

Occurrence of *Ligula* sp. plerocercoids in *Ladigesocypris irideus* (Ladiges, 1960) from South-Western Turkey: new host and new locality recordsSomayeh DOOSTI^{1*}, Fevzi YILMAZ²

ABSTRACT: In this study, the occurrence of the tapeworm *Ligula* cestoda was reported from the body cavity of Anatolian ghizani *Ladigesocypris irideus* collected from Ula pond, Aegean Region of Turkey in November 2018. Six infected fish were observed having eighteen parasites in total with minimum and maximum lengths of 40.23 mm and 51.79 mm, respectively. The prevalence, mean intensity and abundance of infection were assessed as 42.85%, 3 and 1.28 respectively. This study reports the first record of this endoparasite from Anatolian ghizani, a species endemic to South-Western Turkey. This is also the first record of this parasite from Aegean Region that is an evidence of increasing spread of this group in non-infected parts of Turkey mainly through the forced biological invasion.

Keywords: *Ligula* sp., *Ladigesocypris irideus*, endemic fish, Anatolian ghizani, pond ecosystems, biological invasion

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INTRODUCTION

Ligula (Linnaeus, 1758) is the most known genus of Cestoda from Pseudophyllidea that mostly infects members of Cyprinidae (Wootten, 2012). This parasite has the potential to influence fish in many aspects, which causes heavy losses on host species (Brown et al., 2002; Lagrue et al., 2018).

Ladigesocypris irideus (Ladiges, 1960) is a small cyprinid endemic to the Aegean Region of Turkey (Yilmaz et al., 2015). It has been reported from the main watercourses of southwestern Anatolia, i.e. Akçapınar, Balıklı, Gediz, Küçük Menderes, Tersakan, Yuvarlakçay rivers and streams, Köyceğiz Lake and Ula pond (Bogutskaya, 1997; Yilmaz et al., 2006; Fricke et al., 2007; Giannetto et al., 2015; Top and Tarkan, 2015). *L. irideus* inhabits slow running freshwaters especially in areas with tree roots, small caverns and plenty of vegetation. *L. irideus* lives up to 5 years and mostly feeds with small invertebrates, algae, and plant material. Spawning happens mostly in late spring and early summer (Yilmaz and Öğretmen, 2001). Rainfall reduction, water pollution and abstraction, habitat degradation and dam's water retention are the main threatening factors for this species (Freyhof, 2008; Yilmaz et al., 2015).

