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Parasites of juvenile golden grey mullet *Liza aurata* Risso, 1810 in Sarıkum Lagoon Lake at Sinop, Turkey

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Abstract

Juvenile golden grey mullet, *Liza aurata* were collected from Sarıkum Lagoon Lake which connected to the Black Sea at Sinop, Turkey and examined for parasitic fauna. A total of 219 fish were investigated throughout a 1-year period. Parasite species recovered were *Trichodina lepsii*, *T. puytoraci*, *Gyrodactylus* sp., *Ligophorus cephali*, *Ligophorus mediterraneus*, *Solostamenides mugilis*, *Ascocotyle* sp. (metacercaria) and *Ergasilus lizae*. Overall infection prevalence (%) and mean intensity values were 95.9% and 412.65 ± 85.31 parasites per infected fish, respectively. Infection prevalence and mean intensity values for each parasite species in relation to season and fish size were also determined and discussed. While *Ligophorus cephali* and *L. mediterraneus* are new records for Turkish parasite fauna, the juvenile *Liza aurata* is a new host record for *Ligophorus cephali* and *L. mediterraneus*.

Keywords

Golden grey mullet, *Liza aurata*, parasitic fauna

Introduction

The mugilids are among the most cosmopolitan teleost fishes and they are widely distributed in fresh, brackish and coastal marine waters of the tropical and temperate regions of the world. In Turkish waters, this family is represented by 8 species *Mugil cephalus*, *Liza aurata*, *L. ramada*, *L. saliens*, *L. abu*, *L. labeo*, *Chelon labrosus* and *Liza haematocheila* (Syn. *Mugil so-iuy*) since the 1990s. Of these, *Mugil cephalus*, *Liza aurata*, *L. ramada*, *L. saliens*, *Chelon labrosus and L. haematocheila* are found in the Black Sea. *Mugil cephalus*, *Liza aurata* and *L. haematocheila* for fishing in the Black Sea coast of Turkey are the three main mugilid species having a commercial importance. In spite of their ecological and economical importance in the region, the parasitic fauna and parasite ecology of these fish are still incomplete. There are many parasitological studies on *Liza aurata* in the Black Sea (Osmanov 1940, Chernyshenko 1949, Reshetnikova 1955, Solonchenko and Tkachuk 1985; Kovaleva *et al.* 1989, Yurakhno 1993, Pronkina 2001, Pronkina and Belofastova 2005, Belofastova 2005, Dmitrieva *et al*. 2005). These studies are mainly related to the northern part of the Black Sea. Limited numbers of papers have so far been published from the work conducted on parasites of mugilid fishes in Turkish water; on *L. saliens* and *L. ramada* from Aegean Sea by Altunel (1983), on *M. cephalus* from Karacabey Bayramdere Lagoon, Marmara Sea by Öztürk and Aydoğdu (2003), on *M. cephalus* and *L. aurata* from Black Sea (only about trichodinids) by Özer and Öztürk (2004) and on *Liza saliens* from the Dardanelles at Çanakkale (helmints of digestive tract) by Keser *et al*. (2007). However, there is no comprehensive study carried out on the parasites of *Liza aurata* in Turkey. Many data about the systematics of the parasites of the mugilid are available in above papers, but works dealing with quantitative data and ecology and diversity are scarce.

The aim of the present study is to reveal parasite fauna of juvenile golden grey mullet, their prevalences and intensities as well as the quantitative changes of parasite species numbers. The diversity and the existence of parasites in relation to season and size classes of the golden grey mullet were investigated and discussed for the first time on the Black Sea coast of Turkey.

Materials and Methods

Specimens of golden grey mullet were collected by fishing net in the estuary of Sarıkum Lagoon Lake (42°00´N; 34°54´E)

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which connects with the Black Sea on the coast of Sinop, Turkey (Fig. 1). It is typically a lagoon and an eutrophic lake having a brackish characteristic with a salinity between 1–5‰. The lake is inhabited by some aquatic animals, such as turtles and snakes and 8 fish species: golden grey mullet, *Liza aurata*; flounder, *Platichthys flesus*; toothcarp, *Aphanius danfordii*; round goby, *Neogobius melanostomus*, three-spined stickleback, *Gasterosteus aculeatus*; sand smelt, *Atherina boyeri* and common carp, *Cyprinus carpio*. In addition, the lake area is also important for hundreds of aquatic bird species to rest, particularly during their winter migration.

Samplings were carried out monthly during one year. The captured fish were fixed by 4% formaldehyde solution until parasitological examination. A total of 219 fish specimens were observed. At necropsy, total lengths of fish were measured. The lenght of fish varied between 44 and 168 mm during whole sampling period. Fish were grouped according to the following three size classes after total lengths had been measured: <50 mm, 50–100 mm, and 100> mm. Gills, eyes, peritoneal cavity, mesenteries, and peritoneal viscera were examined for parasites. For identification; trichodinids air-dried smears were stained according to Klein's silver nitrate ($AgNO_3$) method (Lom and Dykova 1992) in order to study details of the adhesive disk. The specimens of *Gyrodactylus* sp. were flatted and mounted in ammonium picrate-glycerin (Malmberg 1970). The specimens *Ligophorus* spp. were mounted in glycerine jelly (Gusev 1983) and the description of their were performed according to the articles of Sarabeev *et al*. (2005), Dmitrieva *et al.* (2009a, b). Digenean metacercaria were isolated from cysts using preparation needles and fixed with glycerine-picric acid. The copepod parasite was removed from the gill filaments, dissected, mounted in lactophenol as temporary slide preparations. The prevalence and mean intensity levels of the parasite species were determined according to Bush *et al*. (1997). Mean intensity values are given with standard error (SE). Water temperature (°C) and salinity (‰) levels were recorded using a U-10 Horiba digital water analyser at the sampling sites.

