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INCIDENCE OF CHIRONOMID PHORETICS ON HELLGRAMMITES IN STREAMS OF SOUTHERN MAINE

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ABSTRACT - Hellgrammite nymphs (*Nigronia serricornis* Say) were collected in streams of southern Maine, 1995-1996, to assess the rate of phoresy by midge larvae. The number, location, and identification of phoretic midge larvae (Diptera: Chironomidae) were recorded for each nymph. *Nanocladius (Plecopteracoluthus) n. sp.* was the only chironomid species identified from hellgrammite hosts. Phoretic midges occurred in three of four populations and were observed on approximately 55% of all individuals examined ($n = 108$). However, frequency of phoresy ranged from 0 to 86.4%, depending on the stream. Midge phoretics occurred at a mean rate of over 1.5 per host and the number of phoretics was significantly correlated with host head capsule width. The dorsum of the first abdominal segment was the most frequent attachment site for midges. Observed frequency of phoresy in these streams were similar to published rates for chironomid/hellgrammite associations. This is the first documentation of chironomid phoresy on hellgrammites in Maine.

INTRODUCTION

Symbiotic relationships are complex interactions between species and often require the symbiont to locate, recognize, and associate with a host. Phoresy is a form of symbiosis where a host species transports another around during all or most of the symbiont's life cycle (Steffan 1967). In freshwater systems, midge larvae (Diptera: Chironomidae) have been documented as phoretics on a variety of invertebrate hosts including snails (Mancini 1979, White et al. 1980), bivalves (Forsyth and McCallum 1978), and several insect orders (e.g. Roback 1977, White and Fox 1979, Furnish et al. 1981, Epler 1986, de la Rosa 1992). In particular, at least six species within the insect order Megaloptera (dobsonflies, fishflies, or alderflies) serve as hosts for chironomid phoretics.

Megaloptera larvae (often called hellgrammites) are generally large (25-65 mm or larger), predatory, holometabolous insects common in many aquatic habitats (see Evans and Neunzig 1996 for review). Studies documenting midge phoresy rates on hellgrammites have reported frequencies as high as 93% of all individuals with symbionts (e.g. Benedict and Fisher 1972), but most reported rates of phoresy tend to be

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somewhat lower (Hilsenhoff 1968, 65%; Gotceitas and Mackay 1980, 39%; Furnish et al. 1981, 63%; de la Rosa 1992, 23%). Several chironomid species have been observed associated with hellgrammites in North America, but *Nanocladius (Plecopteracoluthus) downesi* (Steffan) has been documented most frequently. White et al. (1980) suggested that for chironomids, phoresy is a relatively common phenomenon in the Piedmont and Coastal Plain region of South Carolina. However, rates of chironomid phoresy are unknown for many other areas of the U.S.

In Maine, occurrence of chironomid phoretics on hellgrammites has not been documented and the prevalence of these associations is unknown. During preliminary sampling of a stream in southern Maine, chironomid phoretics were observed attached to nymphs of the hellgrammite, *Nigronia serricornis* Say. Here, I report the incidence of chironomid/hellgrammite associations in four streams in southern Maine. I will document the diversity and occurrence of chironomid phoretics as well as the common sites of attachment (e.g. on the thorax or abdomen, dorsally or ventrally). In addition, I will quantify the relationship between host size and the likelihood of carrying midge phoretics.

