartholomae, 1980).

Potamanthus myops is a univoltine species (Munn & King, 1986) living in small to mid-sized streams from the Great Lakes to Florida (USA) (Edmunds *et al.*, 1976). The nymphs are found in riffles habitats and are classified as clingers and sprawlers on surface rock material even though they possess mandibular tusks (McCafferty, 1975). Species within the family Potamanthidae are in the collector-gatherer functional group (Edmunds, 1984). The purpose of this study was to investigate the ecology of *P. myops* nymphs over a one year period in the Chippewa River. Ecological parameters examined included nymphal population densities, biomass, dispersion within the riffle habitat, feeding habits, and behavior.

Materials and methods

Study area

The site chosen for study was a 5400 m^2 riffle in the Chippewa River, a fourth order stream flowing through mixed agricultural and hardwood forests of central Michigan. Bankfull width was 60 m with water depth averaging 0.2 m during late summer and increasing to 1.5 m during spring. Discharge ranged from 5.0 to 17.5 $m^3\ s^{-1}$ annually. Rooted vegetation, dominated by *Potamogeton pectinatus* L., *Ceratophylum demersum* L., and *Cladophora* sp., was present throughout the riffle areas during the summer. The riffle substrate consisted of sand, gravel, and cobble with some large woody debris.

Sampling

Benthic samples were collected using three transects and a systematic sampling design with a random starting point. The transects were 45 m apart and ran perpendicular to the bank. On nine separate dates, from October 1980 to October 1981, 28 to 34 samples were collected with a 0.093 m^2 Surber sampler fitted with a 0.5 mm mesh net. Samples were preserved in 12.5% formalin. Current velocity (cm s^{-1}) was determined at each benthic sample location using a General Oceanics flow meter, with readings taken at six-tenths depth.

Biomass

Nymphs were weighed to the nearest 0.1 mg on a Mettler H-30 balance. Wet weight values were multiplied by a previously established conversion factor (Munn & King, 1986) to determine biomass as mg dry wt m^{-2}.

Dispersion

A Chi square test was performed on data from each sample date to test whether the population fit a negative binomial distribution (Elliott, 1977). K values were calculated using equation 1 (Elliott, 1977), where n = sample number, $\bar{x}$ = mean nymphs per sample period, and s^2 = sample variance.

$$k = \frac{\bar{x}^2 - s^2/n}{s^2 - \bar{x}} \qquad \text{equation 1.}$$

Degree of sampling precision (D) values were calculated from equation 2 (Elliott, 1977), where n = sample number, k = value from equation 1, and $\bar{x}$ = mean nymphs per sample period.

$$D = \frac{1}{n\bar{x}} + \frac{1}{nk}, \qquad \text{equation 2.}$$

Pearson correlation coefficients (Sokal & Rohlf, 1973) were computed comparing current velocities with transformed insect densities (log x + 1) for eight of the sampling periods.

Food habits

Late instar nymphs were collected in midsummer, placed in 95% ethanol and immediately transferred to 6% formalin. Alcohol could not be used as a preservative because of its ability to plasmolyze plant cells; whereas, formalin induces regurgitation (Shapas & Hilsenhoff, 1976).

Gut contents of two nymphs were mixed together with 250 ml of distilled water, filtered through a gridded Millipore filter (0.45 μm) under low vacuum (100 mm Hg), and dried. A 22 mm^2 section was placed on a glass slide and cleared with cedarwood oil. Five slides were prepared and examined under a 562 × compound microscope fitted with an ocular micrometer. Ten random fields were selected per slide with food material (e.g. detritus and algae) measured for total area.

Behavior

Nymphal behavior was observed under both laboratory and field conditions. Nymphs were brought into the laboratory and placed in a 2.0 × 0.5 m plexiglass recirculating stream with natural substratum from the study site. Nymphs were observed in relation to their orientation to the substratum. Field observations consisted of noting where nymphs were positioned on the rocks and any behavioral attributes.