Normality of the data was checked using Kolmogorov-Smirnov test. Kruskal-Wallis test (Nonparametric ANOVA) was performed to compare in the mean intensity values of parasite species for infection sites, length classes of fish as well as for the seasons in which this study was conducted. The analyses were carried out using the computer programmes GraphPad Instat 3.0. P-values less than 0.05 was considered to be significant.

Results

The current study is the first to report on parasite fauna of golden grey mullet captured from the Black Sea coast of Turkey. A total of eight parasite species were identified: two species of protozoa, four of monogenea, one of digenea and one of copepoda (Table I; Fig. 2, 3, 4, 5).

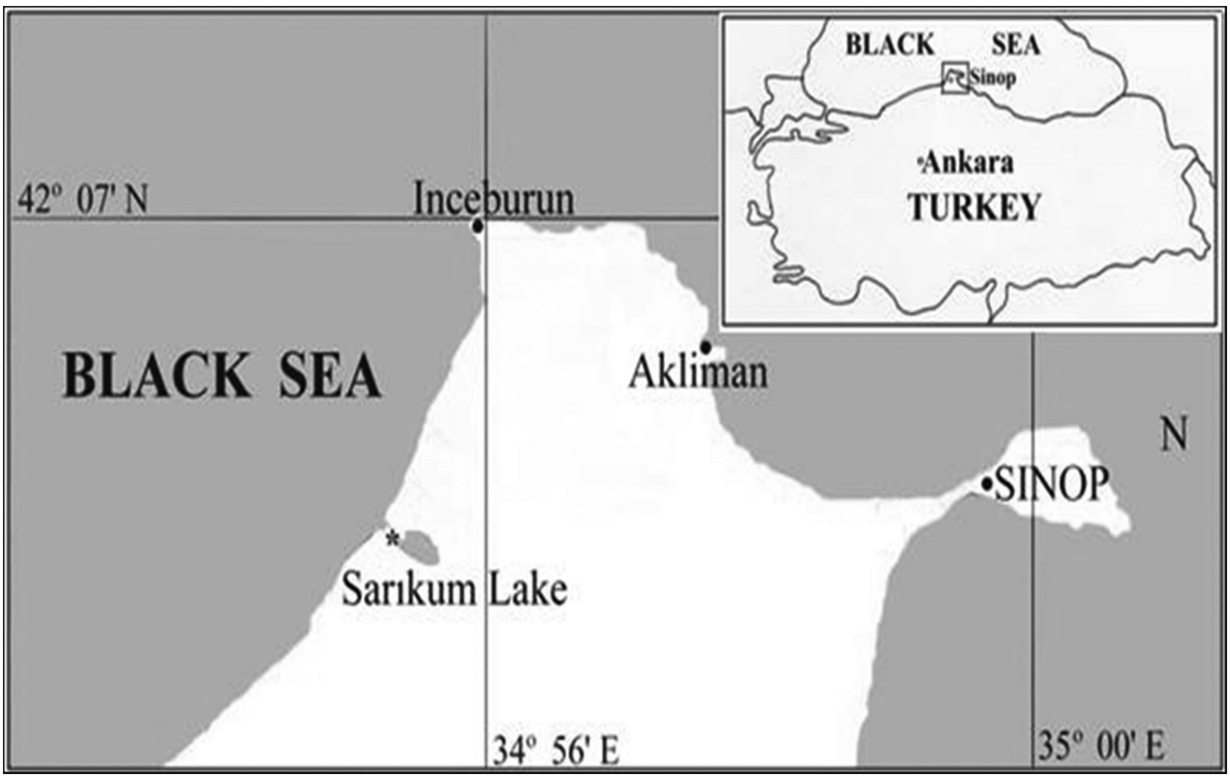


Fig. 1. Map of Sarıkum Lake showing the sampling area (*)

Table I. Infection site (microhabitat), prevalence and mean intensity levels of parasite species found in golden grey mullet, *Liza aurata*

Parasite species	Microhabitat	Prevalence (%)	Mean intensity ± SE
Trichodina lepsii	gills, skin, fins	66.2	570.77±120.93
Trichodina puytoraci	skin, fins, gills		
Gyrodactylus sp.	skin, fins, gills	15.5	1.85±0.26
Ligophorus cephali			
Ligophorus mediterraneus	gills	18.7	4.76±0.81
Solostamenides mugilis	gills	9.1	1.85±0.29
Ascocotyle sp.	Heart, liver, gills	49.3	19.10±1.66
Ergasilus lizae	gills	14.2	2.77±0.46
Overall		95.9	412.65±85.31

SE: standard error.

Table I summarises parasite list with indications of prevalence, mean intensity and infection site (microhabitat). The overall infection prevalence (%) and mean intensity values recorded from the total number of fish specimens were 95.9% and 412.65 ± 85.31 parasites per infected fish, respectively. Statistically significant differences in mean intensity values were found in relation to seasons (Table II).

