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Original Article

Ligula intestinalis infection of *Pseudorasbora parva* in Hirfanlı Dam Lake, Kırşehir, Turkey

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Abstract

Ligula intestinalis was found during the parasitological investigations of *Pseudorasbora parva* specimens collected from Hirfanlı Dam Lake, Turkey. It was found that 8.78% of all specimens were infected with *L. intestinalis* including 17 female (3.8%) and 22 males (4.95%). 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 lake.

Keywords: Parasite; *Ligula intestinalis*; *Pseudorasbora parva*; Hirfanlı Dam Lake

1 | INTRODUCTION

Parasitic diseases are very common in fish all over the world (Roberts and Janovy 2000; Gholami *et al.* 2011; Bozorgnia *et al.* 2012; Vanacker *et al.* 2012; Mehraban *et al.* 2014). *Ligula intestinalis* is a significant fish parasite because of its heavy infections that can cause mortality of the host and considered an important threat to fisheries (Brown *et al.* 2002). The plerocercoids of *L. intestinalis* have been noted from the body cavity of a wide range of fish hosts, especially members of the Cyprinidae (İnnal *et al.* 2007; Hoole *et al.* 2010). This cestoda, which presents a complex life cycle with a copepod, makes the fish to develop an infection when the fish feed on infected copepod. Fish eating birds serve as the ultimate host in which *L. intestinalis* reaches sexual maturity rapidly and lays eggs into water (McGuigan and Sommerville 1985; Ergönül and Altındağ 2005a). The second intermediate host develops in the abdominal cavity of the fish and effects health, inhibiting gametogenesis and behaviour (Brown *et al.* 2002; Carter *et al.* 2005; Trubiroha *et al.* 2009). Schabuss *et al.* (2005) examined endocrine changes in individuals, infected by *L. intestinalis*.

Pseudorasbora parva is a small cyprinid species that inhabits pools, shallow lakes, irrigation canals and rivers. This species is one of the prominent invasive species and have inhabited European inland waters in recent years (Gozlan *et al.* 2010). This species possesses several characteristics such as high reproductive potential, parental care, and habitat use and considerable tolerance to water pollution and wide range of environmental conditions (Záhorská *et al.* 2009; Gozlan *et al.* 2010).

Ligula intestinalis (Cestoda) is a common intestinal parasite of many fish species over the globe including Turkey (Öztürk and Altunel 2001; Yıldız *et al.* 2003; Ergönül and Altındağ 2005b; Akmirza 2007; İnnal and Keskin 2006;

İnnal *et al.* 2007; Gholamı *et al.* 2011; Demirtaş and Altındağ 2011; Turgut *et al.* 2011; Zhokhov and Pugacheva 2012; Bozorgnia *et al.* 2012; Mehraban *et al.* 2014; Aslan *et al.* 2015; Saç *et al.* 2016). A wide variety of fish families including Cyprinidae, Esoxcidae, Cobitidae, Salmonidae, Pleuronectida and Siluridae have been recorded to be infected with this parasite (İnnal *et al.* 2007; Bouzid *et al.* 2008).

Previous research (*e.g.* Bozorgnia *et al.* 2012; Song and Park 2018) *P. parva* individuals have been infected by *L. intestinalis* (pleorocercoid). This study describes the infection *P. parva* with *L. intestinalis* in Hirfanlı Dam Lake for the first time. Other fishes of the lake including *Atherina boyeri* and *Aphanius marassantensis* were also found to be infected as well. The aim of this study is to determine the occurrence of the parasites on host and investigate the effects of *L. intestinalis* infection through condition factor and length–weight relationship analyses.

2 | METHODOLOGY

2.1 Study area

There exist three dam chains (Hirfanlı, Kesikköprü, Kapulukaya) in the Central Kızılırmak Basin. Hirfanlı Dam Lake, which forms the first and largest chain, was opened in 1959 (DSİ 1968). The Hirfanlı Dam (Figure 1) is an important source of income for the people in the surrounding villages.