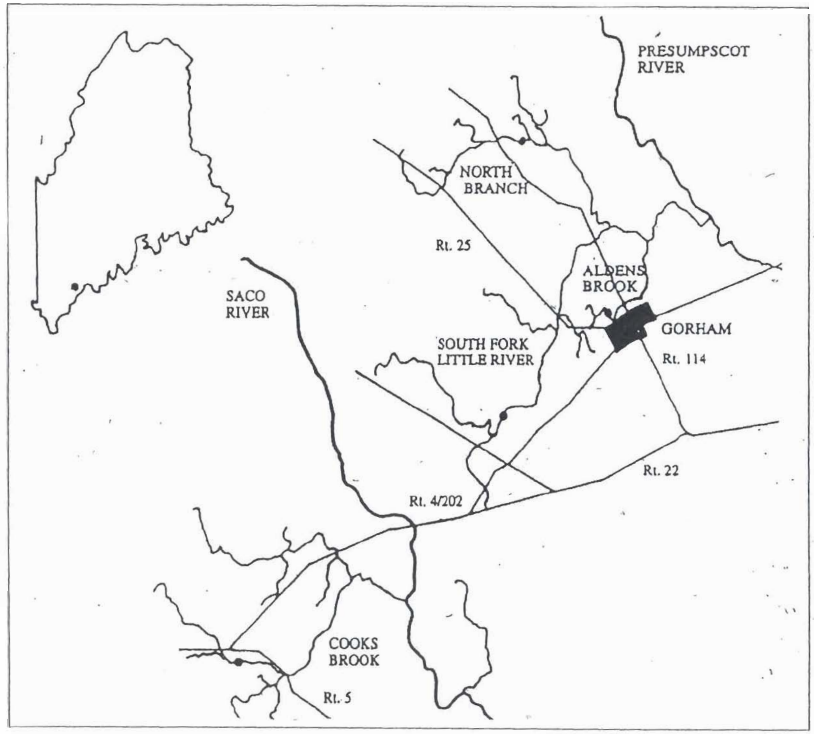

Figure 1. Location of sites sampled for *N. serricornis* larvae in southern Maine, 1995 and 1996.

RESULTS

Chironomid phoretics were observed on hellgrammites from three of four sites (Table 1). No hellgrammite larvae from Aldens Brook contained phoretics. A new, unidentified species of *Nanocladius (Plecopteracoluthus) n. sp.* was the only midge identified from hosts and is currently being described by R. Jacobsen and O. Saether (R. Jacobsen, personal communication). Collections yielded 108 hellgrammite larvae, 59 (54.6%) of which carried phoretic larvae. Within-site phoresy ranged from 0-86.4% (Table 1). The number of commensals per host ranged from 1 to 4 (overall mean = 1.54 per host). All thoracic and abdominal segments, except Ab10, were used as attachment sites

Table 1. Occurrence of chironomid phoretics on larvae of the hellgrammite, *Nigronia serricornis*, and characteristics of hosts in streams of southern Maine in 1995-1996. SFLR = South Fork of the Little River; Branch = North Branch.

Site	Date	# of larvae	mean head width (mm ± S.E.)	% with phoretics	mean # midges per hellgrammite (± S.E.)
Cooks	23.XI.95	12	1.2 ± 0.20	41.7	1.8 ± 0.49
	25.II.96	28	1.3 ± 0.17	57.1	1.7 ± 0.24
	7.IV.96	16	1.9 ± 0.16	62.5	1.7 ± 0.23
Aldens	19.I.96	20	1.8 ± 0.18	0.0	0.0
Branch	14.III.96	10	1.6 ± 0.21	80.0	1.6 ± 0.26
SFLR	22.III.96	22	2.0 ± 0.21	86.4	1.3 ± 0.13

Table 2. Percent occurrence of midge commensals on specific locations of larval *Nigronia serricornis* from southern Maine streams, 1995-1996. Aldens omitted as no phoretics were observed. SFLR = South Fork Little River; Branch = North Branch.

		Thorax		Abdomen		number of
Site	Date	nota	sterna	nota	sterna	midges
Cooks	23.XII.95	0	11.1	55.5	33.3	9
	25.II.96	0.4	0.4	74.0	18.5	27
	7.IV.96	0	11.8	70.5	17.6	17
Branch	14.III.96	7.7	23.1	61.5	7.7	13
SFLR	22.III.96	12.0	20.0	60.0	8.0	25
Total		5.5	13.2	65.9	15.4	91

METHODS

Hellgrammite nymphs, *Nigronia serricornis*, were collected from riffles in Cooks Brook (York County), Aldens Brook, North Branch, and South Fork Little River (Cumberland County), Maine, between November 1995 and April 1996 (Fig. 1). All sites are located within 20 km of the University of Southern Maine, Gorham campus. The sites are 2nd or 3rd order streams located within forested reaches dominated by white pine (*Pinus strobus*) and eastern hemlock (*Tsuga canadensis*). Aldens, S. Fork Little River, and North Branch are in the Presumpscot River watershed while Cooks Brook is located in the Saco River watershed. Cooks Brook was sampled in November, February, and April while the remaining sites were each sampled once in January or in March. Three, 90-second kick samples (net width = 46 cm, mesh = 0.5 mm) were taken in riffle areas and combined to represent a composite site sample. Samples were transported live to the lab in large buckets with stream water and several large stones.

