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TANAORHAMPHUS LONGIROSTRIS (ACANTHOCEPHALA) IN GIZZARD SHAD FROM CAESAR CREEK LAKE, OHIO[1]

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ABSTRACT. Gizzard shad, *Dorosoma cepedianum,* were collected from Caesar Creek Lake, Ohio, from March through October, 1982. A short period of infection by *Tanaorhamphus longirostris* occurred from April through July. Both prevalence and intensity were low, with overall mean intensity of 2.25. No relationship could be detected between infection by the worm and the size of the host fish. Maturation and reproduction by the worms peaked in May. Male and female worms were found together in only 14.5% of the infections. It is proposed that the short period of infection results from failure of the late-appearing juvenile worms to develop to maturity. Distribution of worms within the intestine of the gizzard shad was as follows: segment I = 52%, segment II = 22%, segment III = 13%, segment IV = 13%. All of the worms found in the last segment occurred late in the infection period. Infection in June and July was dominated by juvenile worms. These apparently failed to develop because no worms were found in August or October.

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INTRODUCTION

Van Cleave (1916) provided data suggesting that *Tanaorhamphus longirostris* (as *Neoechinorhynchus longirostris*) exhibited a seasonal pattern of occurrence in the gizzard shad *Dorosoma cepedianum* (LeSueur). In that report, as well as an earlier paper (Van Cleave 1913), he noted that *T. longirostris* (then as *Neorhynchus longirostris*) had a very short life in the gizzard shad. By implication, in his discussion of associated *Gracilisentis gracilisentis* in both papers, he suggested a possible relationship between this periodicity and that of the food habits of the definitive host. He later reported that examination of stomach contents of the gizzard shad failed to suggest the probable intermediate host (Van Cleave 1916). I have since shown that the calanoid copepod *Diaptomus pallidus* Herrick serves as an intermediate host for *T. longirostris* (Hubschman 1983).

In 1981 and 1982, fishes were collected from Caesar Creek Lake, Ohio. Fishes were collected by electrofishing, gill net, and seining. The first year's collections established that *T. longirostris* parasitizes *D. cepedianum* in Caesar Creek Lake (fig. 1). The number of fish examined at that time, while sufficient to provide worms in a variety of developmental stages, was not suf-

Life Pattern of Tanaorhamphus longirostris

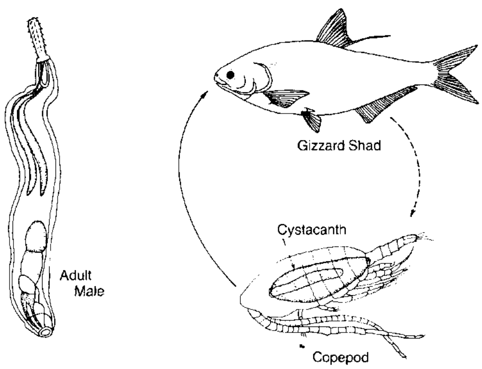

FIGURE 1. The life cycle of *Tanaorhamphus longirostris* (Van Cleave 1913) as it is known at this time. The adult worm occurs in the gut of the gizzard shad *Dorosoma cepedianum* (LeSueur) and the cystacanth in the calanoid copepod *Diaptomus pallidus* Herrick. The dashed arrow indicates that the timing and directness of the passage remains to be determined.

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ficient to establish a pattern of occurrence. In 1982, collections were obtained on a more regular basis from March through October. The data obtained from these collections confirm the short duration of the adult forms of *T. longirostris* in the gizzard shad during the summer months in Caesar Creek Lake.

METHODS AND MATERIALS

More than 500 gizzard shad, *Dorosoma cepedianum* (LeSueur), were examined for parasites. The 1981 collections were preliminary and were irregular. All of the quantitative data reported here are based upon 250 gizzard shad collected on the following dates: 24 March, 21 April, 27 April, 14 May, 17 June, 2 July, 14 July, 2 August, and 5 October, 1982. Fish were fixed in the field in 10% formalin. These were later transferred through graded series to 70% alcohol. All worms, therefore, were fixed and preserved within the gut of the host shad.

The digestive tract of the gizzard shad is a very complex organ system. For this study, the gut was divided into four segments (fig. 2). The first segment (I) was that portion of the intestine from the gizzard to the first flexure (the duodenum with digestive caeca). The second segment (II) was from the first flexure to the second flexure. The third segment (III) was the first series of complex loops and folds closely applied to the surface of the gizzard and embedded in liver tissue. The fourth segment (IV) was the remaining portion of the intestine extending posteriorly, then becoming the second (and major) series of loops and folds before reaching the anus.