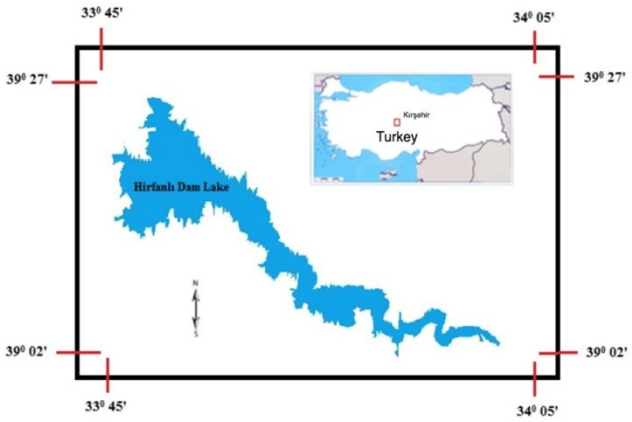

FIGURE 1 Hirfanlı Dam Lake, Kırşehir, Turkey.

2.2 Sampling

A total of 444 specimens were collected from the commercial fishers in 2016 captured with gill nets (13 – 80 mm mesh) and fyke net (140 mm mesh) from Hirfanlı Dam Lake, Kırşehir. *Atherina boyeri* and *Aphanius marasantensis* individuals were caught along with *P. parva* individuals but not included in this study.

The fork length (to the nearest 0.1 cm) and total weight (to the nearest 0.01 g) for each specimen were measured. Sex was determined by macroscopic examination of gonads. Later the fish were dissected and examined for parasites. The parasites, if found, were quantified and their weight (to the nearest 0.01 g) and length (to the nearest 0.1 cm) were measured.

2.3 Length and weight relationship (LWR)

LWR equation is a traditional method used for the determination of the growth features of populations. Based on the collected specimens; sex, total length, the average length, weight, and the LWR for both sexes (*i.e.* male and female) and combined sexes were recorded. The LWRs were estimated by the 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 that indicates 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 (Ricker 1973). The *a* and *b* constants could be estimated from linear functions.

2.4 Condition factor (CF)

The CF was calculated for all individuals by using the conventional formula described by Worthington and Richard (1936),

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

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

Statistical analyses of data were carried out in IBM SPSS Statistics package program for Mac (Version 23).

3 | RESULTS

There were more male specimens in the total number of individuals studied (sex ratio: 1 : 0.63; ♂ : ♀). A total of 405 non-infected individuals were identified including 155 female and 250 male (Figure 2). Out of 39 infected specimens 17 were female (3.8% of the total individuals and 43.58% of infected individuals) and 22 were male (4.95% of the total individuals and 46.41% of infected individuals). The mean, minimum and maximum lengths, weight and condition factors of the infected and non-infected individuals are presented in Table 1.

Fork length ranged between 3.6 and 9.3 cm for non-infected fish group whereas it varied from 4.6 to 7.7 cm for infected counterparts. Total weight ranged between 0.42 and 8.5 g for non-infected fish and from 0.98 to 4.04 g for infected counterparts (Table 1). The slope value (*b*) of non-infected female individuals was 3.04 and it was 2.96 for males (Figure 3). On the other hand, for infected specimens, the *b* values were 1.68 (female) and 2.01

(male).

The condition factor values of non-infected female, male and all individuals were calculated as 1.33, 1.28 and 1.29 respectively. Whereas these values were 0.91, 0.92 and 0.92 for female, male and pooled individuals respectively (Table 1). For the parasite *L. intestinalis*, it was determined that the average length of individuals was 4.34 cm (range 0.9 – 9.8) and the mean weight was 0.25 g (0.03 – 0.91) (Table 1).

FIGURE 2 Non-infected (A) and infected (B) *Pseudorasbora parva* individuals from Hirfanlı Dam Lake.

