

LIGULA INTESTINALIS (L., 1758) INFECTION OF EURYHALINE FISH THE SAND SMELT *ATHERINA BOYERI* RISSO, 1810

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ABSTRACT: *Ligula intestinalis* was found during the parasitological investigations of *Atherina boyeri* specimens collected from Hirfanlı Reservoir, Turkey. It was found that 0.004% of all individuals were infected by *L. intestinalis* including 2 female (0.0011% of all individuals) and 5 male (0.0028% of all individuals). It was determined that the length weight relationship equivalents of infected individuals with population differed from those of non-infected individuals. The *b* value of the infected individuals was found to be lower than the *b* value of the non-infected individuals. It is thought that the results obtained in this study will be beneficial in preserving and improving the ecological potential of the water system.

KEYWORDS: *Atherina boyeri*; parasite; sand smelt; euryhaline fish; Hirfanlı Reservoir

INTRODUCTION

Ligula intestinalis plerocercoid were identified firstly from inland waters of Turkey in Eğirdir Lake, Hirfanlı, Mamasın, Porsuk and Kesikköprü Dam Lakes by Güralp (1968). This cestode, as the first intermediate host, offers a complex life cycle with a copepod, and the fish become infected by consuming the infected copepod. Fish-eating birds serve as the last host where *L. intestinalis* reaches sexually mature and releases their eggs. The second intermediate host develops in the abdominal cavity of the fish and has an impact on fish health, inhibits gametogenesis and behaviour (Carter *et al.*, 2005; Trubiroha *et al.*, 2009).

Parasites reach sexual maturity in the guts of birds within a few days and begin to reproduce (Dubinina, 1980). There are few reports on infestation of human with the parasite. So *L. intestinalis* may be act a food borne parasite (Eslami, 2006). It has been identified from such as Cobitidae, Cyprinidae, Salmonidae, Esoxidae, Pleuronectidae or Siluridae (İnnal *et al.*, 2007; Bouzid *et al.*, 2008). *L. intestinalis* (Cestoda) is a common intestinal parasite of many fish species in Turkey (Öztürk and Altunel, 2001; Oğuz *et al.*, 2004; Akmirza 2007; İnnal *et al.*, 2007; İnnal *et al.*, 2010; Demirtaş and Altındağ, 2011; Turgut *et al.*, 2011; Aslan *et al.*, 2015; Saç *et al.*, 2016; Benzer, 2020).

Atherina boyeri Risso, 1810 is a commercially important fish found throughout the Mediterranean and adjacent seas. It is euryhaline, mostly prefer coastal and shallow brackish waters system including coastal lagoons, salt marshes and inland waters (Andreu-Soler *et al.*, 2003; Bartulovic *et al.*, 2004). As a carnivorous or opportunistic predator species, it feeds on zooplankton and benthic organisms (Bartulovic *et al.*, 2004; Doulka *et al.*, 2012).

Data on parasites and relations of fish host *A. boyeri* are limited. Many ecological and pathological researches have revealed that parasite can affect population dynamics, both

in wild fish and in water systems (William and Hoole, 1992). In the studies carried out; the condition factor of infected fish was found to be lower than healthy fish (Mc Mahon, 1976). There are various parasitic studies in *A.boyeri* fish (Bello *et al.*, 1997; Leonardos and Trilles, 2003; Leonardos and Trilles, 2004; Ravichandran *et al.*, 2011; Kvach *et al.*, 2019).

The goal of this research was to investigate the *L.intestinalis* fauna at *A.boyeri* Risso, 1810 in Hirfanlı Reservoir for condition and length weight relationship of host fishes. This study is very important for the determination of *L.intestinalis* plerocercoid fauna in different freshwater systems in Turkey with euryhaline fish *A.boyeri*. It is the first report for *L.intestinalis* infection in *A.boyeri* from Hirfanlı Reservoir.

MATERIALS AND METHOD

The study was carried out in the Hirfanlı Reservoir (Fig. 1). Constructed in 1959, the Hirfanlı Reservoir is on Kızılırmak River, 70 km far from the south of Kırıkkale. It is located at 856 m altitude with a capacity of $7.63 \times 10^9 \text{ m}^3$ and an area of 320 km^2 . The depth, length and width of the lake are 58 m, 90 and 15 km, respectively. It is 24 km far from Ankara - Kırşehir and 30 km from Ankara - Adana (DSİ, 1968).