The prevalence and mean intensity values of *Trichodina lepsii* and *T. puytoraci* were given as *Trichodina* spp. for pooled data rather than by each trichodinid species. Proportions of 100:15 (*T. lepsii* : *T. puytoraci*) were observed on the stained slides. *Trichodina* spp. was the most abundant and had 66.2% infection prevalence and mean intensity values of 580.77 ± 120.93 parasites per infected fish. On the contrary, *Solostamenides mugilis* was the least (Table I). If the number of parasite species in the individual host is regarded, it is apparent that the majority of golden grey mullet were infected with only two parasite species (Fig. 6).

Seasonal prevalence and mean intensities of all parasite species infecting *L. aurata* are reported in Table II. The overall mean intensity values of parasite species on *L. aurata* varied significantly among the seasons ($P<0.05$) and the highest mean intensity occurred in spring as 943.91 ± 265.57 parasites per infected fish. During this research study, all parasite species, except *Ergasilus lizae*, were recorded on fish in all seasons. When seasonal number of parasite species in *L. aurata* are regarded, minimum value was found in spring with three parasite species (Fig. 7A).

The infection parameters of parasite species in these three size classes of fish studied are given in Table 3. *Trichodina*

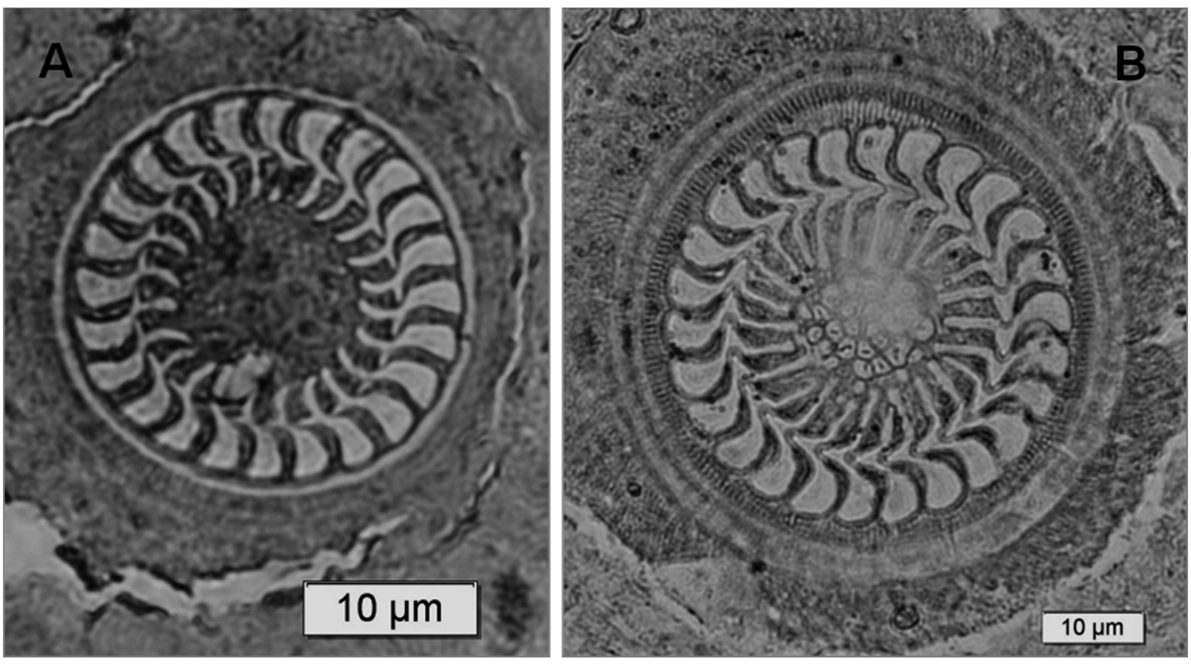


Fig. 2. Photomicrographs of *Trichodina* spp. stained with Klein's silver nitrate ($AgNO_3$). **A.** *Trichodina lepsii* Lom,1962, **B.** *Trichodina puytoraci* Lom, 1962 (original)

Table II. Seasonal infection prevalence and mean intensity levels of parasites found in *L. aurata* (n: examined fish number, min-max °C: water temperature)

Parasite species	Prevalence (%)				Mean intensity (± SE)			
	Spring (n: 62)	Summer (n: 75)	Autumn (n: 38)	Winter (n: 44)	Spring (18.2–21.9°C)	Summer (24.4–27.8°C)	Autumn (11.2–21.9°C)	Winter (7.1–9.8°C)
Trichodina lepsii	87.09	50.67	23.68	100	976.02±274.31^{a}	7.08±2.66^{b}	4.56±1.19^{b}	709.02±185.83^{a}
Trichodina puytoraci								
Gyrodactylus sp.	25.81	4.00	2.63	31.82	1.5±0.18^{a}	1.00±0.00	1.00±0.00	29.26±8.44^{b}
Ligophoruscephali								
Ligophorus mediterraneus	17.74	8.00	7.89	47.73	7.64±2.04^{a}	1.00±0.00	5.00±2.65^{b}	4.29±0.97^{b}
Solostamenides mugilis	8.06	33.33	13.16	50	1.33±0.33	1.04±0.04	1.33±0.24	1.50±0.26
Ascocotyle sp.	12.90	80.00	84.21	18.18	4.75±2.53^{a}	21.00±2.30^{b}	21.91±2.92^{b}	8.00±4.26^{a}
Ergasilus lizae	0.0	16.00	47.37	2.72	0.00±0.00	1.25±0.13^{a}	3.78±0.75^{b}	3.00±0.00
Overall	90.32	96.00	100	100	943.91 ±265.57^{a}	21.93±2.32^{b}	22.05 ± 2.89^{b}	714.14±186.09^{c}