Larvae were sorted from detritus and preserved in 70% EtOH. Head capsule width was measured for each larva using a stage micrometer on a Wild MZ8 dissecting microscope. The number and location of chironomid phoretics was recorded (Fig. 2). Midge larvae were identified by D. Goldhammer and later verified by R. Jacobsen. The relationship between host size and number of midges was examined with Pearson product-moment correlations.

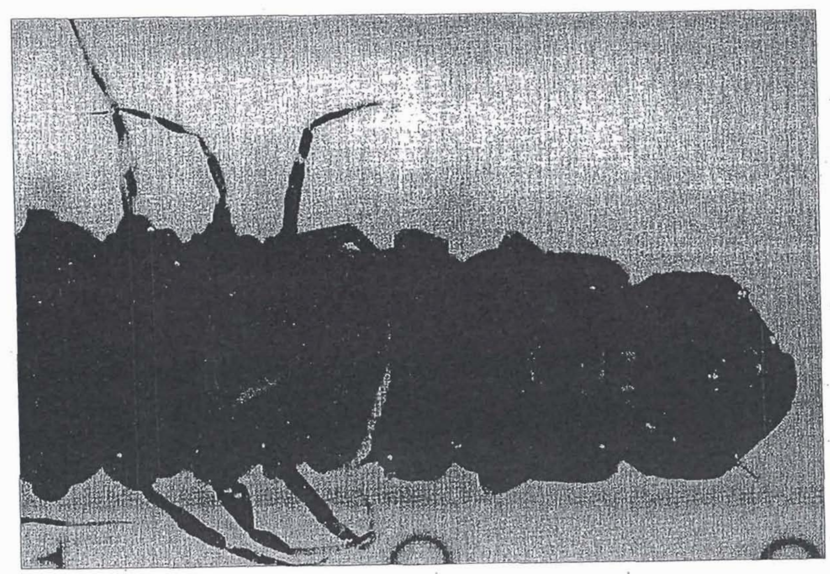

Figure 2. *Nigronia serricornis* larva with midge commensal attached to venter of third thoracic segment. Scale is in centimeters.

for midges. The midges occurred most frequently on the dorsum of the first abdominal segment (28 of 91), but were found on both dorsal and ventral aspects. Midges were found almost 2.5 times more frequently on the dorsum than on the venter of hosts (71.4 vs 28.6%, respectively; Table 2). When all hellgrammites from all streams and dates were combined, the number of larvae per host was significantly positively correlated with host head capsule width ($r = 0.32$, d.f. = 106, $P < 0.01$). However, only data from Cooks Brook exhibited a significant correlation when sites or dates were examined individually (Table 3). There was a significant site difference in mean head capsule width of hellgrammites ($H_{5,102} = 19.13$, $P = 0.002$).

DISCUSSION

In these southern Maine streams, phoretic midge associations on hellgrammites were common, occurring in three of four streams examined and on over half of all individuals. The only symbiont observed was a new, undescribed species of *Nanocladius (Plecopteracoluthus) n. sp.* and the overall incidence rate (54.6%) was similar to other reported rates of association among chironomids and Megaloptera from other regions (Hilsenhoff 1968, 65%; Gotceitas and Mackay 1980, 39%; Furnish et al. 1981, 63%). In fact, one site (SFLR) had an observed frequency of phoretics nearly as high as any rate reported in the literature (86% *vs* 93% reported by Benedict and Fisher 1972). These observations suggest that phoresy between hellgrammites and chironomids is a common phenomenon in Maine streams.

Although chironomid phoretics have not been previously reported for Maine, *Nanocladius downesi* has been reported as a symbiont on hellgrammites and stoneflies from New Hampshire. Benedict and Fisher (1972) reported finding *N. downesi* symbionts on over 90% of the *Chauliodes pectinicornis* Latreille (Megaloptera) specimens from samples in the Oyster River and noted that nymphs of the stonefly, *Acroneuria abnormis* Newman, in the North River "seemed to be heavily infested" (p. 111). Thus, chironomid phoretic associations may be common throughout New England.