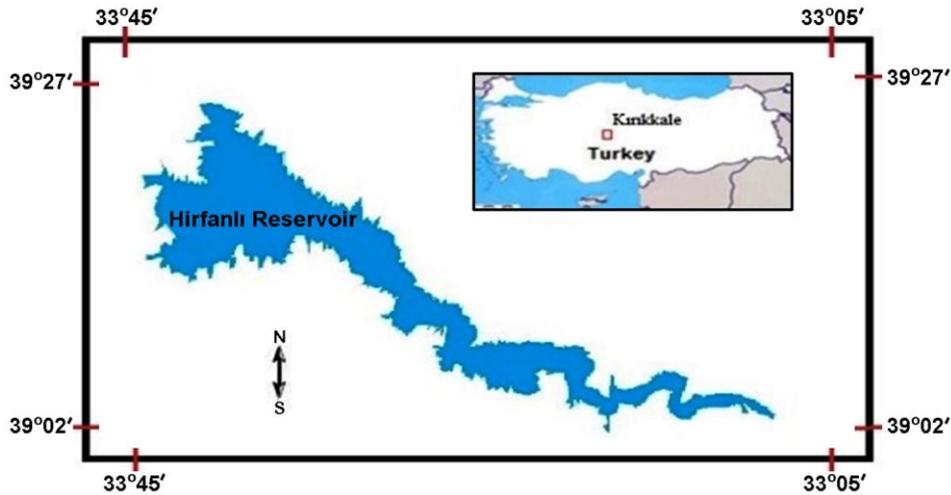


Fig. 1. Hirfanlı Reservoir.

The fish samples were collected from the Hirfanlı Reservoir. A sum of 1750 fish samples was collected with gill net and fyke net from Hirfanlı Reservoir, Kırşehir in 2016 - 2017. For each fish collected the fork length (nearest to 0.1 cm) and total weight (nearest to 0.01 g) were recorded and the sex was determined by the macroscopic examination of gonads. Fish were dissected and the parasites were examined. The parasites were determined numerically and their weights (nearest to 0.1 g) and lengths (nearest to 0.1 cm) were measured.

The length and weight relations (LWR) equation is a traditional method used for the determination of the growth features of populations. From the collected samples; sex and length composition, the average length and weight, and the LWR for each sex and combined sexes were identified. The relationship between length (L) and body weight (W) for nearly all species of fish can normally be represented by the LWR following equation:

$$W = aL^b$$

Where W is the body weight of fish (g), L is the length (cm) and 'a' and 'b' are constants. The parameter 'b' (also known as the allometry coefficient) has an important biological meaning, indicating the rate of weight gain relative to growth in length or the rate at which weight increases for a given increase in length. If b is equal to 3, isometric pattern of growth takes places, if b is not equal to 3, then allometric pattern of growth takes places, it may be positive if it is greater than 3 or negative otherwise (Ricker, 1973). The a and b constants could be estimated from linear functions.

The condition factor (CF) was calculated for all individual fish for *A. boyeri* using the conventional formula described by Worthington and Richard (1936).

$$CF = W \frac{100}{L^3}$$

Where CF is condition factor, W is the body weight (g) and L is the length (cm).

Statistical analysis of data was carried out using IBM SPSS Statistics package program for Mac Ver. 23.

RESULTS AND DISCUSSION

A total of 1750 fish specimens were investigated (Fig. 2). In this research, 611 out of 1750 individuals were identified as female and 1139 as male. The mean, min, max values of length, weight and condition factor values of the infected and non-infected individuals by *L. intestinalis* are given in Table 1. There were about 34.91% females and 65.09% males (sex ratio 1:0.54). It was found that 0.004% of all individuals were infected by *L. intestinalis*. When the all population was examined, 2 female (0.0011% of all individuals) and 5 male (0.0028% of all individuals) infected individuals were identified. It was found that 28.57% of the infected fish were female and 71.43% were male.

Fork length ranged between 2.9 and 9.5 cm for non-infected fish and from 5.8 to 6.8 cm for infected individuals. Weight ranged between 0.144 and 6.420 g for non-infected fish and from 2.240 to 2.834 g for infected individuals (Table 1).

Slope value (b) of noninfected female individuals from Hirfanlı Reservoir was found to be 2.6515 and b value of non-infected male individuals was found to be 2.7738 (Fig. 3). The b value of female *A. boyeri* infected by *L. intestinalis* was found to be 1.5694 and the b value of male was 1.0074 (Fig. 3).

The condition factor values of non-infected female, male and all individuals were determined as 0.890 ± 0.177 , 0.869 ± 0.161 and 0.877 ± 0.167 respectively. The condition factor values of infected female, male and all individuals were determined as 1.066 ± 0.120 , 0.988 ± 0.154 and 1.010 ± 0.140 respectively (Table 1).