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

Groups	*N*	Sex	Measurements (Mean ± SE, range)		
			Length (cm)	Weight (g)	Condition factor
Non-infected fish	155	F	6.03±1.62 (3.6–9.3)	3.54±2.32 (0.4–8.5)	1.33±0.20 (0.7–2.0)
	250	M	5.95±1.46 (3.6–9.2)	3.15±2.08 (0.5–8.3)	1.3±0.21 (0.9–1.9)
	405	Pooled	5.98±1.54 (3.6–9.3)	3.30±2.19 (0.4–8.5)	1.3±0.2 (0.7–2.0)
Infected fish	17	F	7.17±0.45 (6.3–7.3)	3.35±0.50 (2.5–4.0)	0.91±0.12 (0.6–1.2)
	22	M	5.63±0.70 (4.6–7.5)	1.64±0.49 (1.0–2.7)	0.92±0.19 (0.6–1.3)
	39	Pooled	6.3±0.98 (4.6–7.7)	2.38±0.99 (1.0–4.0)	0.92±0.16 (0.6–1.3)
Parasite	39	-	4.34±2.29 (0.9–9.8)	0.25±0.21 (0.03–0.9)	-

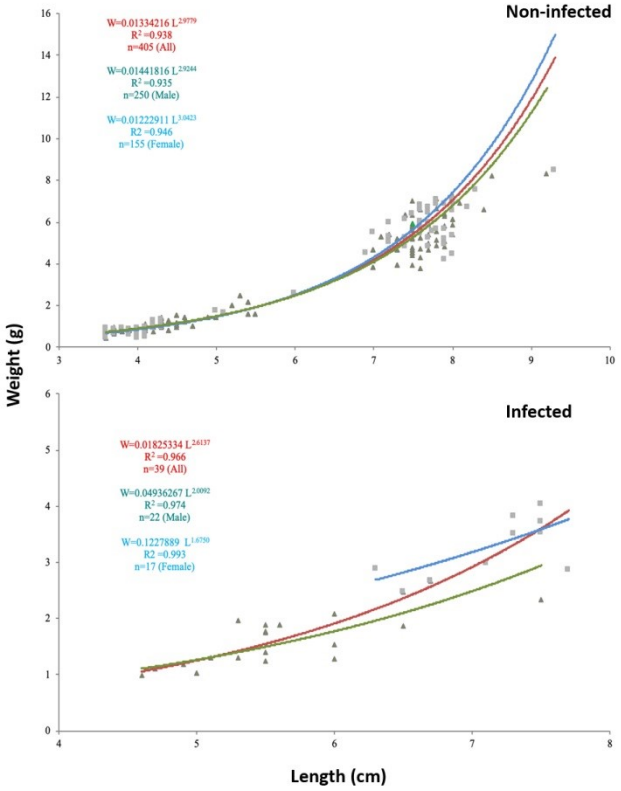

FIGURE 3 Length-weigh relationships of infected and non-infected specimens of *Pseudorasbora parva* collected from Hirfanlı Dam Lake.

4 | DISCUSSION

In this study, of 444 individuals, 3.8% female and 4.95% male were found to be infected. It was determined that the LWRs 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 calculated for non-infected individuals (Table 1).

Kelle (1978) compared LWRs between *L. intestinalis* infected and non-infected specimens of several fish species. The *b* values of infected male, female and pooled individuals in this study were found to be lower than *b* values of healthy (*i.e.* non-infected) individuals. However, a range of varying *b* values were reported for healthy individuals from different areas (*b* = 3.02, Tarım River, Huo *et al.* 2012; *b* = 3.32, Hirfanlı Dam Lake, Kırankaya *et al.* 2014; *b* = 2.93, Marmara Lake, İlhan and Sarı 2015; *b* = 2.84, Mogan Lake, Arslan and Özeren 2019; *b* = 2.87, Mogan Lake, Benzer *et al.* 2016; *b* = 3.04 (♀) and 2.97 (♂), Hirfanlı Dam Lake, Benzer and Benzer 2018). LWR parameters *a* and *b* values can be affected by a number of factors including sex, gonad maturity, health status, season, habitat, nutrition, environmental conditions which are further influenced by temperature, stomach fullness, general fish condition, differences in length range of fish

specimens and even fishing gears used for collection (Tesch 1971; Froese 2006). Ergönül and Altındağ (2005b) found a remarkable difference between the *b* values of infected and non-infected tench collected from Mogan Lake which were 2.745 for infected and 3.04 for non-infected. The LWRs' *b* values were recorded 3.383 and 3.222 for the non-infected and infected individuals respectively by Saç *et al.* (2016) based on fish from Büyükçekmece Reservoir.