Results and discussion

Population ecology

Degree of sampling precision (D) for the population ranged from 16 to 41%, (Table 1), which falls within the 'tolerated' level of precision for aquatic insect studies (10–40%) (Cummins, 1975). This tolerance level relates to a 95% confidence level with a 10 to 40% error.

P. myops nymphs maintained a low population density throughout the year (Table 1). Highest average densities occurred from August to October 1980 after the second years cohort completed hatching (Munn & King, 1986). Mean densities decreased during the winter, with much of this loss due to catastrophic drift which is reported to occur from ice cover and the physical effects of ice breakup in the spring (Olsson, 1983). In spring mean densities leveled off, then decreased from early May to mid-July. This reduction was due to the emergence of adults which extends from June through August. Lowest densities were in mid-July (4.6 m^{-2}). Upon hatching of the next cohort, mean densities increased rapidly to 68 nymphs m^{-2} and remained high until spring (Table 1).

Few density estimates for *Potamanthus* are found in the literature. Zelinka (1980) reported values ranging from 133 to 206 nymphs m^{-2} for the European species *P. luteus*, which are greater than densities from our study.

Biomass

Mean biomass was inversely related to population densities (Table 1). During the winter, total weight was lowest due to nymphs overwintering as early instars (Munn & King, 1986). A rapid increase in biomass occurred during the spring, reaching a maximum of 67.6 mg m^{-2} in June, followed by an immediate decrease because of adult emergence. A slight increase in biomass was seen by late summer and fall as nymphs of the next cohort were collected. Zelinka (1980) reported biomass estimates of 70 to 1200 mg m^{-2} for *P. luteus* in Europe.

Dispersion

P. myops nymphs fit a negative binomial distribution on all sampling dates with k values below 2.0 (Table 1). This is not unusual since the majority of aquatic insects possess a contagious distribution, especially in lotic systems (Cummins, 1975; Elliott, 1977; Resh, 1979).

Table 1. Population data for *P. myops* nymphs from October 1980 to October 1981. Values are average density of nymphs m^{-2} (SE = standard error), sampling precision (D), degree of dispersion (k), and mean biomass (mg m^{-2}) (SE = standard error).

Date	N	Density (SE)	D	K	Biomass (SE)
30 OCT	32	66.2 (10.9)	0.16	1.40	23.6 (4.8)
10 MAR	34	46.2 (13.6)	0.31	0.33	21.6 (7.8)
8 MAY	31	48.6 (13.7)	0.29	0.41	41.5 (14.2)
31 MAY	33	36.8 (14.0)	0.41	0.19	63.1 (25.8)
21 JUN	32	14.7 (5.5)	0.39	0.24	67.6 (27.4)
11 JUL	30	4.7 (1.8)	0.41	0.36	14.9 (9.1)
30 JUL	31	11.8 (2.7)	0.23	1.30	13.4 (6.0)
22 AUG	28	68.0 (17.6)	0.27	0.55	17.6 (5.4)
31 OCT	33	55.8 (13.2)	0.24	0.58	24.2 (6.1)

at: 478/ms.

Alley & Anderson (1968) found a contagious distribution common where one or a few environmental parameters disproportionately influence spatial distribution. Three important factors are considered to determine microdistribution of aquatic insects which include current velocity, substrate composition, and food (Hynes, 1970; Barber & Kevern, 1973; Rabeni & Minshall, 1977).

A positive correlation ($r = 0.3032$, $P < 0.05$) was found between nymph density and water velocity on March 10, 1981. There was no correlation from May through June during adult emergence. By mid-July densities were negatively correlated with current velocity with this continuing until late August ($r = 0.8086$, $P < 0.01$). During this period females are depositing eggs into the water (Munn & King, 1986). We believe that nymphs hatch in slower waters and remain there until they can actively migrate into faster waters. By fall (October), nymphs were more common in high velocity waters, although there was no significant correlation. Thus, nymphs have a yearly cycle where they reside in faster flowing water from the fall to the spring, occur in slower moving water in late summer where eggs were laid and young nymphs grow, and return to the faster flowing water by fall. The current velocities from our study do not necessarily relate to the velocities which nymphs experience at the rock surface, but instead relate to current velocities which affect the deposition of eggs.