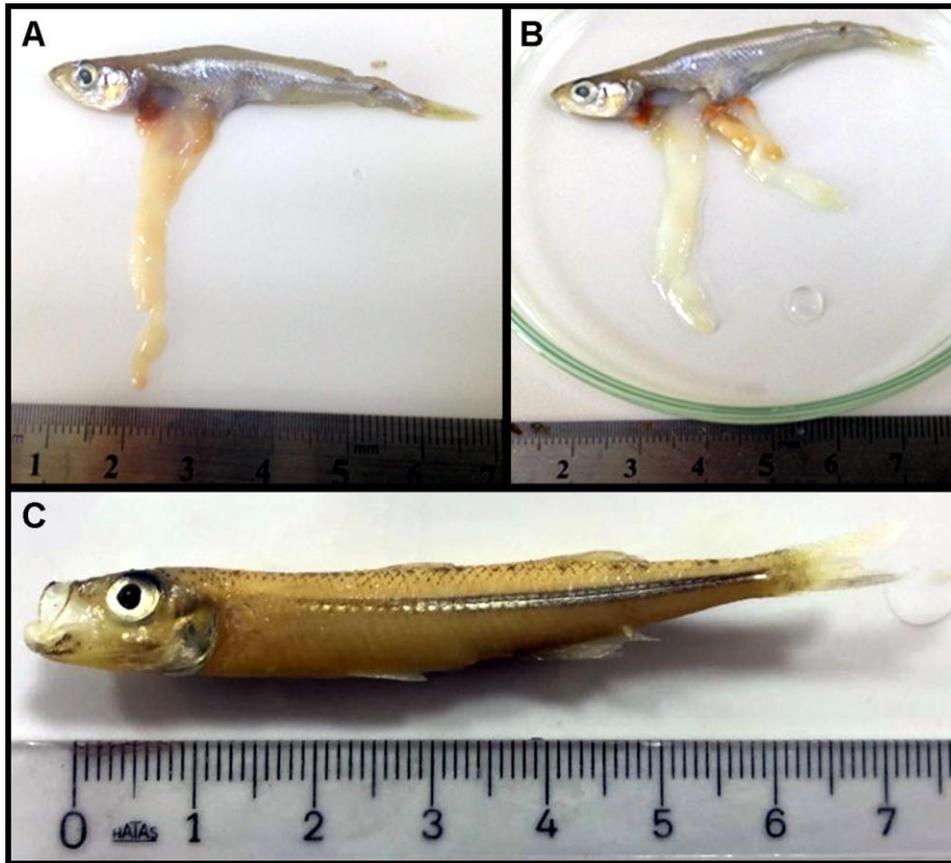


Fig. 2. *A. boyeri*: A, Infected; B, non-infected; C, individual.

It was determined that the average length of *L. intestinalis* individuals extracted from *A. boyeri* individuals in Hirfanlı Reservoir was 4.60 ± 1.827 cm (3.0-8.5) and the weight average was 0.2957 ± 0.2917 g (0.02-0.91) (Table 1).

The presence of large plerocercoids in a fish cavity affects the placement of many organs such as the liver, the intestines, the reproductive glands or the swimming bladders (Loot *et al.*, 2001; Trubiroha *et al.*, 2009).

Gholami *et al.* (2011) were detected parasites in 63 fishes (*Aphanius dispar*). Gholami *et al.* (2011) found the average parasite length and weight 41.48 mm and 0.19 g, the max and min parasite lengths 64.2 mm and 22.7 mm, the max and min parasite weight 0.3 and 0.047 g, respectively. Akmirza (2007) determined that the weight of the plerocercoid varied between 0.2-0.7 g and an average of 0.41 g in October and 0.43 g in November. Also it was observed higher infection of females with *L. intestinalis* plerocercoids in *Rhodeus amarus*.

Table 1. Length, weight and condition factors of all fish and parasite individuals.