Table 3. Correlations between number of midges per host and host size in streams of southern Maine in 1995-1996. *Hellgrammites from Aldens included and omitted prior to estimating correlations. Inclusion of Alden hosts is the more conservative estimate. SFLR = South Fork Little River; Branch = North Branch.

Site	Date	d.f.	r-value	P
Cooks	23.XII.95	10	0.86	<0.01
	25.II.96	26	0.48	<0.01
	7.IV.96	14	0.15	n.s.
Branch	14.III.96	8	0.50	n.s.
SFLR	22.III.96	20	0.20	n.s.
Overall w/out Aldens*		86	0.41	<0.01
Overall with Aldens*		106	0.32	<0.01

The ventral mesothorax is the attachment site most frequently reported for chironomid phoretics on Megaloptera (e.g. Benedict and Fisher 1972, Gotceitas and Mackay 1980, Furnish *et al.* 1981). However, in the present study the abdominal nota were most frequently colonized. In a study of a related hellgrammite, *Corydalus cornutus* Latrielle, Tracy and Hazelwood (1983) also found *N. downesi* occurring more frequently on the abdomen than the thorax. They speculated that the ventilatory movement of the gill tufts on *C. cornutus* might maintain an oxygen-rich microhabitat for phoretic larvae. In contrast, *N. serricornis* do not possess gill tufts on the abdomen, yet symbionts still occurred there most frequently. Further documentation of whether midges move to other regions of the host after initial colonization is needed to determine whether phoretic midges actually show site preferences on the host body. In addition, little is known about grooming behavior of hellgrammites. The potential sites available for symbiont attachment on hellgrammite larvae may differ between species, depending on extent to which a species cleans all or parts of the body. Thus, the distribution of phoretic midges on hellgrammite hosts may be determined by host behavior, not symbiont choice.

In this study there was a positive correlation between the number of phoretics and host body size and this is in agreement with other studies on phoresy rates (e.g. Hilsenhoff 1968, Furnish et al.1981). Although there was an overall correlation between host size and number of phoretics, there was much variation in the number of symbionts per host and mean head capsule width of hosts was different among the hellgrammite populations. When sites were examined separately, North Branch and South Fork Little River did not show a significant correlation between host size and number of phoretics. The North Branch site had the largest mean size of hellgrammites (Table 1), yet one of the smallest hellgrammites collected from that site (head capsule width = 0.8 mm), held two midge larvae which had total body lengths nearly equal to the total length of the host. Thus, the relationship between host head capsule width and number of phoretics in these streams is less clear than reported in other studies. Likewise, hosts were collected on different sampling dates and thus expected to be of different sizes due to differences in instars (although all sampling dates were winter or very early spring periods). Further investigations are planned to separate season and instar effects.

It was suggested by Steffan (1967) that phoretic relationships between Chironomidae and other aquatic insects are adaptations to life in strong currents. Presumably, the symbiont is less likely to be washed downstream when attached to a large host. In addition, Gotceitas and Mackay (1980) suggested that attachment to large predators conferred some protection from predation by other invertebrates since a large host was not a likely target of consumption. The occurrence of phoretic midges on the smallest hellgrammite larvae suggests that the host body size/phoresy relationship is less specific than believed in regard to safety from currents or invertebrate predators as small hosts are more prone to dislodgement by currents and are more susceptible to predation by invertebrates than are large hosts. Also, other large, known hosts of *N. downesi* (e.g., the stonefly, *Acroneuria abnormis*) occur in these streams and none carried phoretic midges.

This survey documents the occurrence and rates of chironomid phoresy on hellgrammites in some streams of southern Maine. The high incidence of phoresy in these streams suggests that this relationship is common (at least locally) in Maine even though chironomids are a likely component of hellgrammite diets (e.g. Stewart et al. 1973, Devonport and Winterbourn 1976). The observed association between midges and some of the smallest hellgrammites captured and the lack of associations between midges and other large, potentially available hosts suggests that this chironomid/hellgrammite association is rather specific in these streams. The benefits gained by midges which attach to potential predators must outweigh the costs associated with attachment or the relationship would not be maintained. It remains unclear how or why chironomid midges locate, identify, and attach to hosts and whether certain environmental conditions influence this phenomenon. Further research is needed to understand the trade-offs involved in maintaining these interesting insect-insect relationships.

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