Food habits

Gut analysis from summer collected nymphs showed contents consisting of 96.8% detritus and 3.2% diatoms. This is in agreement with observations by Shapas & Hilsenhoff (1976) on an unknown species of *Potamanthus* from Wisconsin. Mayflies vary their diet seasonally (Brown, 1961; Chapman & Demory, 1963; Gray & Ward, 1979) due to temperature (Brown, 1961), food availability in the habitat and/or age of insect (Hawkins, 1985). Lord (1975) found *P. myops* nymphs feeding mostly on *Cladophora* sp. in the Huron River, Michigan, demonstrating the flexibility of this species.

P. myops nymphs are detritivores, which places them in the collector-gatherer functional group.

This is supported by the presence of numerous, medial hairs on *P. myops* forelegs which, according to Meier & Bartholomae (1980), the nymphs use to collect detritus from the surface of rocks at night.

Nymph behavior

When late instar nymphs were released into an artificial stream they swam to the substratum, secured themselves to a rock, and crawled to the edge of the rock and down the side until they reached the rock-sand interface. At this point the nymphs made lateral movements using their large mandibular tusks to displace the sand below the rock, thus enabling them to crawl beneath the rock. The nymphs remained on the underside of the rock during the daylight, moving out onto the surface only at night. Nymphs continuously undulated their lateral gills. This behavior is important when nymphs are underneath rocks since oxygen would be in relatively short supply.

In the field, nymphs were observed clinging to the undersides of rocks 10 to 20 cm in diameter, with two to three nymphs per rock. When agitated, a nymph would raise its head and abdomen and open its mandibular tusk. The tusks would close on a foreign object, but were unable to exert any pressure. Raising the posterior abdominal segments has been observed in other mayflies and may be advantageous since it increases the apparent size of the insect thus causing a tactile and/or visual predator to reject the prey (Peckarsky, 1980). The large mandibular tusks of *P. myops* nymphs could have an added advantage in fending off potential predators.

In summary, *P. myops* nymphs remain at low densities throughout the year with highest mean densities occurring in late summer and fall. Biomass was greatest prior to adult emergence in early June, falling off rapidly during the emergence period, and remaining low until the next spring. *P. myops* nymphs had a contagious distribution throughout the year with k values never exceeding 2.0. The contagious distribution was due to eggs being deposited in riffle sections and settling out in slower moving water. Larger nymphs moved into faster water and remained there until emergence. Stomach analyses and morphological characteristics showed the nymphs to feed on detritus, thus placing them in the collector-gatherer functional group. Nymphs were found to reside on the underside of rocks in the riffle areas. When agitated the nymphs use a 'scorpion-like' defense posture to facilitate warding off potential predators.

Acknowledgements

We thank Dr. G. Godshalk, Dr. J. B. Johnson, Dr. A. Miller, and J. Munn for reviewing the manuscript, along with Dr. W. Fairchild for his statistical assistance. We also thank Dr. W. P. McCafferty for taxonomic assistance.

References

Alley, W. P. & R. F. Anderson, 1968. Small-scale patterns of spatial distribution of the Lake Michigan macrobenthos. Proc. Conf. Great Lakes Res. 11: 1–10.

Barber, W. E. & R. N. Kevern, 1973. Ecological factors influencing macroinvertebrate standing crop distribution. Hydrobiologia 43: 53–75.

Bartholomae, P. G. & P. G. Meier, 1977. Notes on the life history of *Potamanthus myops* in Southeastern Michigan (Ephemeroptera: Potamanthidae). Great Lakes Entomol. 10: 227–232.

