The Host–Parasite Relationships and Seasonal Occurrence of *Fessisentis friedi* (Acanthocephala: Fessisentidae) in the Isopod (*Caecidotea communis*)

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ABSTRACT: A total of 2,996 isopods (*Caecidotea communis*) from the Old Reservior, Durham, New Hampshire were examined during the period March 1975 through August 1976. One hundred and sixty-eight (5.6%) were infected with larval stages of *Fessisentis friedi*. Prevalence was high in isopods between 4.0–12.9 mm in length. Mean intensity was highest in medium size isopods between 8.0–11.9 mm. Most of the cystacanths found were facing posteriad in the isopods. Cystacanths occupied the left and right sides of the hemocoel more frequently than the median area. Cystacanths of *F. friedi* were precocious in their development in isopods.

Although larval acanthocephalans were recovered throughout the sampling period, *F. friedi* exhibited a definite seasonal prevalence in isopods. Prevalence reached its highest values in April through July 1975. It then declined and remained low in August through March 1976. Although prevalence was again high in April through July 1976, the number of isopods infected was significantly lower than the number infected in the same months of 1975. Recruitment of acanthellae of *F. friedi* into the isopod population occurred in late May through July 1975 and April through July 1976. Factors believed to be involved in the maintenance of this seasonal occurrence are discussed.

Haley and Bullock (1953) described *Fessisentis vancleavi* from sunfish of the "Old Reservoir" at Durham, New Hampshire. Fried, Kitchen, and Koplin (1965) investigated the seasonal periodicity of *F. vancleavi* in *Catostomus commersoni* in Pennsylvania. Fried and Koplin (1967) examined the morphological variability of *F. vancleavi.* Nickol (1972), who revised the genus *Fessisentis*, renamed this species *F. friedi.*

Miller (1954), in an unpublished Master's Thesis (University of New Hampshire), partially investigated the host–parasite relationships of larval *F. friedi* in *Asellus militaris* (shown to be *Caecidotea communis* by Bowman, 1975). Nickol and Heard (1973) examined the relationships of *F. necturorum* infecting *A. scrupulosus.*

The present study was undertaken to elucidate some aspects of the host–parasite relationships and seasonal occurrence of larval *F. friedi* in its intermediate host (*Caecidotea communis*).

Materials and Methods

The area of study was the "Old Reservoir," located in Durham, New Hampshire. It is a long, narrow body of water that is divided by a culvert. Isopods were collected by removing them individually from leaf litter with the aid of forceps in that region of the reservoir west of the culvert during the months of March 1975 through August 1976. This area is shallow, with large amounts of vegetation and leaf litter. There are many overhanging bushes, elm and pine trees. The leaf litter consists of elm leaves and pine needles.

Isopods were brought to the laboratory alive. They were sexed and measured by a substage micrometer. The length was measured from the anterior margin of the cephalothorax to the posterior margin of the abdomen. The live isopods were dissected within 36 hr of collection. Any acanthocephalans present were removed and relaxed in distilled water, and their number and sex recorded where possible. They were then assigned to stages of acanthella or cystacanth. These stages were invariably found in the hemocoel. The areas occupied were: left, right, and median. Cystacanths were oriented with the presoma either facing anteriad or posteriad.

Divisions of the year, based on ambient water temperatures, were established as follows: April–July 1975; August–November; December–March 1976; and April–July 1976.

Prevalence is the percent of infected hosts in a given sample. Mean intensity is the num-

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Table 1. Prevalence and mean intensity of *F. friedi* recovered from 2,996 *C. communis* of various size classes (mm), examined during March 1975 through August 1976.

Isopod size	No. isopods examined	No. infected and prevalence	Mean intensity	Standard deviation
2.0–2.9	153	0 (0.00)	0.00	0.00
3.0–3.9	191	3 (1.57)	1.00	0.12
4.0–4.9	452	22 (4.86)	1.13	0.46
5.0–5.9	209	10 (4.78)	1.00	0.21
6.0–6.9	83	7 (8.43)	1.00	0.28
7.0–7.9	123	7 (5.69)	1.00	0.23
8.0–8.9	145	20(13.79)	1.40	0.68
9.0–9.9	311	23 (7.39)	1.26	0.68
10.0–10.9	396	29 (7.32)	1.17	0.60
11.0–11.9	315	29 (9.20)	1.27	0.52
12.0–12.9	171	11 (6.43)	1.00	0.25
13.0–13.9	129	3 (2.30)	1.00	0.15
14.0–14.9	122	3 (2.45)	1.00	0.16
15.0–15.9	90	0 (0.00)	0.00	0.00
16.0–16.9	86	1 (1.16)	1.00	0.11
17.0–17.9	20	0 (0.00)	0.00	0.00
Total	2,996	168 (5.60)		

ber of worms per infected host. Statistical procedures used were from Sokal and Rohlf (1969).

