PERSISTENCE OF MERMITHIDAE (NEMATODA) INFECTIONS IN BLACK FLY (DIPTERA: SIMULIIDAE) POPULATIONS

M. H. COLBO

Department of Biology, Memorial University, St John's, Newfoundland, Canada A1B 3X9

ABSTRACT. Data on the persistence of mermithid infections in black fly populations over several years indicate mermithid infection rates are relatively stable over several years in a stream. These data were from specific sites in a variety of streams all having the same simuliid fauna present each season. This suggests that the suitability of the stream bed for the free living phase is very important in regulating mermithid populations.

INTRODUCTION

Mermithidae are cosmopolitan parasites of arthropods, with 67 species reported from the Simuliidae (Poinar 1981). In Simuliidae preparasites penetrate the host larvae in running water, grow to adult size and obtain all requirements for the life cycle before emerging. They emerge into the water from either larval or adult hosts by rupturing the abdomen, which kills the host. Emerging larvae enter the stream substrate, molt to the nonfeeding adults, which mate and lay eggs in the substrate (Gordon 1984, Anderson and Shemanchuk 1987). In northern areas mermithids spend 6–11 months in the free living phase (Colbo and Porter 1980, Gordon 1984).

In any region, certain black fly larval populations have a very high mermithid infection rate (prevalence) suggesting a potential as biocontrol agents (Gordon 1984). Much of the data needed to critically assess this potential are not available. Long term persistence of the parasites in a habitat is one area where data are lacking. This note provides observations on this for several sites collected as an adjunct to other studies.

MATERIALS AND METHODS

Samples of larval simuliids were obtained from the eastern Avalon Peninsula, near St. John's, Newfoundland, over a 10-year period. Methods and initial data were presented in Colbo and Porter (1980). Stream substrate with larvae attached were quickly removed from the water, placed in a plastic container, packed in ice and returned to the laboratory. A minimum of 100 simuliids per sample were dissected. Those older than 4th instar were examined by dissecting microscope, with younger larvae examined as wet squashes with a compound microscope. Numbers of larvae infected and worms per infected larva were recorded.

Three sites within 15 km of St. John's were extensively sampled in the initial study viz.—Little Pond outlet stream below the culvert under the Trans-Canada Highway, Beachy Cove Brook about 100 to 200 m below Witch Hazel Road and the first 50 m of the outlet of Five Mile Pond West at the corner of the Trans-Canada Highway and Witless Bay Line. A number of other local sites were sampled once per year between 1976 and 1979, and 5 of these streams sampled at the same sites in 1986: Nagles Hill stream in Pippy Park, St. John's; Voisey's Brook off Indian Meal Line at the Portugal Cove Ball Park; Piccos Brook tributary near Flat Rock; Jones Pond outlet at and 50 m above Marine drive; a small stream crossing Marine Drive about 700 m from Middle Cove Road; and Outer Cove Brook in the Middle Cove Road ditch 100 m above junction with Outer Cove Road. All these permanent streams are 1–3 m wide.

RESULTS AND DISCUSSION

Infections in *Prosimulium mixtum* Syme and Davies populations at the same site in consecutive years were examined by arbitrarily dividing the data into low (<2%), moderate (2.1–10%) and high (>10%) mermithid prevalence classes. The data from 46 comparisons indicated only 2 of 18 low prevalence sites increased in the subsequent year. The 2 sites were in a 1- to 2-m wide stream at the upstream end of a *P. mixtum* larval habitat having mermithid prevalence rates exceeding 20% about 200 m downstream. In the 2.1–10% class, 4 of 14 sites changed (2 increased and 2 decreased), and all were in streams <3 m wide in *P. mixtum* larval habitats having mermithid prevalence rates exceeding 10% in the same stream section. In the high prevalence class, 7 of 14 sites decreased in the subsequent year, but in all cases the stream still had patches of *P. mixtum* larval habitat with prevalence rates >10% within a 100 m of the site showing the decline. The shifts between classes all reflected small shifts of mermithid populations within a stream.

Examining the prevalence 9–10 years subsequent to first sampling date (Tables 1 and 2) yielded mixed results. In the Little Pond outlet

Table 1. Prevalence of mermithids in *Prosimulium mixtum* larvae sampled just prior to pupation in the spring 8–10 years apart. The first numbers are percent infection and bracketed numbers are mean number of worms per host. The distance between sites is not equal or the same for each location but is the same between years at the same location.

