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Parasite fauna of Golden Grey Mullet *Liza aurata* (Risso, 1810) collected from Lower Kızılırmak Delta in Samsun, Turkey

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Summary

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. *Liza aurata* is one of eight mugilid species survive in Turkish waters. Parasite fauna of the golden grey mullet *Liza aurata* (Risso, 1810) collected from Lower Kızılırmak Delta in Samsun, Turkey were investigated in the present study. Standard parasitological investigation methods were applied and standard indices of infection were calculated. A total of 10 parasite species were identified and they are; *Trichodina puytoraci, Trichodina lepsii, Ligophorus mediterraneus, Ligophorus cephali*, *Microcotyle mugilis, Ascocotyle (Phagicola) longa*, *Haplosplanchnus pachysomus*, *Tylodelphys clavata*, *Neoechinorhyncus agilis* and *Ergasilus lizae*. Overall infection prevalence was 100 % and both the mean intensity and abundance values were 190.09 ± 43.15 parasites per infected/examined fish. *Ligophorus*-group parasites were the most abundant (97.83 %) and *Tylodelphys clavata* was the least (4.35 %) among all parasite species identified. Water temperature (C), dissolved oxygen (mg/lt), salinity (ppt) and nitrate (mg/lt) values were also presented. According to results obtained in the present study, *Ligophorus cephali*, *Ligophorus mediterraneus*, *Thylodelphys clavata* and *Ascocotyle (Phagicola) longa* are new parasite records for *L. aurata* and *Ligophorus mediterraneus, Ligophorus cephali* and *Ergasilus lizae* are the new parasite records for Turkish parasite fauna of fish in Turkey.

Keywords: *Liza aurata*; parasite fauna; Kızılırmak delta; Turkey

Introduction

The mugilids are among the most cosmopolitan teleost fishes and they are widely distributed in fresh waters, brackish waters and coastal marine waters of the tropical and temperate regions of the world. They are known to be euryhaline fishes and are prevalent in coastal lagoons due to their high mobility and tolerance to environmental conditions such as temperature and salinity. The family Mugilidae includes 17 genera and >75 species in the world (Nelson, 2006). Mugilid species are commonly found along the Mediterranean and Black Seas and represented with four genera and nine species. In Turkish waters, there are eight species of Mugilidae and they are; *Mugil cephalus* L., 1758*, Liza aurata* (Risso, 1810), *Liza ramada* (Risso, 1827)*, Liza saliens* (Risso, 1810)*, Liza abu* (Heckel, 1843)*, Oedalachilus labeo* (Cuvier, 1829)*, Chelon labrosus* (Risso, 1827) and *Liza haematocheila* (Temminck & Schlegel, 1845). Of these, golden grey mullet *L. aurata* is found in the Black Sea region of Turkey. There have been several published studies on the parasite fauna of this fish species (see Table 1 for detailed list). Dmitrieva *et al*. (2012) also provided updated information on *Ligophorus* species which are all specific to mugilids. However, research studies on the parasite fauna and parasite ecology of golden grey mullet are very rare and still incomplete. The objective of this investigation was to study the natural parasite fauna of *Liza aurata* from Kızılırmak Delta, an area of ecologically important and protected by the law, in Samsun, Turkey and to extend our knowledge about its parasite fauna, infection levels and distribution of its parasite species.

Materials and Methods

Kızılırmak Delta is one of the biggest wetlands in Turkey with the largest bird diversity of 322 and 25 fish species. It is located in the border of Samsun city (41° 38’ 38.84” N and 36° 04’ 09.89” E) and lies at the sea level. Parasitological investigation was conducted in the lagoon lakes of Karaboğaz (170 ha) and Liman (272 ha) (Fig. 1). These lagoons have direct connection with the Black Sea time to

Table 1. Parasite species reported from golden grey mullet from different locations by different authors