Specimens of *Fessisentis friedi* from the isopods have been deposited at the Manter Parasitology Lab of the University of Nebraska State Museum.

Results

Host–parasite relationships

A total of 2,996 isopods were examined in the period from March 1975 through August 1976. One hundred and sixty-eight (5.6%) were infected with larval stages of *Fessisentis friedi.* There was no significant difference between the number of infected male (79) and female (89) isopods. Of the 168, 145 (86.3%) had single infections and 23 (13.7%) had multiple infections. There was no significant difference between the number of multiple infections in female (15) and male (8) isopods. The ranges and mean lengths of infected male and female isopods were 3.0–16.0 (9.15 mm) and 3.0–12.0 (8.37 mm), respectively. The number of acanthocephalan larvae was not related to the size of infected isopods.

Isopods smaller than 3.9 mm and larger 13.0 mm were seldom infected (Table 1). Prevalence increased in isopods over 4.0 mm, and was generally stable in isopods up to 12.9 mm, except for those 8.0–8.9 mm in length, where prevalence was maximum (13.79%). Generally, mean intensity was low in all isopod size-classes. However, it reached its highest values in medium sized isopods between 8.0–11.9 mm.

The total number of acanthocephalans recovered from the 168 infected isopods was 198. The maximum intensity was four. The sex distribution of cystacanths was close to the theoretical value of 1:1, 86 male and 82 female.

One hundred and one (60.1%) cystacanths were directed posteriorly and 67 (39.8%) directed anteriorly. There was a significant difference between the number of cystacanths directed posteriorly (46) and anteriorly (26) in male isopods ($\chi^2 = 5.54$, $P < 0.025$), but not in female isopods.

The number of larval acanthocephalans found in each position in the hemocoel was as follows: 86 (50.2%) occupied the left side; 68 (39.7%) occupied the right side; and 17 (9.9%) occupied a median position. More cystacanths occupied the left and right hemocoel positions than the median position ($\chi^2 = 46.2$, $P < 0.005$; $\chi^2 = 30.6$, $P < 0.005$, respectively). They were not found in the gill (opercular) area. Five female and three male cystacanths were bent and reflected on themselves.

Seasonal occurrence

Isopods were infected with cystacanths of *F. friedi* in every month sampled (Table 2). *Fessisentis friedi* exhibited a distinct seasonal prevalence. Following a March 1975 low, prevalence increased sharply in April to a peak in June, and decreased in July. Prevalence remained low and similar in August through March 1976. It then increased in April 1976, peaked again in June, and decreased during July through August. Mean intensity was low throughout the sampling period, with highest intensity values occurring during April through June 1975 and July 1976, corresponding to the high prevalences during these times.

A significantly larger number of infected isopods was collected during April through July 1975 ($\chi^2 = 106.68$, $P < 0.005$) and in the same months of 1976 ($\chi^2 = 32.64$, $P < 0.005$) when compared to the other established

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Table 2. Prevalence and mean intensity of *F. friedi* in 2,996 *C. communis* examined during March 1975 through August 1976.

Month	No. isopods examined	No. infected and prevalence	Mean intensity	Standard deviation	Mean length of infected isopod	Standard deviation
Mar. (75)	205	5 (2.4)	1.0	.15	11.70	2.19
Apr.	176	16 (9.1)	1.3	.38	10.00	1.66
May	298	51 (17.1)	1.3	.57	9.93	1.67
June	96	20 (20.8)	1.4	.66	10.14	1.28
July	210	11 (5.2)	1.0	.22	4.18	.60
Aug.	221	3 (1.4)	1.0	.11	4.33	.57
Sep.	162	3 (1.9)	1.0	.13	4.00	0.00
Oct.	173	4 (2.3)	1.0	.15	5.50	.58
Nov.	178	3 (1.7)	1.0	.12	6.66	1.33
Dec.	198	6 (3.0)	1.0	.17	9.50	3.01
Jan. (76)	173	1 (0.6)	1.0	.07	9.00	0.00
Feb.	186	2 (1.1)	1.0	.10	11.00	1.41
Mar.	112	2 (1.8)	1.0	.13	12.00	2.82
Apr.	114	6 (5.3)	1.0	.22	9.83	1.72
May	112	7 (6.3)	1.0	.24	10.94	.83
June	112	13 (11.6)	1.0	.32	9.30	2.47
July	123	12 (9.8)	1.3	.41	4.58	2.10
Aug.	147	3 (2.0)	1.0	.14	5.16	.57
Total	2,996	168 (5.6)				

divisions of the year (RXC test of independence; analysis completed by A posteriori simultaneous test procedure). Prevalence, however, was higher in April through July 1975 than in these months in 1976.

