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OBSERVATIONS ON THE OCCURRENCE OF *Diplostomum spathaceum* AND *Schistocephalus* SP. IN NINESPINE STICKLEBACKS *(Pungitius pungitius)* FROM THE BELCHER ISLANDS, NORTHWEST TERRITORIES, CANADA

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Abstract: All 175 ninespine sticklebacks, *Pungitius pungitius* (Linné), collected from the Belcher Islands were parasitized by *Diplostomum spathaceum* (Rudolphi) and 43% by *Schistocephalus* sp. *D. spathaceum* metacercariae were mostly confined to a dorso-ventral band encircling the lens of the eye, and were concentrated in the anterio-dorsal sector of this band. The central area of the lens was thus relatively free of diplostomula, probably minimizing interference with the vision of the fish. The frequency distribution of *D. spathaceum* abundance in *P. pungitius* was closely approximated by a negative binomial, while that for *Schistocephalus* was best fitted by a Poisson. None of the fish condition factors examined appeared related to the intensity of the parasitic infections.

INTRODUCTION

The ninespine stickleback, *Pungitius pungitius* (Linné), is common in the shallows of lakes on the Belcher Islands of Hudson Bay, where it comprises a food item for piscivorous birds and for larger fish such as the arctic char, *Salvelinus alpinus* (Linné). This paper presents the results of analyses carried out on a preserved collection of *P. pungitius* to determine the prevalence and intensity of infection by *Diplostomum spathaceum* (Rudolphi) and *Schistocephalus* sp., two helminth parasites abundantly found in the host. Pathogenic effects of these worms on their host are investigated here by examining relationships between fish condition factors and levels of parasitism.

No information is available on the parasites of *P. pungitius* in the Hudson Bay region of northern Canada, although the occurrence of *Schistocephalus solidus* and *D. spathaceum* in *P. pungitius* has been reported for other areas of North America,[7] the U.K.[4] and the Soviet Union.[5] *D. spathaceum* in the eyes of its host sometimes causes blindness.[6] Lester[8] attempted to measure mortality due to *D. adamsi* Lyster and Huizinga in perch, *Perca flavescens* (Mitchill), from Lake Ontario. Arme and Owen[2] described the pathogenic effects of *S. solidus* plerocercoids on threespine sticklebacks, *Gasterosteus aculeatus* Linné; they entail reductions in liver weight and in packed cell volume of erythrocytes, and a suppression of oocyte maturation in females.

MATERIALS AND METHODS

The samples of *P. pungitius* were obtained by hand seine in shallow water near the shore of the Kasegalik River (55°55′ N, 79°37′ W) between 10 July and 3 August 1959 and fixed in 5% formaldehyde. For each preserved specimen measurements were made of fork length, total weight, and eviscerated weight. For this, the esophagus was severed immediately anterior to the stomach and all organs removed from the body cavity. Liver and gonads were weighed separately, as were any *Schistocephalus* plerocercoids found in the coelom. Numbers of *D. spathaceum* metacercariae were recorded during dissections of the fish eyes. Becauses otoliths had deteriorated in the preservative, the fish could not be aged. There were 73 females and 98 males in the collection.

Poisson and negative binomial probability functions were fitted to frequency distributions for *D. spathaceum* and *Schistocephalus* occurrences in the fish, using the FORTRAN programs of Davies.[4] Fish condition was expressed both as Clarke's condition factor (eviscerated weight ÷ length^3) and as Le Cren's condition factor (actual eviscerated weight ÷ estimated eviscerated weight), where estimated eviscerated weight is calculated from the length-weight regression on a log scale. Liver condition (liver weight ÷ eviscerated weight) and gonad condition (gonad weight ÷ eviscerated weight) were also determined for each specimen. To quantify the extent of *Schistocephalus* infections, the following index was used in regression analyses: Parasite index = weight of *Schistocephalus* ÷ eviscerated host weight.

RESULTS

The *P. pungitius* ranged in size between 29 mm (242 mg) and 59 mm (1985 mg) fork length, with an average of 38 mm (766 mg). All were infected by *D. spathaceum*, which varied in numerical abundance from 7 to 111 per fish (average = 32). The metacercariae were distributed along a dorso-ventral band around the lens, leaving a clear area in the centre (Figure 1). Diplostomula were concentrated predominantly on the anterior dorsal sector of the band, with progressively fewer specimens found towards the diagonally opposite sector. In specimens with only a few metacercariae a larger portion of the lens surface was clear, but the parasites were still distributed along the dorso-ventral band. There was also a tendency for them to be more abundant on the hemisphere of the lens facing the retina than on the outer hemisphere. The lenses were clear, never opaque, but most were pitted in spots where the diplostomula had been in contact.