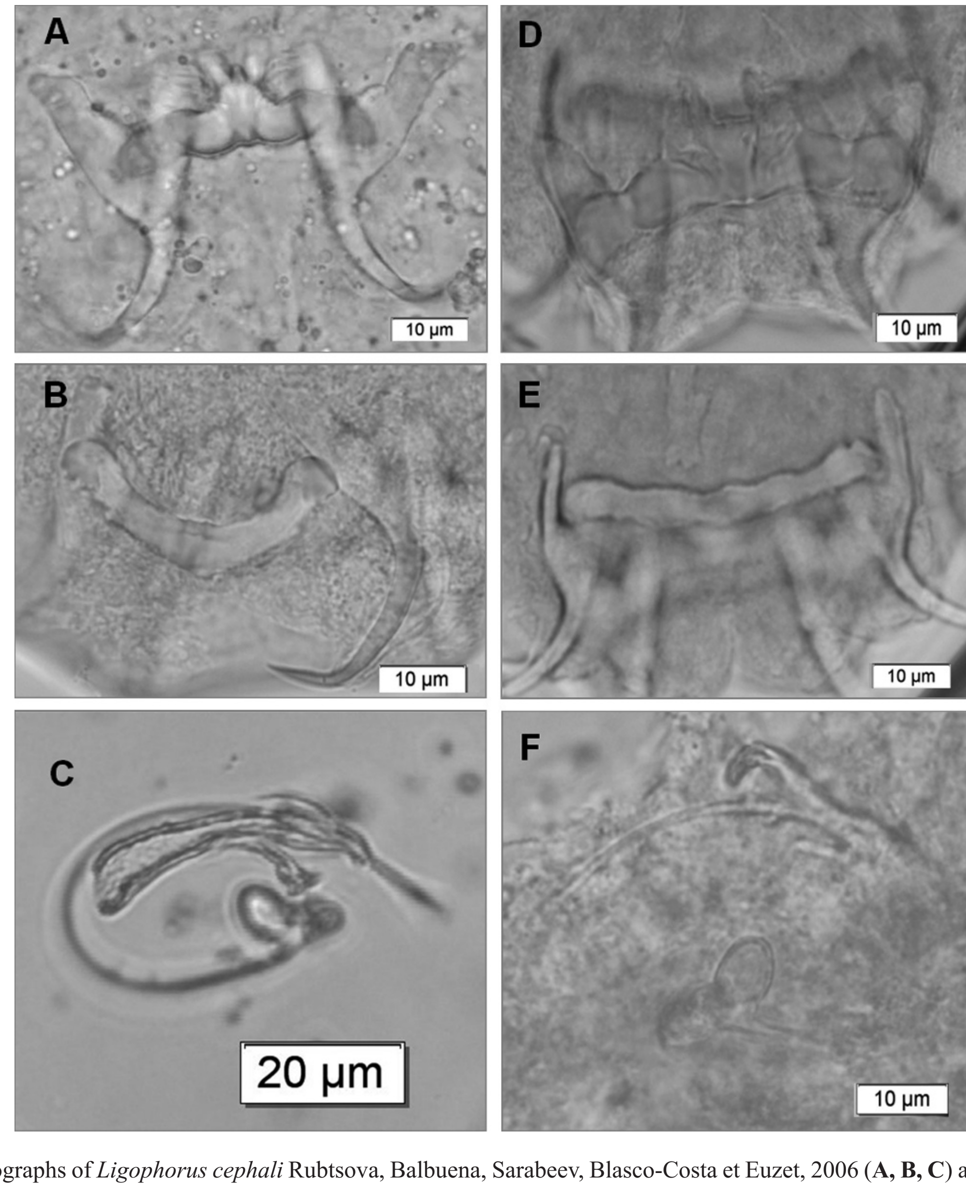


Fig. 3. Photomicrographs of *Ligophorus cephali* Rubtsova, Balbuena, Sarabeev, Blasco-Costa et Euzet, 2006 (**A, B, C**) and *L. mediterraneus* Sarabeev, Balbuena et Euzet, 2005 (**D, E, F**) stained with ammonium picrate-glycerin. (**A, D**). ventral bar; (**B, E**). dorsal bar; (**C, F**); Male copulatory complex (original)

Table III. Infection prevalence and mean intensity levels of parasites founded in *L. aurata* according to fish lenght classes (n: examined fish number)

Parasite species	Prevalence (%)			Mean intensity (± SE)		
	<50 mm (n: 8)	50–100 mm (n: 121)	100 mm> (n: 90)	<50 mm	50–100 mm	100 mm>
Trichodina lepsii *T. puytoraci*	50	85.95	41.11	3.00±1.41a	635.46±145.21b	489.51±241.25a
Gyrodactylus sp.	25	22.31	5.50	1.00±0.00	2.00±0.32	1.40±0.24
Ligophoruscephali *L. mediterraneus*	0.0	23.14	14.44	0.00±0.00	3.96±0.95a	6.46±1.49b
Solostamenides mugilis	12.5	9.92	7.77	1.00±0.00	1.83±0.37	1.71±0.56
Ascocotyle sp.	0.0	23.14	88.88	0.00±0.00	12.18±2.81a	21.53±1.95b
Ergasilus lizae	0.0	0.0	34.44	0.00±0.00	0.00±0.00	2.77±0.49
Overall	75	94.21	100	2.83±1.47a	584.35±133.38b	222.48±101.54c

Means followed by the same superscript letter are not significantly different.