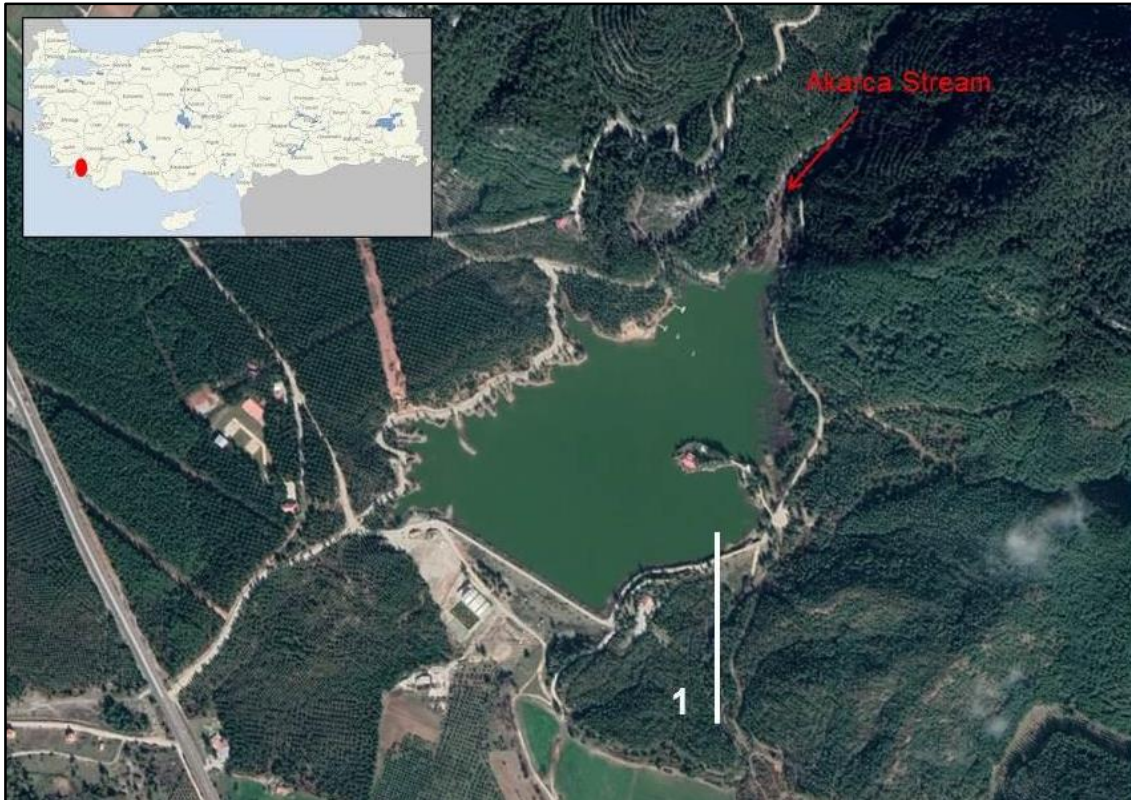
In Turkish inland waters, *Ligula* cestode infection is one of the most stated causes of fish stocks declining. Since the first record by Güralp (1968) several reports of infection have been given from various regions of Turkey referring to the infection as *Ligula intestinalis* (Cantorary and Özcan, 1975; Keskin and Erk'akan, 1987; Yilmaz et al., 1996; Yıldız et al., 2003; Innal et al., 2007; Aydoğdu et al., 2008; Innal et al., 2010; Özbek and Öztürk, 2010; Demirtaş, 2011). Also, some other studies reported intensity and infection prevalence of parasites by size, sex and seasonal distribution on the host fish species (Kır et al., 2004; Tekin et al., 2006; Kurupınar and Öztürk, 2009; Özbek and Öztürk, 2010; Turgut et al., 2011). In addition, the effect of parasites on physiological and anatomical structures of fish and pathological investigation on infected hosts were also reported (Akmirza, 2007; Korkmaz and Zencir, 2009; Saç et al., 2016; Aydoğan et al., 2018).

The present study aims to report the first occurrence of *Ligula* plerocercoids from a new host species *L. irideus* and a new locality (Ula pond in the Aegean Region of Turkey).

MATERIALS AND METHODS

Study Area

Ula pond is an artificial reservoir constructed on Akarca streambed in 1987, for irrigation purpose and water supply of fire helicopters. The pond has an area of 9750 km² and 2.5 km long (37°07' N, 28°23'E) and it is fed by Akarca stream (Figure 1). Until 1988, *L. irideus* and Aegean chub *Squalius fellowesii* were composing the only fish fauna of the pond. However, after the release of a large number of common carp *Cyprinus carpio* in the pond for sport fishing other alien species as gibel carp *Carassius gibelio*, goldfish *Carassius auratus*, and Eastern mosquitofish *Gambusia holbrooki* species were also introduced unintentionally into the pond (Top and Tarkan, 2015). The output water of the pond runs slowly in summer and does not show a significant increase in winter. This small output water does not join with any other water basin. Therefore, fish are trapped in small pools during summer and become easily exposed to threats.



Şekil 1. Ula Pond, Mugla province (Sampling areas are shown by white line) (<https://earth.google.com/>).

Fish Collection

A total of 14 *L. irideus* samples were collected in November 2018, from the output water of Ula pond using electrofishing (SAMUS 725MS) during fieldwork aimed to collect data on the biology of this endemic fish species. The samples were brought to the laboratory on the same day. For each collected fish, total, fork and standard lengths (nearest to 0.1 cm), also total weight (nearest to 0.1 g) were recorded. After measuring the biological characteristics of fish, specimens were dissected to examine the body cavity and viscera. The parasites were identified using the following references: Cheng (1973), Ekingen (1983), Chubb et al. (1987), Yamaguti (1959) and Schmidt (1986). The numbers of plerocercoides occurring in each fish specimen were counted. The numbers of plerocercoides occurring in each fish specimen were counted. The total length and weight of parasites were measured. Prevalence (%), mean intensity and abundance were also calculated as per Bush et al. (1997) and Gholami et al. (2011).