Discussion

Host–parasite relationships

The cystacanths of *Fessisentis friedi* are free and unencysted in the hemocoel of isopods. The proboscides of all cystacanths were fully inverted, and in a few instances, the resulting vestibule was covered by a small plug of yellow material. Female and male cystacanths were similar in size and were impossible to differentiate without the aid of a microscope.

Fessisentis friedi is precocious in its development in isopods. The testes, seminal vesicles, and cement glands of male cystacanths stain darkly, indicating possible presence of semen. The ovaries of female cystacanths were fragmented, forming masses of ovarian balls. Similar fragmentation was observed for *Prosthorhynchus formosus*, *Neoechinorhynchus rutili*, *F. necturorum*, and *Acanthocephalus jacksoni* (Schmidt and Olsen, 1964; Merrit and Pratt, 1964; Nickol and Heard, 1973; Muzzall and Rabalais, 1975b).

The sex ratio of *F. friedi* of 1:1 infecting isopods is similar to that found by other authors working with larval acanthocephalans, most notably Parenti, Antoniotti, and Beccio (1965); Crompton and Whitfield (1968); Amante, Fresi, and Laneri (1967); and Muzzall and Rabalais (1975b).

Although more cystacanths of *F. friedi* occupied the left side (86) than the right side (68) of the hemocoel, the difference was not significant. A larger number of cystacanths were directed posteriorly (101) than anteriorly (67); however, this difference was only significant in male isopods. Similar results have been reported by Muzzall and Rabalais (1975b) for *A. jacksoni* infecting *Lirceus lineatus*, and by Nickol and Heard (1973) for *F. necturorum*, which faced posteriad in *Asellus scrupulosus*.

The overall prevalence (5.6%) of *F. friedi* infecting isopods is quite low when compared to the results of Seidenberg (1973), Hine and Kennedy (1974), and Muzzall and Rabalais (1975b).

A few authors (Munro, 1953; Hynes, 1955; Hynes and Nicholas, 1963) demonstrated that larval acanthocephalans interfered with the development and attainment of sexual maturity of amphipod and isopod intermediate hosts. Muzzall and Rabalais (1975b) never observed female isopods infected with *A. jacksoni* carrying eggs in the field or laboratory.

The following observations of isopods infected with *F. friedi* were noted in the present study: one male and six females were in precopula, four females carried eggs, three females had live young in the brood pouch, and two females had empty brood pouches. These

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results suggest that a small number of female isopods infected with *F. friedi* appear to undergo "normal" development and mating behavior to sexual maturity. It is not known if the number of eggs or larvae carried by infected female isopods is smaller than those carried by noninfected females. Similar results were reported by Spaeth (1951), who found that female *Hyalella azteca* infected with *Leptorhynchoides thecatus* developed ova and bore young.

Pigmentation differences between infected and noninfected isopods were not observed.

Seasonal occurrence

Several authors (Hynes and Nicholas, 1957, 1963; Awachie, 1965; Seidenberg, 1973; Spencer, 1974; Muzzall and Rabalais, 1975a) demonstrated seasonal occurrence of larval acanthocephalans infecting their respective intermediate hosts. On the other hand, Hine and Kennedy (1974) did not observe a seasonal occurrence of *Pomphorhynchus laevis* infecting *Gammarus pulex*.

Fessisentis friedi exhibits a seasonal occurrence in prevalence and, to a lesser degree, in mean intensity in its isopod intermediate host (Table 2). Two periods of high prevalence were observed. One occurred in the months of April through July 1975. Prevalence was again high in the same months of 1976, constituting the second period. The difference in magnitude of these two periods cannot be accounted for.

It is difficult to explain the seasonal occurrence of a parasite in its intermediate host without knowing the seasonal aspects of the definitive host–parasite system. Fried et al. (1965) found that white suckers (*Catostomus commersoni*) were infected with *F. friedi* in October through December and not in May. The investigation of Miller (1954) in the Old Reservoir may help to explain the seasonal occurrence of *F. friedi* in isopods from the same locality. He found that pickerel (*Esox americanus*) averaging 9.4 inches in length harbored adults of *F. friedi* in February, March, and May. In February and March fish were caught in water 5 feet in depth or more. Pickerel may have become infected during the previous spring while spawning and/or in the winter, since Miller found isopods to be a common food item at this time. He seined pickerel in shallow water in the spring and summer; they were not trapped in deep water. As pickerel move into shallow areas of ponds and lakes ("Old Reservoir") to spawn in the spring (Scarola, 1973), eggs of *F. friedi* may be released into the environment.