Locations	Year	Sites				
		1	2	3	4	5
Nagles Hill Stream	1977	12.8 (1.8)	17.2 (1.6)	7.1 (1.5)	3.2 (2.3)	1.0 (2.0)
	1986	—	6.0 (1.0)	—	2.8 (1.0)	6.0 (1.7)
Jones Pond outlet	1977	0	1.0 (1.0)	4.7 (1.4)	8.8 (1.4)	7.3 (1.3)
	1978	0	1.4 (2.0)	3.3 (1.5)	6.6 (1.4)	—
	1986	—	—	0.0	0.3 (1.0)	—
Tributary Piccos Br.	1977	1.0 (2.0)	1.5 (1.0)	4.0 (1.5)		
	1986	8.0 (1.1)	15.0 (1.7)	—		

Table 2. Distribution of larval *Stegopterna mutata* and *Prosimulium mixtum* and mermithid prevalence in *P. mixtum* in Little Pond outlet stream on April 14, 1986, and the mean mermithid prevalence for late spring samples in 1976–79 calculated from data of Colbo and Porter (1980).

	Meters from culvert outflow					
	15	26	59	70	103	237
St. mutata/100 cm^2 *	11	0	7	240	250	15
P. mixtum/100 cm^2	130	420	340	112	278	16
% infected	0	0.5	4.9	8.8	6.3	20.6
No. of worms/host	0	1.0	1.2	1.3	1.6	2.1
$\bar{x}$ % infected 1976–79	1.6	4.3	6.1	12.3	10.0	21.4
$\bar{x}$ worms/host 1976–79	1.0	1.4	1.2	1.9	2.4	3.1

* No mermithids found in this species in any of the years sampled.

stream, the distribution of *Stegopterna mutata* (Malloch) and *Prosimulium mixtum* larvae and the mermithid parasitism pattern were comparable to that found from 1976 to 1979 (Colbo 1979, Colbo and Porter 1980, Table 2). Two others, Voisey's and Outer Cove Brook, were negative in 1977 and 1986. Three sites changed considerably over the period. In Jones Pond outlet stream a 100-m section of stream (sites 1–3 in Table 1) was diverted after 1979; however, *P. mixtum* populations were still abundant in 1986, but mermithid prevalence was very low. In the Nagles Hill stream and the Piccos Brook tributary, mermithids persisted, but the mermithid population shifted downstream about 2–300 m. It is concluded that *P. mixtum* mermithid populations persist at a given prevalence rate over many years if not disturbed, but shifts in distribution within a stream may occur.

The general survey data from the *Simulium venustum/verecundum* complex were highly variable between subsequent years, probably reflecting variability of stream temperatures between years. This affects hatching times and development rates of the hosts and the parasites. Therefore, the one-time survey samples collect host preimaginals in several stages of development from stream to stream and year to year in

Table 3. Prevalence of Mermithidae in *Simulium venustum/verecundum* complex along a 90-m section of Beachy Cove Brook 240 m below a lake in 1977 and 1986.

Distance (m)	1977			1986	
	May 15	June 2	June 15	May 15	
	instars				
	all	all	all	</=4	>4
240	55	25	37	8	0
260	33	19	46	14	4
280	—	14	46	32	0
300	14	25	68	28	2
330	—	13	48	25	0

the same stream, which can bias recorded mermithid prevalence. In contrast, the winter developing *P. mixtum* populations develop in relatively cold constant water temperatures for some weeks, making comparable late instar sampling feasible, as pupation does not occur before the spring rise in water temperature. Sampling before pupation is critical as nonparasitized larvae pupate early, increasing the parasite prevalence in the remaining larvae.

A second problem with mermithid surveys of *S. venustum/verecundum* host populations is that the host is a complex of 5 sibling species (AC(gb), EFG/C, CC, AA and ACD) here (Rothfels et al. 1978). Unpublished data of McCreadie and Colbo indicate the 5 cytotypes have different spatial and temporal distribution patterns. In addition, Colbo and Porter (1979) suggested mermithids were very species specific. Thus different sites and dates can have different sibling species, making one-time sample comparisons invalid. Sequential sampling of hosts at the same site over the season can yield comparative data, as sibling species temporal sequence is similar. Five sites were sampled in this way. Two had a mermithid prevalence of >10% before pupation in 1976, 1977, 1978 and in 1986, while 3 had a prevalence of <2% in 1977 and 1986.