It was found that condition factor (CF) values of infected individuals were lower than non-infected individuals in Hirfanlı Dam Lake (Table 1). Different CFs of *P. parva* were reported in various studies (*CF* = 0.967, Hirfanlı Dam Lake, Kırankaya *et al.* 2014; *CF* = 0.21–1.31, Arslan and Özeren 2019). The CF of infected fishes is reported to be significantly lower than the healthy ones (Mahon 1976). Fish infected with *L. intestinalis* may show physiological disorders such as swelling and stretching in the abdominal wall, change of blood parameters, smaller gonads, decreasing condition factors, and may even lead to death with severe infection (Brown *et al.* 2002).

Although *L. intestinalis* may infect a range of freshwater fishes but cyprinids are the most common group (Sweeting 1977; Barus and Prokes 2002; Ergönül and Altındağ 2005b). In Turkey, *L. intestinalis* infection of freshwater fish in inland waters is reported to pose a serious threat (Öztürk and Altunel 2001). It has been observed that internal organisms, especially gonads, are damaged when the get infected with this parasite. Having a large plerocercoid in fish cavity affects the growth of organs such as the liver, intestines, reproductive glands or swimming bladders (Loot *et al.* 2001; Trubiroha *et al.* 2009).

The mean length and weight of *L. intestinalis* extracted from *P. parva* were 4.34 cm (0.9 – 9.8 cm) and 0.25 g (0.03 – 0.91 g) respectively (Table 1). The maximum and minimum lengths of this parasite were reported 138.02 mm and 24.54 mm respectively by Mehreban *et al.* (2014). In this study the mean parasite length and weight were 41.48 mm (22.7–64.2 mm) and 0.19 g respectively. The maximum and minimum of parasite weight were reported 0.3 and 0.047 g respectively (Gholami *et al.* 2011). The weights of the plerocercoids changed between 0.2 and 0.7 g and have an average weight of 0.41 g in October and 0.43 g in November (Akmirza 2007). Environmental factors may impact its prevalence (Loot *et al.* 2002). The plerocercoid is mostly reported in cyprinid fishes, usually 2–60 cm in length and often represented 25% of the body weight of infected fish (Mehlhorn 2008). A direct relationship between *L. intestinalis* length and host fish is evident (Arme and Owen 1968). However, the length of the parasite varies depending on the length of the host fish (Bauer 1965; Hajirostamloo 2008).

It has been reported that the number of *L. intestinalis* individuals decreases with the increasing age of infected fishes (Dence 1958; Brown *et al.* 2002) and infection is more common in small fishes (Korkmaz and Zencir 2009; Kurupınar and Öztürk 2009). In the Kunduz Dam Lake of Turkey, the highest infection was observed in large fishes, while the infection rate decreased as the fish size decreases (Özbek and Öztürk 2010).

In this study, mostly male individuals were infected with *L. interstinalis* in Hirfanlı Dam Lake (Table 1). In the case of infection of the parasite *L. intestinalis*, differences were evident between sexes in other studies. It has been reported that all individuals infected with *Ligula* are male (İnnal and Keskin 2006; Kurupınar and Öztürk 2009). This study reports higher proportion of infection by female parasite, similar to the findings of Gholami *et al.* (2011).

5 | CONCLUSIONS

It was found that 8.78% of *P. parva* specimens were infected with *L. intestinalis* and male individuals were affected the most. Both slope '*b*' values and CF of infected individuals were lower than 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 lake in the future.

Although cyprinid fishes have commonly been reported to be infected with *L. intestinalis*, but other families such as Catostomidae, Salmonidae and Galaxiidae were also infected (Dubinina 1980; Groves and Shields 2001; Barus and Prokes 2002). In the study lake *L. intestinalis* were also observed in *Atherina boyeri* which resembles the need for further investigation to detect the presence of this parasite in other freshwater fishes. Studies to determine the role of bird species in the transmission process may reveal important information.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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