The frequency distribution for *D. spathaceum* in *P. pungitius* (Figure 2) is overdispersed, with a variance/mean ratio of 10.7. The distribution is closely approximated by a negative binomial probability function (X^2 = 9.46, 7 d.f., difference not significant) and it significantly departs from a Poisson (X^2 = 59.01, 5 d.f., $P < 0.005$).

Schistocephalus sp. was found in 43% of the *P. pungitius* examined with an average of 1.3 per infected fish in the population. Individual plerocercoids ranged in weight from 1 to 370 mg. The frequency distribution (Figure 3), with a variance/mean ratio of 0.76, was very closely approximated by a Poisson (X^2 = 2.23, 3 d.f., no significant difference). A best fit for the negative binomial probability function was achieved only by utilizing a high k-value ($k = 12.319$), at which the negative binomial itself approximates a Poisson (X^2 = 2.39, 3 d.f.).

A multivariate analysis indicated that fish condition, gonad condition and liver condition were not significantly affected by the intensity of the *D. spathaceum* and *Schistocephalus* infections.

DISCUSSION

Diplostomula generally appear to be scattered more or less at random on the lenses of parasitized fish, and the distinctive distribution of the diplostomula on *P. pungitius* lenses has not been reported previously. This type of metacercarial positioning will probably minimize their interference with the vision of the fish, but the adaptive significance of such behaviour for the parasite is not clear. In

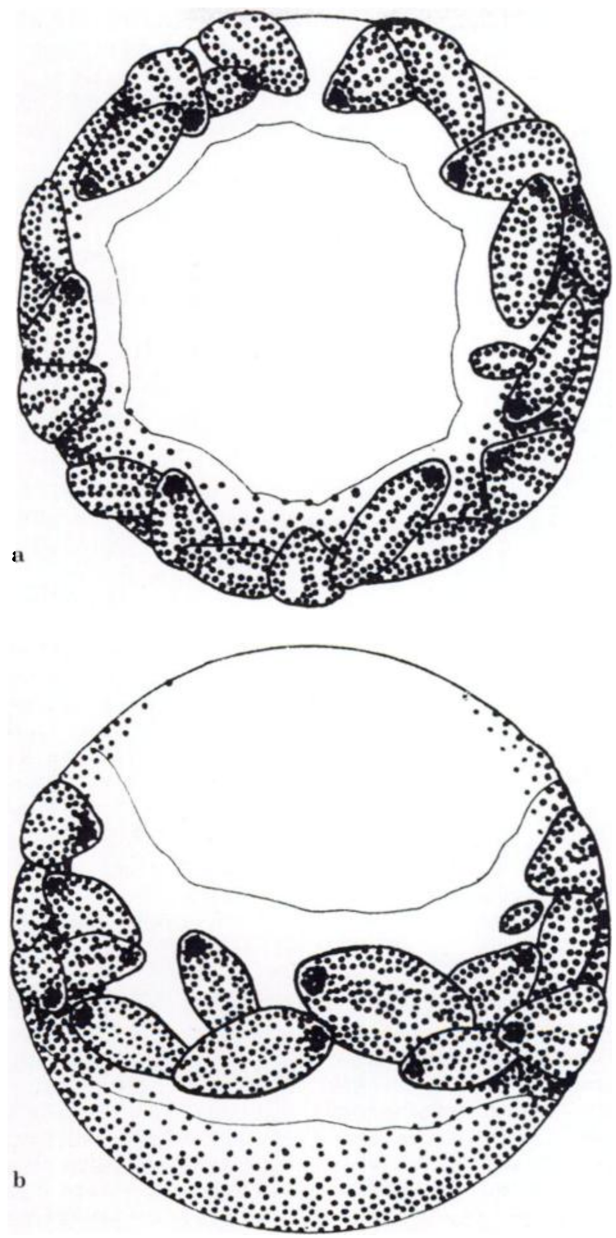

FIGURE 1. a) Lateral view of *P. pungitius* lens parasitized by *D. spathaceum.* The metacercariae are distributed in a dorso-ventral band which completely encircles the lens, leaving a clear area in its centre. b) Diplostomula on the lens of *P. pungitius*, ventral aspect.

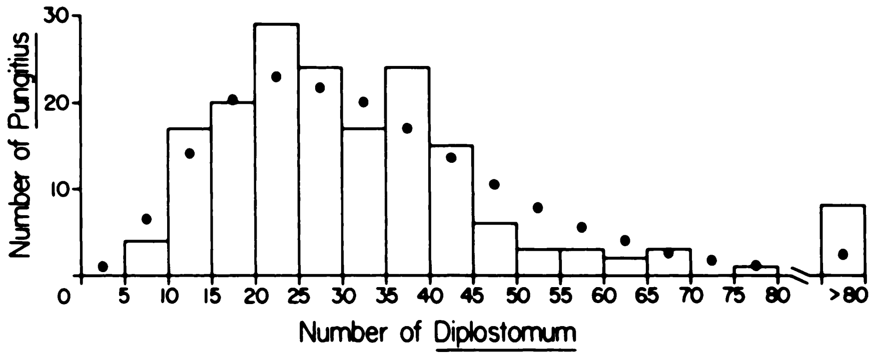

FIGURE 2. Frequency distribution of *D. spathaceum* in *P. pungitius*. A fitted negative binomial distribution is indicated by the large dots (•).

an area of high *D. spathaceum* prevalence and high predator pressure on sticklebacks, it could possibly serve to reduce the initial effects of the larvae on the fish so that the metacercariae may have sufficient time to reach the infective stage before the fish becomes more heavily infected and, with impaired vision, more susceptible to predation.