The data for Beachy Cove Brook sites (Table 3), which had a high prevalence in the *S. venustum/verecundum* complex over many years, illustrate the above points. In 1977, larvae of the complex were just hatching on May 15 with first pupation on June 15, while in 1986 pupation had started by May 15, but early instars of the complex were also present and heavily infected. The mean air temperatures for April and May were 1.8 and 4.7°C in 1977 and 4.2 and 6.1°C in 1986 at St. John's airport. These temperature differences probably altered host development patterns and the mermithid infection rates in these 2 years. Two samples of *S. venustum/verecundum* complex larvae taken at this site on May 16 and 30, 1986, were cytotyped. Fifteen mature larvae in the May 16 sample were AC(gb), EFG/C and CC, while the 15 from May 30 were all CC (J. W. McCreadie, personal communication). The change in sibling composition shows differences in hatching times of siblings as well as differences in susceptibility to mermithids as suggested by Colbo and Porter (1980). Therefore, sampling once a year at a site will produce highly variable prevalence rates with a mixed host population. The current data support the view that mermithid species are very specific to a given host. Thus the continued assigning of mermithids from several simuliid hosts all over North America to one species (e.g., Harkrider 1988) is erroneous. The result is a masking of the various host-parasite relations that must occur for the parasites to survive. What is required is an examination of black fly mermithid parasites using current taxonomic techniques to clarify their classification and biology.

The outlet of Five Mile Pond West with a pure spring population of the EFG/C cytotype of *S. venustum* has a high prevalence of mermithids which infect the larvae but emerge only from the adults (Colbo and Porter 1980). The prevalence in channel 2 at the boulder dam was 20.2 and 18.3%, and 15 m downstream it was 30.4 and 29.2% in 1978 and 1986, respectively, while the main channel after all branches have joined was 21.3 and 28.1% in 1978 and 1986, respectively. Mixed samples from this stream in 1977 yielded prevalence rates of <30%. Both above cases indicate a long term persistence of mermithid infections at a high prevalence in this host complex inhabiting 2- to 3-m wide permanent streams.

The above study and Colbo and Porter (1980) have shown the mermithids are widespread with high and low prevalence infections persisting for at least 10 years. The wide distribution is because at least some adults are always infected and they deposit the worms at oviposition sites (Colbo 1982, Gordon 1984). Why sites with higher prevalence are rare but relatively stable is not explained. The survival of the free living stages in the stream bed, a virtual unknown part of their biology, is likely the key.

ACKNOWLEDGMENTS

I thank John McCreadie for providing the cytotypes of the simuliid larvae. The comments of G. F. Bennett, R. Gordon and D. Larson were much appreciated. Financial support was from Natural Sciences and Engineering Research Council operating grants.

REFERENCES CITED

Anderson, J. R. and J. A. Shemanchuk. 1987. The biology of *Simulium arcticum* Malloch in Alberta. Part II. Seasonal parity structure and mermithid parasitism of populations attacking cattle and flying over the Athabasca River. Can. Entomol. 119:29–44.

Colbo, M. H. 1979. Distribution of winter-developing Simuliidae (Diptera) in eastern Newfoundland. Can. J. Zool. 57:2143–2152.

Colbo, M. H. 1982. Size and fecundity of adult Simuliidae (Diptera) as a function of stream habitat, year and parasitism. Can. J. Zool. 60:2507–2513.

Colbo, M. H. and J. N. Porter. 1980. Distribution and specificity of Mermithidae (Nematoda) infecting Simuliidae (Diptera) in Newfoundland. Can. J. Zool. 58:1483–1490.

Gordon, R. 1984. Nematode parasites of black flies. pp. 821–847. *In:* W. R. Nickle (ed.), Plant and insect nematodes. Marcel Dekker, New York.

Harkrider, J. R. 1988. A field study of larval black flies (Diptera: Simuliidae) by *Neomesomermis flumenalis* (Nematoda: Mermithidae) in southern California. Environ. Entomol. 17:391–397.

Poinar, G. O. Jr. 1981. Mermithid nematodes of black flies. pp. 159–170. *In:* M. Laird (ed.), Blackflies: the future for biological methods in integrated control. Academic Press, London.

Rothfels, K. H., R. Feraday and A. Kaneps. 1978. A cytological description of sibling species of *Simulium venustum* and *S. verecundum* with standard maps for the subgenus *Simulium* Davies (Diptera). Can. J. Zool. 56:1110–1128.