Following a low prevalence in March 1975, more isopods became infected and prevalence increased during April through June 1975 as water temperature increased (Table 2). Most of the isopods infected in April through June were of medium size between 8.0–11.9 mm. An abrupt decrease in prevalence occurred in July and August due to the natural mortality of large, infected individuals from the isopod population in June. The ranges and mean lengths of infected and noninfected isopods decreased from 7.0–14.0 (10.30 mm) in June to 2.0–7.0 (3.71 mm) in July. This decrease in prevalence also resulted from the addition to the population of many small, uninfected isopods. In late May through early June, large numbers of female isopods carried eggs and larvae. Small isopods between 2.0–5.0 mm were prevalent in July through September. Prevalence remained low and generally uniform in August 1975 through March 1976. At the end of September, new leaves, which provide a suitable substrate for isopods, entered this host–parasite system. Stark (1965) and Seidenberg (1973) noted a similar "dilution" of infected individuals of the old generation with a new uninfected generation of *Gammarus zaddachi* infected with *Diplocotyle*, and *Asellus intermedius* infected with *Acanthocephalus dirus*, respectively.

Although cystacanths were recovered in all months sampled in 1975, it is believed that late May through July 1975 was the period when most isopods became infected, since 12 acanthellae, representing the recruitment portion of the population, were recovered during this period. The range and mean length of these infected isopods was 6.5–14.0 (9.18 mm). During the fall of 1975 and winter of 1976, the size of infected (Table 2) and noninfected isopods increased. One acanthella was recovered in December 1975. Seventeen acanthellae were recovered in April through July, constituting the recruitment period in 1976. The range and mean length of isopods infected with acanthellae during this time was

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3.0–12.0 (5.76 mm). The prevalence of cystacanths of *F. friedi* in isopods increased in April through June 1976 as water temperature increased, dropped slightly in June, and declined in August when water temperature was maximum (30°C).

The seasonal occurrence of *F. friedi* in isopods may be related to the spawning habits of pickerel which harbor adults of *F. friedi*; the close timing between the release of eggs into the environment and the appearance of a new generation of isopods; and changes in the composition of the isopod population.

Acknowledgments

Acknowledgment is due to Drs. Wilbur L. Bullock and Robert A. Croker, Zoology Department, University of New Hampshire for their review of the early manuscript and to Dr. Thomas E. Bowman, Department of Invertebrate Zoology, Smithsonian Institution, who kindly identified the isopod species.

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Observations on the Subfamily Aetholaiminae Jairajpuri, 1965 (Nygolaimidae: Nematoda)

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ABSTRACT: *Mylodiscus nanus* Thorne, 1939 is redescribed from specimens collected in the State of Bahia, Brazil. It has an axial odontostyle and therefore does not belong with *Aetholaimus* Williams, 1962 to the Nygolaimidae, subfamily Aetholaiminae. The abrupt esophageal expansion, location of dorsal esophageal gland orifice, and presence of oval organs in the lateral chord indicate that it belongs to Discolaimidae. *Dorylaimus rotundicauda* de Man, 1880, currently placed under *Carcharolaimus* Thorne, 1939, is redescribed from specimens collected in the Netherlands and Switzerland. The presence of a mural tooth and of three "cardiac glands" show that it belongs to the Nygolaimidae; it is transferred to *Aetholaimus*. The latter genus now contains four species and is briefly reviewed.

In 1939 Thorne described a new genus and species *Mylodiscus nanus* from a single female collected on the Island of Sumatra, Indonesia. He placed this genus in the subfamily Actinolaiminae of the family Dorylaimidae because of the presence of sclerotization in the stomatal region. He could not decide whether it had an axial stylet or a mural tooth.

In 1962 Williams described a new genus and species *Aetholaimus bucculentus* from the Island of Mauritius, which he placed in the family Nygolaimidae because it possessed a mural tooth instead of an axial odontostyle. He noted, however, that this species also possessed a character reminiscent of the Actinolaiminae, viz. sclerotization in the stomatal region; and he noted certain resemblances between *Aetholaimus* and *Mylodiscus*. In 1965 Jairajpuri united these two genera into the new subfamily Aetholaiminae—recently raised to family rank by Andrássy (1976); again he noted that the position of *Mylodiscus* required further clarification.

During a survey of plant parasitic nematodes in the State of Bahia, Brazil, carried out in cooperation with Dr. R. D. Sharma, the second author collected several females and juveniles of *Mylodiscus*, so that redescription is possible and its taxonomic position can be clarified. Paratypes of *Aetholaimus bucculentus* were kindly put at our disposal by Mr. D. J. Hooper, Rothamsted, England, and Dr. M. S. Jairajpuri lent a specimen from India, identified by him as *Ae. indicus*.

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