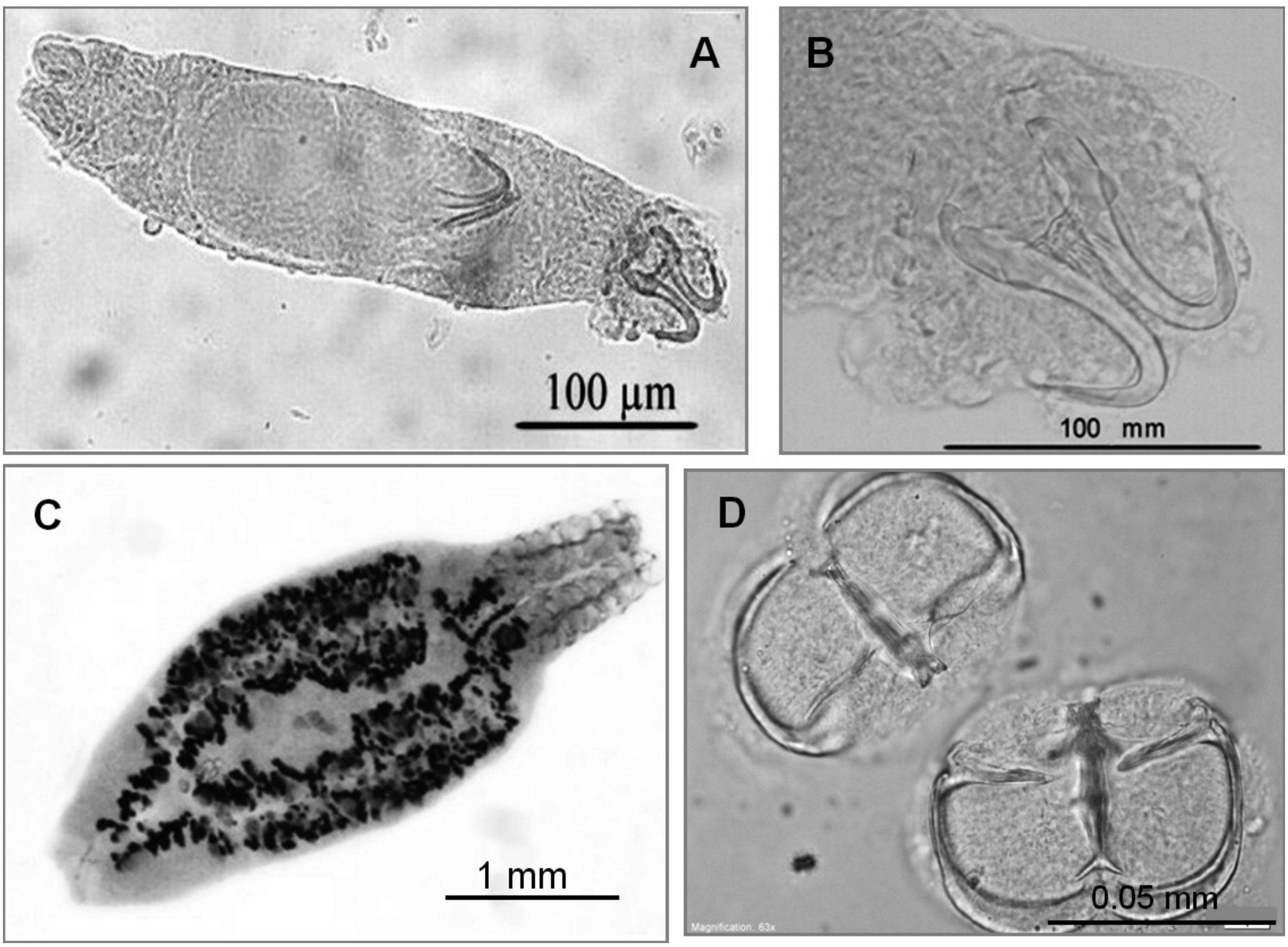


Fig. 4. Photomicrographs of monogenean parasite species stained with ammonium picrate-glycerin. **A.** *Gyrodactylus* sp.; **B.** Haptor of *Gyrodactylus* sp.; **C.** *Solostamenides mugilis* (Vogt 1878); **D.** Clamp of *S. mugilis* (original)