Brown, D. S., 1961. The food of the larvae of *Chloeon dipterum* L. and *Baetis rhodani* (Pictet) (Insecta, Ephemeroptera). J. Anim. Ecol. 30: 55–75.

Chapman, D. W. & R. L. Demory, 1963. Seasonal changes in the food ingested by aquatic insect larvae and nymphs in two Oregon streams. Ecology 44: 140–146.

Cummins, K. W., 1975. Macroinvertebrates. In B. A. Whitton (ed.), River Ecology. Blackwell Sci. Publ., England: 170–188.

Edmunds, G. F., S. L. Jenson & L. Berner, 1976. The mayflies of North and Central America. Univ. of Minn. Press. Minneapolis. 330 pp.

Edmunds, G. F. Jr., 1984. Ephemeroptera. In R. W. Merritt & K. W. Cummins (eds), An introduction to the aquatic insects of North America. 2nd. ed. Kendall/Hunt Publishing Co. Dubuque, Iowa: 94–125.

Elliott, J. M., 1977. Some methods for the statistical analysis of samples of benthic invertebrates. 2nd. ed. Freshw. Biol. Assoc. Sci. Publ. no. 25. 160 pp.

Gray, L. J. & J. V. Ward, 1979. Food habits of stream benthos at sites of differing food availability. Am. Midl. Nat. 102: 157–167.

Hawkins, C. P., 1985. Food habits of species of Ephemerellid mayflies (Ephemeroptera: Insecta) in streams of Oregon. Am. Midl. Nat. 113: 343–352.

Hynes, H. B. N., 1970. The ecology of running waters. Univ. of Toronto Press. 541 pp.

Lord, R. J., 1975. *Potamanthus*, taxonomy, ecology, life history. M.S. Thesis. Univ. of Michigan, Ann Arbor, Michigan, 65 pp.

McCafferty, W. P., 1975. The burrowing mayflies of the United States (Ephemeroptera: Ephemeroidea). Trans. Amer. Ent. Soc. 101: 447–504.

Meier, P. G. & P. G. Bartholomae, 1980. Diel periodicity in the feeding activity of *Potamanthus myops* (Ephemeroptera). Arch. Hydrobiol. 88: 1–8.

Munn, M. D., 1982. Life history and ecology of *Potamanthus myops* (Potamanthidae: Ephemeroptera) in the Chippewa River, Midland Co., MI. M.S. Thesis. Central Michigan University, Mt. Pleasant, MI 89 pp.

Munn, M. D. & R. H. King, 1986. Life history of *Potamanthus myops* (Walsh) (Ephemeroptera: Potamanthidae) in a central Michigan stream. Am. Midl. Nat. In press.

Olsson, T. I., 1983. Seasonal variation in the lateral distribution of mayfly nymphs in a boreal river. Holar. Ecol. 6: 333–339.

Peckarsky, B. L., 1980. Predator-prey interactions between stoneflies and mayflies: behavioral observations. Ecology 61: 932–943.

Rabeni, C. F. & G. W. Minshall, 1977. Factors affecting microdistribution of stream benthic insects. Oikos 29: 33–43.

Resh, V. H., 1979. Sampling variability and life history features: Basic considerations in the design of aquatic insect studies. J. Fish. Res. Board Can. 36: 290–311.

Shapas, T. J. & W. L. Hilsenhof, 1976. Feeding habits of Wisconsin's predominant lotic Plecoptera, Ephemeroptera, and Trichoptera. Great Lakes Entomol. 9: 175–188.

Sokal, R. R. & F. J. Rohlf, 1973. Introduction to Biostatistics. W. H. Freeman and Co. San Francisco. 368 pp.

Zelinka, M., 1980. Differences in the production of mayfly larvae in partial habitats of a barbel stream. Arch. Hydrobiol. 90: 284–297.

Received 7 January 1986; in revised form 7 July 1986; accepted 19 September 1986.