RESULTS

Out of fourteen collected *L. irideus* samples six of them were found infected having 1 to 11 parasites. Due to morphology, the abdomens of infected *L. irideus* specimens were salient and stretched as the body cavity and viscera were coiled up with plerocercoides. In this study, total, fork and the standard length of fish samples ranged between 22.13-67.23 mm, 20.41-61.15 mm and 18.56-53.20 mm, respectively. Total weight ranged between 1.17 and 3.49 gr for infected fish. As most parts of viscera were found devastated during dissection sex determination of fish was not possible.

The examined parasites were identified as plerocercoides of *Ligula* sp. being those flat with no divided scolex dome at the apex and arrowed annulation. It has no external segmentation of strobila but a round anterior end. The maximum and minimum of parasite length were 69.41 mm and 7.32 mm and

also the maximum and minimum of parasite weight were 0.33 gr and 0.07 gr, respectively. The prevalence, mean intensity and abundance of infection by plerocercoid of *Ligula* were found 42.85%, 3 and 1.28, respectively (Table 1).

Table 1. Details of infected *L. irideus* with *Ligula* sp. plerocercoids and non-infected specimens from Ula pond (Mugla, Southwest Turkey)

Fish No.	Fish TL (mm)	Fish FL (mm)	Fish SL (mm)	Fish Weight (gr)	Total Parasite No	Prevalence (%)	Mean Intensity	Abundance
1	67.23	61.15	53.2	3.49	2			
2	57.86	50.71	46.97	1.95	2			
3	55.52	50.45	45.77	1.81	-			
4	55.41	50.11	45.32	2.10	1			
5	53.35	49.84	44.84	2.09	11			
6	55.18	51.76	45.29	1.87	1			
7	54.65	50.48	45.21	2.88	-			
8	52.56	47.13	42.63	1.17	1			
9	51.66	46.26	42.25	1.28	-			
10	46.73	41.68	37.55	1.07	-			
12	39.26	37.12	33.95	0.72	-			
13	29.10	26.52	23.67	0.22	-			
14	22.13	20.41	18.56	0.09	-			
Total						42.85	3	1.28

DISCUSSION

With a three-hosted life cycle, *Ligula* cestode can infect many freshwater fishes in its plerocercoid stage which inhabits the fish's abdominal cavity in its second host (Lagrue et al., 2018). This parasite has the potential to influence fish in many aspects, which causes heavy losses on host species (Brown et al., 2002; Lagrue et al., 2018). Besides giving serious harm to fish stocks and economic value, it can also affect non-commercial but endangered species like Anatolian ghizani *Ladigesocypris irideus* (Ladiges, 1960) which is a small cyprinid endemic to Aegean Region of Turkey (Yilmaz et al., 2015).

Due to Turgut et al. (2011) prevalence of *L. intestinalis* plerocercoid was found highest in the autumn as 73.3% value while the same value in Korkmaz and Zencir (2009) studies was found 96.8% in winter and informed as 21 parasites mostly in spring by Tekin et al. (2006). This data was mentioned as maximum 12.6% in summer by Kurupinar and Öztürk (2009). In the present study, prevalence of *Ligula* plerocercoid was found 42.85% in winter. The smaller value can be due to the shorten period of investigation as the study was not seasonal but restricted to a one-month samplings carried on in a small group of specimens. The presence of stretched and salient abdomen in the examined fish was related to the number and size of parasites in their body cavity (Kır et al., 2004; Hoole et al., 2010; Mehraban et al., 2014). Hence Aydoğan et al. 2018 stated that infected cyprinid specimens behave differently when compared to others such as swimming closer to the surface, less predation avoidance and losing depth preference, which would make them more vulnerable to predation by avian predators and also less vigilant to escape from deep net (Loot et al., 2002; Gabagambi et al., 2019). Figure 2a and b report the infected *L. irideus* and the plerocercoids of *Ligula* sp. found in collected samples. As was observed by Saç et al. (2016) the difficulty in determine the sex of the infected fish was probably due to absence or degeneration of sexual organs possibly caused by compression or potential inhibition acted by the parasite on development of the reproductive system with diverting gonad development to somatic growth

in infected fish (Arme, 1968; Loot et al., 2002; Cowex et al., 2008; Hoole et al., 2010). Moreover, the infected fish samples were found to be bigger and heavier than the other fish. It has been suggested that the increase in *Ligula* infection may be related to increasing fish size due to the consumption of more infected copepods in larger fish (Loot et al., 2001; Özbek and Öztürk, 2010). The highest number of *Ligula* plerocercoids in this study was 11 small ones in a 53.35 mm (TL) length sample, which explains the decreased size of plerocercoids due to inadequate place in the body cavity for parasites growth.