Upon collection from the gut, worms were transferred to a mixture of 70% alcohol and two percent glycerin and later mounted in glycerin jelly. This process provided good clearing for subsequent microscopic examination of internal organs. For this study, sexual maturity was defined as follows: female worms with a "floating ovary" and not yet in the ovarian ball stage were considered immature or juvenile. Those worms in which the ovarian mass had fragmented or had fully developed eggs in the pseudocoel were considered mature females. Male worms were considered immature or juvenile if the cement gland apparatus appeared to be not yet functional. Male worms with cement glands that had begun secretion were considered mature.

RESULTS

Of the 250 gizzard shad examined from the 1982 collections, 55 were parasitized with *Tanaorhamphus longirostris*. The number of worms per host varied from one to nine with a mean intensity of 2.25. No other helminth parasite was recovered from the intestine of the shad examined from 1981 or 1982.

The size range of the fish examined was from 27 to 260 mm total length. The mean length of all fish examined was 170 mm and for those infected was 183 mm. No fish less than 135 mm contained worms. A summary of pertinent data is provided in table 1. Prevalence is the percentage of infected fish in a given sample (date). Intensity is the number of worms per infected fish.

DISCUSSION

OCCURRENCE IN THE GIZZARD SHAD. In Caesar Creek Lake, the occurrence of

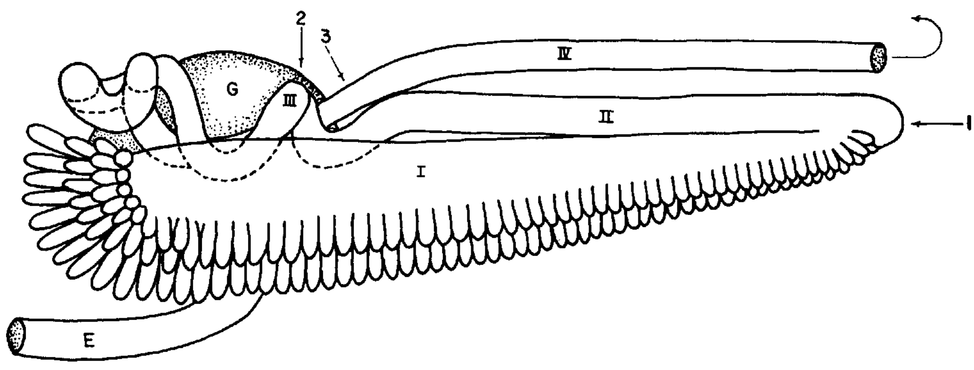

FIGURE 2. Diagrammatic representation of the gut of the gizzard shad *Dorosoma cepedianum*. Roman numerals (I–IV) indicate the segments of the intestine that were isolated for examination. Arabic numerals (1–3) indicate the order of cuts that were made to separate the gut segments. The gizzard (G) and the esophagus (E) are provided for orientation. Liver tissue which normally occupies the space around and between the loops of segment III has been omitted for clarity.

TABLE 1

Gizzard shad from Caesar Creek Lake, Ohio, examined for Tanaorhamphus longirostris.

	Fish Examined			Fish Infected				
Date	Number	Mean Length	Range	Number	Mean Length	Range	Prevalence	Mean Intensity
24 Mar.	13	160	85-210	0	—	—	0	0
21 Apr.	25	192	140-215	8	197	190-215	32	1.37
27 Apr.	33	160	136-210	6	175	138-197	18	1.33
14 May	33	172	135-228	20	169	135-235	60.6	2.15
17 June	32	182	145-223	18	188	150-223	56	2.88
2 July	37	185	165-260	2	195	187-202	5.4	4.5
14 July	15	103	27-200	1	170	170	6.6	1
2 Aug.	37	158	31-225	0	—	—	0	0
5 Oct.	25	184	169-260	0	—	—	0	0
	250 (Total)	170 (Mean)	27-260 (Range)	55 (Total)	183 (Mean)	135-235 (Range)	22 (Mean)	2.25 (Mean)

Tanaorhamphus longirostris in the gizzard shad is apparently of short duration. This observation agrees with the reports of Bangham and Venard (1942), Jilek (1978), Samuel et al. (1976), and Van Cleave (1916) for other bodies of water. The prevalence data suggest that the period of maturation and reproduction peaks in early summer (fig. 3). Likewise, the intensity of infection is very low. The maximum infection was nine worms with the overall mean intensity of 2.25. This also agrees with the authors above.

Within the intestine of the host, worms were found not to be evenly distributed. The gut of the shad may be divided into four anatomically distinct regions (Bodola 1966, Heinrichs 1982). In the laboratory, these segments (fig. 2) were isolated in separate dishes for examination. The distribution of the worms by segments was as follows: segment I = 52%; segment II = 22%, segment III = 13% and segment IV = 13%. All of the worms that occurred in segment IV were found on two dates in the latter half of the infection period (June 17 and July 2). Because migration by the worms following capture of the fish is possible, for example, fish restrained by a gill net may deplete gut contents before fixation, the capture method was compared with worm distribution. There was no apparent relationship between worm attachment site within the host and method of capture. The distribution of worms within the intestine may be based upon the biological life-cycle characteristics (discussed below).