	Non Infected fish			Infected fish			Parasite
	N	Sex	Mean \pm SE (Range)	N	Sex	Mean \pm SE (Range)	Mean \pm SE (Range)
L	609	F	6.299 \pm 0.602 (4.3-8.2)	2	F	6.250 \pm 0.495 (5.9-6.6)	4.6 \pm 1.827 (3.00-8.50)
	1134	M	6.219 \pm 0.724 (2.9-9.5)	5	M	6.380 \pm 0.376 (5.8-6.8)	
	1743	F+M	6.248 \pm 0.685 (2.9-9.5)	7	F+M	6.343 \pm 0.373 (5.8-6.8)	
W	609	F	2.258 \pm 0.651 (0.589-3.762)	2	F	2.593 \pm 0.322 (2.365-2.820)	0.296 \pm 0.292 (0.02-0.91)
	1134	M	2.144 \pm 0.732 (0.144-6.420)	5	M	2.643 \pm 0.255 (2.240-2.834)	
	1743	F+M	2.184 \pm 0.707 (0.144-6.420)	7	F+M	2.557 \pm 0.247 (2.240-2.834)	
CF	609	F	0.890 \pm 0.177 (0.277-1.515)	2	F	1.066 \pm 0.120 (0.980-1.151)	-
	1134	M	0.870 \pm 0.161 (0.277-1.745)	5	M	0.988 \pm 0.154 (0.895-1.259)	
	1743	F+M	0.877 \pm 0.167 (0.277-1.745)	7	F+M	1.010 \pm 0.140 (0.895-1.259)	

Environmental factors that cause fluctuations show the prevalence and impact of this parasite on the intermediate host. Vectors have an important place in the spread of foreign species. In particular, migratory waterfowl in wetlands can also be an effective vector for the propagation of some species (Hirsch *et al.*, 2018).

Çolak (2013) was studied metazoan parasites of *A. boyeri* in Lake Iznik. 271 *A. boyeri* individuals (208 female and 63 male) mean length 8.4 \pm 2.2 cm (range 3.1–12.2 cm) and mean weight 4.7 \pm 3.5 g (range 0.1–11.7 g) were determined. Çolak (2013) detected four types of parasites such as *Diplostomum* sp. (mean 3.50 \pm 3.03); *Tylodelphys clavata* (mean 10.41 \pm 14.89); *Bothriocephalus cf. acheilognathi* (mean intensity 31.83 \pm 57.74); and *Eustrongylides excisus* (mean 1.16 \pm 0.39).

Kvach *et al.* (2019) were described a new species, *Gyrodactylus ginestrae*, a parasite of *A. boyeri* from the Black Sea. It was similar to *G. salinae*, which parasitizes the killifish *Aphanius fasciatus* in the Mediterranean region.

It is the first observation of *L. intestinalis* infection in *A. boyeri* from Hirfanlı Reservoir. In this study we calculated the length, weight, and condition values of the *A. boyeri* individuals with and without parasites (*L. intestinalis*). This parasite may be a threat to host's *A. boyeri*, it may cause negative effects on fish growth and also affected on fish reproductive activity. It was observed that the CF of infected fish is lower than from the non-infected fish (Saçet *et al.*, 2016). It was reported that the *Pseudorasbora parva* fish was also infected by *L. intestinalis* (Song and Park, 2008; Bozorgnia *et al.*, 2012; Benzer, 2020).

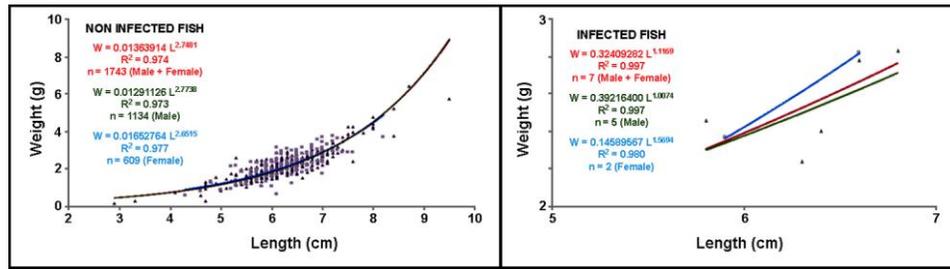


Fig. 3. Length weigh relationships of infected and non-infected specimens of *A. boyeri*.

CONCLUSION

The goal of this research was to investigate the *L. intestinalis* in *A. boyeri* for condition and length weight relationship from Hirfanlı Reservoir. This study is very important for the determination of *L. intestinalis* plerocercoid fauna in different freshwater systems in Turkey with euryhaline fish *A. boyeri*. It is the first report for *L. intestinalis* infection in *A. boyeri* from Hirfanlı Reservoir. It is considered that the data obtained in this study will also contribute to future studies.

A. boyeri is traded internationally in Hirfanlı Reservoir. It is evaluated that the spread of parasites in the population may cause economic damage.

In the present study *L. intestinalis* were observed in *A. boyeri* which require the need for further investigation to detect the presence of this parasite in other freshwater fishes.

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