No previous reports on the occurrence of *Ligula* from *Ladigesocypris irideus* are available in the literature. The only similar study is the occurrence of rhabdochonid nematode *Rhabdochona leucaspis* in *Ladigesocypris ghigii* (Moravea, 2006), which is another cyprinid endemic to Greece with restricted distribution to mainland Greece and Rhodes Island (Stoumboudi et al., 2002; Fricke et al., 2007; Giannetto et al., 2015).

Nevertheless, no previous records of *Ligula* from Aegean Region have been reported in the literature to date. This report underlines the further spread of this parasite throughout Turkey mainly due to the increasing number of introduced fish species throughout the country (Tarkan et al., 2015).

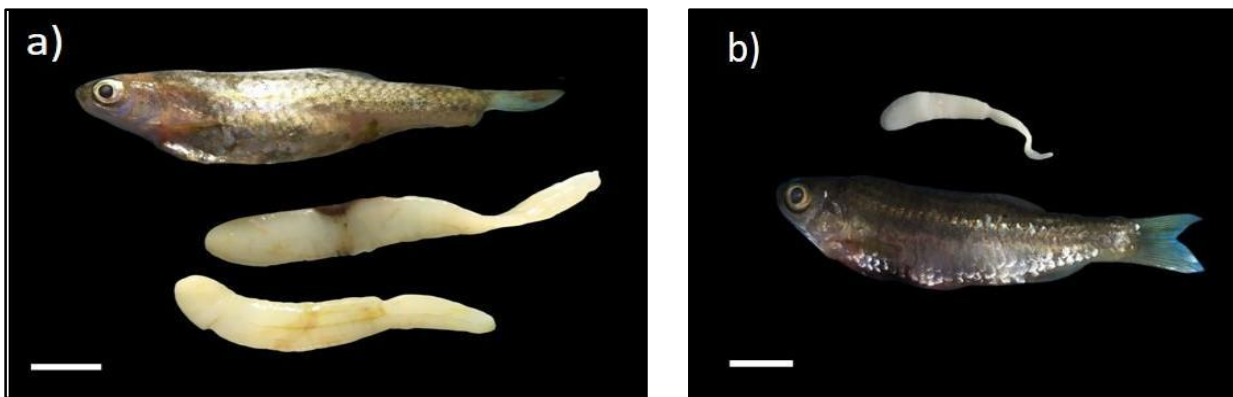


Figure 2. Plerocercoids of the cestode *Ligula* sp. (a and b) from the body cavity of Anatolian ghizani *Ladigesocypris irideus* specimens collected from Ula pond, Aegean Region of Turkey. Scale bar = 1 cm

CONCLUSION

The reported increasing number of infections with *Ligula* species in freshwater fishes of Turkey (Innal et al., 2007) is a concerning situation that could act as a further factor affecting the survival of already threatened endemic and endangered cyprinid species (Brown et al., 2002; Şaşı and Giannetto, 2016) as *Ladigesocypris irideus* due to behavioral change and pathological side effects.

Considering the position of the reservoir, Ula pond is situated in an area fed only by Akarca stream with no previous report of infection. Topcam reservoir is the closest basin with no aquatic connection to Ula pond in which infection with *Ligula* tapeworms has been reported previously (Innal et al., 2007). As the biological invasion threaten the native ecosystem by changing the local biodiversity or even transmission of new parasites (Lagrue et al., 2018) the introduction of cyprinid fish *C. carpio* to Ula pond and impulsively transfer of some infected alien species could be considered as the major source of parasite introduction in this watercourse. Moreover, infected bird species probably have an important role in the transmission of *Ligula* tapeworms in Ula pond being the avian fauna in the region very rich (Hoole 1994; Kiraç et al., 2012). Rainfall reduction and human impact (Hoole et al., 2010) are considered as other potential impacts of spreading parasite infection in the pond.

Although other species in Ula pond have not been examined in term of parasite presence in this study, all fish species of Ula pond can be considered as a potential infection source, which may cause

zoonose also in native people though fish consumption. Further researchers are also suggested to progress a successful infection control strategy for the conservation of endemic fish fauna.

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