SIZE OF HOST. The mean length of fish examined was 170 mm, while those parasitized was 183 mm. However, the shad

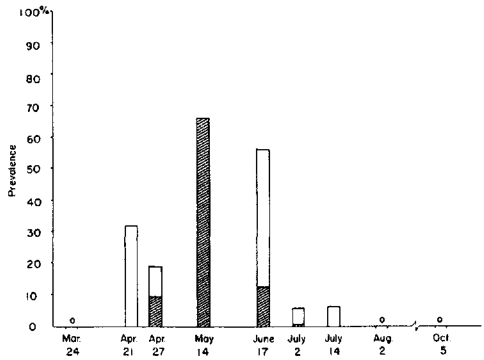

FIGURE 3. Prevalance of *Tanaorhamphus longirostris* in the gizzard shad *Dorosoma cepedianum* in Caesar Creek Lake, Ohio in 1982. Empty portions of bars represent that fraction of the worms collected that were juveniles. Hatched portion of bars represents the fraction occurring as adults.

examined fall into two distinct size classes (ie: 27-85 mm, and 122-260 mm). None of the fish 85 mm or less contained worms. This might be explained on the basis of the three dates on which they were collected. All of the small fish were collected on three dates. On 24 March and 2 August, no fish contained parasites. On 14 July, only one fish, a larger one with a single juvenile worm, was parasitized. Since the smaller fish therefore probably were excluded from the opportunity for infection, data from the larger fish were compared in an attempt to determine the influence of size.

Among those fish over 122 mm in total length, 32.9% were parasitized with *T. longirostris*. Analysis of data derived from the sample of larger fish discloses that the mean total length of this class was 178 mm. The same data derived from those dates upon which parasites were present in the population provides a mean of 177 mm. The mean total length of parasitized fish was 183 mm. There is no significant difference (t-test) between or among these means. Therefore, it cannot be concluded from these data that the larger fish are more suitable hosts for *T. longirostris*.

SEX RATIOS OF PARASITE. The ratio of sexes based upon seasonal distribution was not 1:1 (table 2). The overall occurrence was 53% males and 47% females. The greatest variation occurred on 14 May when there were 60% males and 40% females. While it might be expected that the sex ratio should be 1:1, it might also be expected that males do not live as long as females. The latter phenomenon may be related to whether the males have copulated or not (Crompton 1970). The small number of collections, during the very short infection period, naturally limits speculation on the impact of an unbalanced sex ratio. On 17 June, the last date that adult worms were found together, the adult sex ratio was even. More important however, in terms of the life cycle of *T. longirostris* in Caesar Creek Lake, is the fact that male and female worms occurred together in only 40% of the infections. This includes total seasonal incidence. If the occurrence of males and females together is calculated on the basis of adult worms only, the mating opportunity was limited to 14.5% of the infections. This, obviously relates to the very low prevalence of this infection.

TABLE 2

Sex and state of maturity of Tanaorhamphus longirostris *in gizzard shad from Caesar Creek Lake, 1982.*

Date	Male	Female	Juvenile	Adult
24 Mar.	0	0	0	0
21 Apr.	6	5	11	0
27 Apr.	4	4	4	4
14 May	26	17	0	43
17 June	25	27	42	10
2 July	5	4	8	1
14 July	0	1	1	0
2 Aug.	0	0	0	0
5 Oct.	0	0	0	0
Total	66	58	66	58

DURATION OF INFECTION. In 1982, *Tanaorhamphus longirostris* occurred in the gizzard shad for a short period of time. The worms were found only from April through July. This is a considerably shorter period than that reported by Jilek (1978) for southern Illinois or Samuel et al. (1976) for southeastern Nebraska. Van Cleave (1916), in addition to accounting for a summer infection, reported worms in November and December in northern Illinois. By inferring the possibility of infection during September and October, he projected continuous occurrence from May through December. Therefore, the whole picture may be based upon local conditions that influence intermediate host availability. It is possible, however, that the cycle of infection depends upon not only availability of the cystacanth but also upon the condition of the definitive host.

In my collections, adult worms were found only from late April through early July (fig. 3). Only 50% of the worms in the April collection were sexually mature. By 14 May, all were sexually mature but by 2 July, only a little more than 10% occurred as adults. The juvenile worms found in June and July appeared to be normal when compared with those from the April collections. I could find no reason to consider these to be in a degenerative state. Yet, they apparently failed to develop to maturity. It may be that the internal environment of the shad gut is receptive for a short period of the season. If host susceptibility is indeed periodic, it remains to be determined if it is seasonal. There may be a second pulse of infection during the winter that could not be detected in my spring-to-fall collections.

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EDITOR'S NOTE

New manuscripts usually will be published within 7 months of acceptance in *The Ohio Journal of Science.*