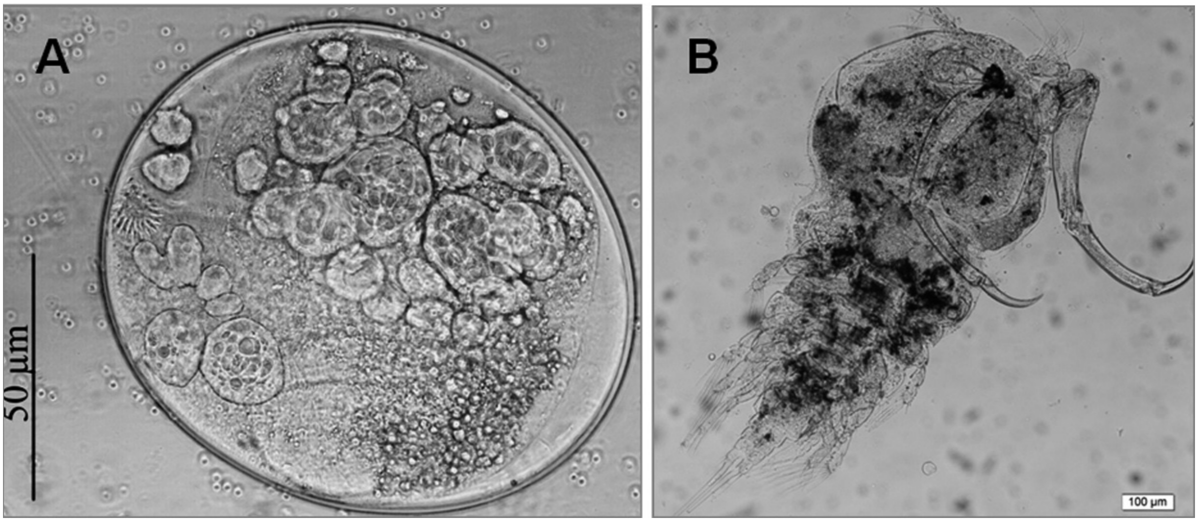


Fig. 5. Photomicrographs of digenean trematoda and copepoda parasites recovered on *L. aurata*. **A**. *Ascocotyle* sp. encysted metacercaria; **B.** *Ergasilus lizae* Kroyer, 1963 (fresh, original)

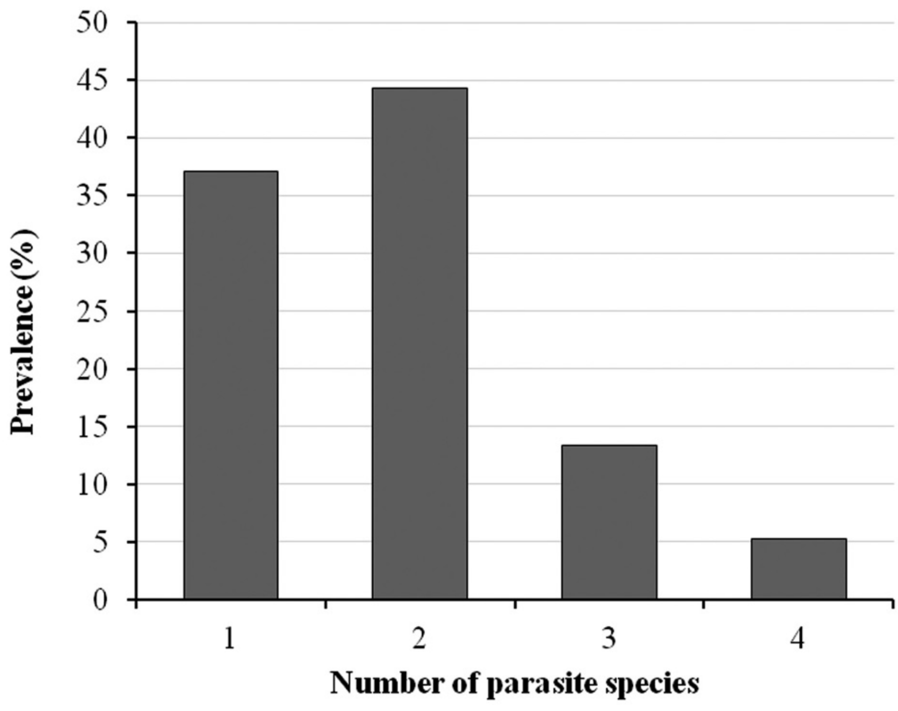


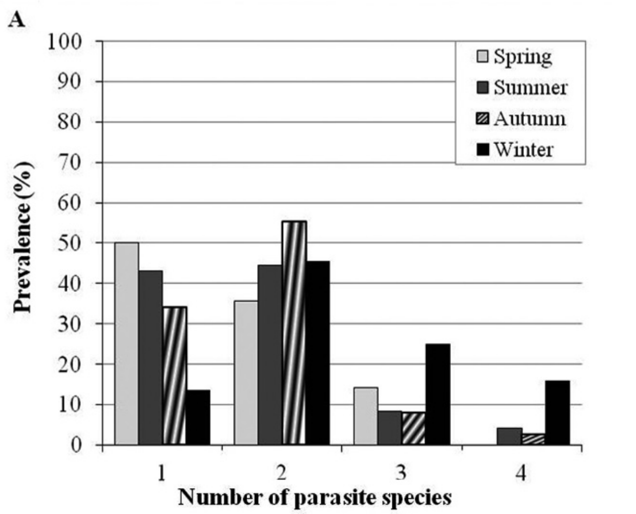
Fig. 6. Infection prevalence (%) with respect to the number of parasite species detected in *L. aurata* during investigation period

lepsii, *T. puytoraci*, *Gyrodactylus* sp. and *Solostamenides mugilis* were found in all size classes. While *Ligophorus* spp. (*Ligophorus cephali*, *L. mediterraneus*) and *Ascocotyle* sp. were absent in the smallest (<50 mm) and *Ergasilus lizae* was found only in the largest (100 mm>). Large fish had higher infection prevalence and intensities than did small fish. (Table III). A similar pattern, more parasite numbers in larger fish, was also seen in the prevalence values of the number of parasite species detected in the size classes (Fig. 7B). The lowest number of parasite species was found in the smallest size class (<50 mm). However, in the other groups, the situation was equal with 4 parasite species. In addition, infection with two parasite species occurred in all size classes and the prevalence values of parasitisation with two species was increased depending on the size of fish (Fig. 7B).