The frequency distribution for *D. spathaceum* in *P. pungitius* exhibits only low overdispersion (k = 4.155) and more nearly resembles a normal distribution than is usually the case for parasitic infections, where k is generally less than one and the parasites are highly aggregated within the host population.[1] Pennycuick[10] obtained k-values between 0.1 and 0.7 for *D. gasterostei* Williams infections in *Gasterosteus aculeatus* from a pond in Somerset England, indicating high overdispersion. She suggested that this overdispersion helped enhance *D. gasterostei* transmission to the definitive host, as heavily infected fish could be more susceptible to predators. In the case of the Belcher Islands *P. pungitius*, where all fish are infected by *D. spathaceum*, there would seem to be little need for generating overdispersion as a means to enhance transmission.

The nearly random distribution of *Schistocephalus* in *P. pungitius*, closely approximating a Poisson, is unlike that encountered by Pennycuick,[10] who found that the frequency distribution of *S. solidus* in *Gasterosteus aculeatus* was best fitted by the log normal, log series or negative binomial probability functions. The prevalence of the infection in Pennycuick's samples was much higher than for the material described here (88% vs. 43%). As she has implied, factors influencing the shape of the frequency distribution for *Schistocephalus* may be difficult to sort out, for it is the weight of the parasite rather than its numbers which primarily determine its effect upon the host.

Although substantial evidence already exists that *D. spathaceum* and *Schistocephalus* can affect fish condition, growth and gonadal development,[2,9] there appears to be little evidence of a deleterious effect on the condition factors examined here. There may be several reasons for this. The time of year of sampling (mid-summer) was important in that the spawning season for *P. pungitius* was over and gonadal development for the next year was only beginning to occur. Consequently, the gonad index was not a sensitive indicator of condition. Similarly, because food availability was at its annual peak during the sampling period, the more parasitized fish would probably not have encountered difficulties in obtaining adequate food, as may be the case at other times of the year. Because of the high nutritional demands of *Schistocephalus* in particular,[10] it is likely that the effect of that parasite would be most acute during the winter months. A winter die-off of sticklebacks aggrevated by *Schistocephalus* parasitism is suggested by Pennycuick's[9] data.

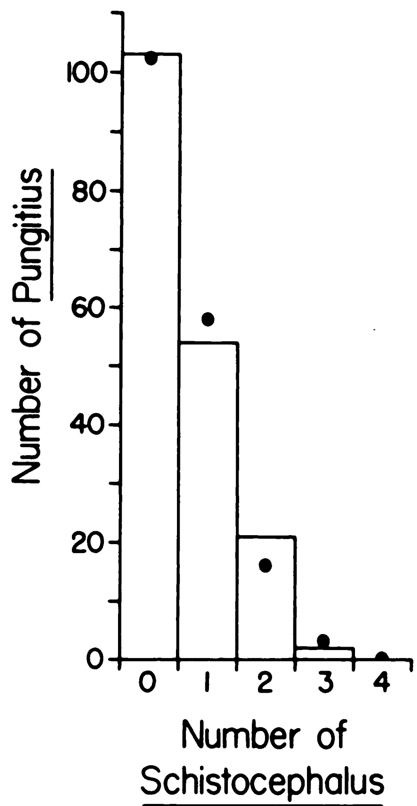

FIGURE 3. Frequency distribution of *Schistocephalus* sp. in *P. pungitius*. The large dots represent values for a fitted Poisson distribution.

Predation pressure may be of importance in accounting for the apparently good condition of parasitized sticklebacks in the Belcher Islands. Piscivorous birds, arctic char, and lake cisco (*Coregonus artedii* Lesueur), are known to prey upon sticklebacks in the area, and it is possible that these predators are effective in removing the more heavily parasitized fish from the population. *P. pungitius* were not found with lenses opaque due to diplostomiasis, although lens opacity is known to occur in other fish species infected by *D. spathaceum*.[6] If Belcher Island sticklebacks do become blinded by the parasite, it is conceivable that they are then selectively removed from the population by predators. Using Pennycuick's[9] formula, the mean parasite index for Belcher Islands *P. pungitius* infected by *Schistocephalus* was only 0.055 compared with 0.266 for Pennycuick's material. The highest index obtained for any of the Belcher Islands fish was 0.203.

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