Water temperature (°C) values recorded monthly; while the highest temperature values was in August (27.8°C), it was the lowest in January (7.1°C). During the study period, salinity

Table IV. Seasonal average values of water temperature and salinity from sampling area and the length of caught fish

Seasons	Temperature (°C)	Salinity (‰)	Fish length (mm)
Spring	19.7±1.12	2.63±0.32	70.47±1.91
Summer	25.9±0.99	3.83±0.59	109.43±1.67
Autumn	17.1±3.20	3.23±1.05	128.74±5.99
Winter	8.5±0.78	2.60±1.25	75.85±2.23



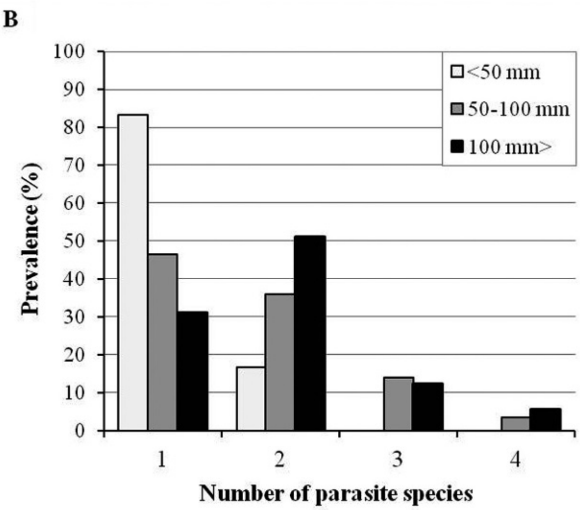


Fig. 7. Infection prevalence (%) with respect to the number of parasites in *L. aurata* related with seasons (**A**) and fish length (**B**)

varied from 1.2 to 5.1‰. The salinity was at its minimum in February (1.2‰) and maximum in January (5.1‰) (Table IV).

Discussion

In the present study, eigth parasite species were identified on juvenile golden grey mullet, *Liza aurata* (Table I) and changes in their population patterns were determined in terms of fish size and seasons (Table II and III).

Trichodina lepsii and *T. puytoraci* were determined as the most common parasites on *L. aurata*. These species have preously been reported from mugilids such as *Mugil cephalus*, *M. saliens*, *M. platanus* and *Liza aurata* in marine and brackish waters (Lom 1962, Bykovskaya-Pavlovskaya *et al.* 1964, Paperna and Overstreet 1981, Grupcheva *et al*. 1989, Özer and Öztürk 2004, Marcotegui and Martorelli 2009).

Trichodina lepsii was commonly found on the gills of the golden grey mullet, scarcely on the skin and fins, for *T. puytoraci* it was the reversed in the present study, similar to those reported by the above mentioned authors. The prevalence (%) of infection was the highest in winter and spring and the lowest in Autumn here. Palm and Dobberstein (1999) observed a similar increase in the *Trichodina* population density on *Platichthyes flesus* in winter, attributed this increase to the bacterial biomass in the enviroment. Similarly, Ogut and Palm (2005) and Ogut and Akyol (2007) also found an increase in the abundance of trichodinids in winter months on *Merlangius merlangus euxinus*. Öztürk and Özer (2010) recorded high level of prevalence and mean intensities of infection in winter and spring on juvenile *Platichthyes flesus* and speculated that were due to seasonal eutrafication and organic pollution. Here in the present study, the observed high level prevalence and mean intensities of infection in winter and spring were probably due to seasonal eutrophication or organic pollution in the sampling areas in agreement with above mentioned authors.

The size of golden grey mullet was one of the affecting factors of the intensity of the *Trichodina* spp.(*T. puytoraci* and *T. lepsii*) in this study, and the differences in the mean parasite intensities between different size classes of fish were statistically significant. Özer (2003a,b) and Öztürk and Özer (2010) also found a tendency to increase in mean intensity of trichodinid-group in relation to the size of host fish. The severity of many ectoparasitic infections increases with host size, possibly as a result of increasing exposure period and larger space for feeding and breeding of the parasite. Hovewer, the highest number of trichodinid parasites was observed on the middle-sized golden grey mullet (50–100 mm) rather than on the largest-sized fish (100 mm>). This could be the result of collected fish length in spring and winter which reflecting the middle-sized fish (Table IV). Thus, fish size class may not be the only reason affecting the infectation values of trichodinids, season should also be taken into consideration.

Four monogenean (*Gyrodactylus* sp., *Ligophorus cephali*, *L. mediterraneus* and *Solostamenides mugilis*) and one digenean (*Ascocotyle* sp. metacercaria) parasites were found on juvenile golden grey mullet during the present investigation. Among monogenea, *Ligophorus* spp. reported to have the highest prevalence, especially in *Liza* species (Merella and Garippa 2001). Because all mugilids studied to date have been infected with more than 1 species of *Ligophorus*, it is natural to assume that this genus is far more diverse than currently described. Strict host-specificity is a common phenomenon among monogeneans and the species of some *Ligophorus* are strictly specific to mugilids; including *Ligophorus cephali* and *L. mediterraneus* on *Mugil cephalus*; *L. szidati* on *Liza aurata* (Mariniello *et al*. 2004, Sarabeev *et al*. 2005, Rubtsova *et al.* 2006, Dmitrieva *et al.* 2009b). Euzet and Suriano (1977) considered that all species of *Ligophorus* are oioxenic, which seemed substantined by ensuing studies (Radujkovic and Raibaut 1989, Caillot *et al*. 1999). However, current records shows that at least some species are stenoxenic. For example, *L. szidati*, whose typical host is *Liza aurata*, have also been reported on the *Liza saliens* (Dmitrieva and Gaevskaya 2001, Dmitrieva 1996, Pankov 2011). So far, *Ligophorus cephali* and *L. mediterraneus* haven't been reported in *Liza aurata*. This paper is the first of their presence on *Liza aurata.* In North Aegean Sea, *Liza aurata* is parasitised by *Ligophorus* spp. (43.4%) (Ragias *et al.* 2005). However, it has been recorded in the present study that the prevalence (18.72%) and mean intensity (4.76 ± 0.81) values of *Ligophorus* spp. (*L. cephali and L. mediterraneus*) on *Liza aurata* is much lower than values recorded from its typically parasites, possible reflecting the effects of differing geographical area and/or host factors. The prevalence of *Ligophorus* spp. was the highest in winter and the lowest in summer (Table 2). Fuentes and Nasir (1990) reported peak levels of *L. mugilinus* prevalence in winter and also noted that the infection rate incerased with the size of the host (*Mugil curema*). Garcia and Williams (1985) found this monogenean parasite absent in the smallest-sized fish (< 50 mm). Despite an increase in the prevalence value in the middle-sized fish here, the mean intensity value was lower than other size classes of fish (Table 3). In general, our findings on the intensity levels of *Ligophorus* spp. partially agree with those reported by the above mentioned authors.

Gyrodactylus sp. and *Solostamenides mugilis* were the other monogenean parasites described in the present study. They both appeared in their highest prevalence values in winter. Miroshnichenko and Maltsev (1998) reported the distribution of *G. zhukovi* on *Mugil so-uiy* from waters of the Azov Sea basin in positive relation with water temperature and salinity decrease. *Solostamenides mugilis* has been reported in *Mugil cephalus*, *Liza haematochielus*, *L. aurata*, *L. ramada*, *C. labrosus*, *L. saliens* (Radujkovic 1982, El-Hafidi *et al.* 1998, Ragias *et al.* 2005, Yemmen *et al.* 2012). This species is a common parasite of Mugilidae fish from the Mediterranean. In this the size of fish had no statistically significant effect on the prevalence of these monogenean species.

To date, species of genera as *Dicrogaster*, *Saccocoelium*, *Haploporus* and *Haplospanchus* have been reported from Mugilidae (Öztürk and Aydoğdu 2003, Ragias *et al*. 2005). No specimens of genera above mentioned were found in this during investigation. The absence of these digenean parasites in this study could be related to the lack of the final and intermadiate hosts in the sampling site. On the other hand, *Ascocotyle* sp. (encysted metacercaria) was the only digenean parasite recorded on golden grey mullet in the present study. The prevalence and mean intensity of *Ascocotyle* sp. were higher in summer and autumn than those in spring and winter (Table II). These values were also possitively correlated with increasing fish size. Coleman and Travis (1998) observed a similar increase in the *Ascocotyle* population density in their investigation and also found older (larger) fish were more heavily parasitized than younger (small) fish. Similarly, Elsheikha and Elshazly (2008) determined an increase in infection prevalence of metacercariae in the mugilid fishes in summer similar to our data. Release of trematode cercariae from the snail host and successful transmission to the fish host is highly temperature-dependent. Thus, the increased prevalence and intensity of metacercariae in the fish during summer may be the result of repeat infections associated with the emergence of snail intermediate host in high temperature followed by rapid and massive release of cercariae. Moreover, smaller fish caught during the winter and spring had low parasite intensity than larger fish caught during the summer and autumn. Considering the higher seasonal average lenght of fish in summer supported possitively the release of metacercaria has having more parasite over their life span.

Ergasilus lizae Kroyer, 1863 is among the common ectoparasites on the gills of mugilid fishes (El-Rashidy and Boxhall 1999, Conroy and Conroy 1986), and has a known wide geographical distrubition that includes the North American Atlantic coast, Uruguay, Israel, Black Sea, Australia, and South American Pasific coast (Knoff *et al*. 1994). *Ergasilus lizae* has so far been reported in *Mugil cephalus* (Oldewage and Van As 1988, Kabata 1992), *M. platanus* (Knoff *et al.* 1994), *M. liza*, *M. curema and M. trichodon* (Bunkley-Williams and Williams 1994) and *L. aurata* (Ben-Hassine and Raibaut 1981, Paperna and Overstreet, 1981). Johnson and Rogers (1973) considered that *E. lizae* is naturally distributed in coastal waters, and Paperna (1975) has affirmed that this species of ergasilid is capable of surviving and reproducing in water with a salinity of less than 2‰. Garcia and Williams (1985) recorded high level of prevalence of *E. lizae* on *M. curema* during the winter period. However, in the present study, both prevalence and mean intensity values of *Ergasilus lizae* were at their highest in Autumn. Paperna and Overstreet (1981) have suggested that infestations due to this parasite occur when the young mullets reach coastal waters and come into contact with older specimens whose standard size exceeds 60 mm and which are already parasitized by the copepod. Although the our findings on seasonal parasite load did not match with those related data reported by above mentioned authors, the size of host fish had more positive correlation as was reported by Paperna and Overstreet (1981).

In conclusion, this paper is the first report on the parasite fauna of the juvenile *Liza aurata* in Turkey. Here in the present study, we report *Ligophorus cephali* and *L. mediterraneus* are a new records for Turkish parasite fauna, and the juvenile *Liza aurata* is also a new host record for *Ligophorus cephali* and *L. mediterraneus.*

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