Parasite species	Location	Authors
Trichodina puytoraci	Sinop, Turkey	Özer & Öztürk (2004)
"	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Trichodina lepsii	Sinop, Turkey	Özer & Öztürk (2004)
"	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Ghar El Mehl LagoonTunisia	Yemmen *et al.* (2012)
Ligophorus szidati	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
"	Mediterranean Sea	Mariniello *et al*. (2004) ve ark., (2004)ve ark., (2004)
"	Azov and Black Sea	Sarabeev & Balbuena (2004)
"	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Azov and Black Sea	Dmitrieva *et al*. (2012)
"	Black Sea	Gaevskaya & Dmitrieva (1997)
Ligophorus vanbenedenii	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
"	Mediterranean Sea	Mariniello *et al*. (2004) ve ark., (2004)ve ark., (2004)
"	Azov and Black Sea	Sarabeev & Balbuena (2004)
"	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Azov and Black Sea	Dmitrieva *et al*. (2012)
"	Black Sea	Gaevskaya & Dmitrieva (1997)
Ligophorus kaohsianghsieni	Azov and Black Sea	Dmitrieva & Gaevskaya (2000)
"	Azov and Black Sea	Dmitrieva *et al*. (2012)
"	Black Sea	Gaevskaya & Dmitrieva (1997)
Ligophorus macrocolpus	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Black Sea	Dmitrieva *et al*. (2012)
"	Black Sea	Gaevskaya & Dmitrieva (1997)
Ligophorus spp.	Greece	Ragias *et al*. (2005)
Microcotyle mugilis	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Black Sea	Gaevskaya & Dmitrieva (1997)
Gyrodactylus alviga	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Haplosplanchnus pachysomus	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Greece	Ragias *et al*. (2005)
Saccocoelium obesum	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
"	Greece	Ragias *et al*. (2005)
"	Mediterranean Sea, Spain	Blasco-Costa *et al*. (2009)
Saccocoelium tensum	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
"	Greece	Ragias *et al*, (2005)
"	Mediterranean Sea, Spain	Blasco-Costa *et al*. (2009)
Saturnius sp.	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
Saturnius papernai	Mediterranean Sea, Spain	Blasco-Costa *et al*. (2009)
"	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Saturnius mugili	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Haploporus benedeni	Greece	Ragias *et al*. (2005)
Dicrogaster contractus	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
"	Greece	Ragias *et al*. (2005)

Lecithaster confusus	Greece	Ragias *et al*. (2005)
Lecithobotrys putrescen	Greece	Ragias *et al*. (2005)
Acanthostomum imbriformis mtc	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Aphanurus stossichi	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Clinostomum piscidium mtc	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Dicrogaster contracta	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Haploporus lateralis	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Lecithaster galeata	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Phagicola sinaceum mtc.	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Wlassenkotrema longicolum	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Capillaria sp.	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
Contracaecum sp.	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
Philometra taurica	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Scolex pleoronectis	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Neoechinorhyncus agilis	Mitras Lagoon, Sardinia	Merella and Garippa (2001)
"	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Greece	Ragias *et al*. (2005)
Ergasilus lizae	Tunisia	Ben Hassein & Raibaut (1981)
Ergasilus nanus	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Acanthogyrus lizae	Greece	Ragias *et al*. (2005)
Caligus pageti	Mitras Lagoon, Sardinia	Merella & Garippa (2001)
Nerocila orbignyi	Mitras Lagoon, Sardinia	Merella &Garippa (2001)
"	Greece	Ragias *et al*. (2005)
Myxobolus exiguus	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Myxobolus mugilis	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
"	Mediterranean Sea	Perugia (1891)
Myxobolus mulleri	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Myxobolus parvus	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Myxobolus branchiale	Azov and Black Sea	Dmitrieva & Gaevskaya (2001)
Pseudalataspora pontica	Black Sea	Dmitrieva & Gaevskaya (2001)
Sphaeromyxa sabrazesi	Black and Mediterranean Sea	Dmitrieva & Gaevskaya (2001)
"	Black Sea	Ovcharenko & Yurakhno (2008)
Zschokkela dogieli	Black Sea	Dmitrieva & Gaevskaya (2001)
Zschokkela nova	Black Sea	Dmitrieva & Gaevskaya (2001)
Zschokkella admiranda	Black and Mediterranean Sea	Ovcharenko & Yurakhno (2008)
Ortholinea divergens	Black Sea	Yurakhno (1993)
Sphaerospora dicentrarchi	Azov and Black Sea	Ovcharenko & Yurakhno (2008)
Polysporoplasma mugilis	Black and Mediterranean Sea	Sitja-Bobadilla & Alvarez-Pellitero (1995)
Chloromyxum kotorensis	Adriatic Sea	Lubat *et al*. (1989)
Myxobolus mugauratus	Black Sea	Pogoroltseva (1964)
Myxobolus rotundus	Black Sea	Chernova (1967)
Kudoa trifolia	Mediterranean Sea	Holzer *et al*. (2006)
Kudoa unicapsula	Mediterranean Sea	Yurakhno *et al*. (2007)

time over a year period. These lagoons have a water column of maximum depth 3 m, with the average 1.5 m.

In the present study, the parasite fauna of golden grey mullet, *Liza aurata* (Risso, 1810), was determined from 46 fish specimens caught by electroshock device or cast-net. Parasitological investigation was conducted at the Faculty of Fisheries and Aquatic Sciences in Sinop. All fish were weighed and measured and their sex was determined. Fish

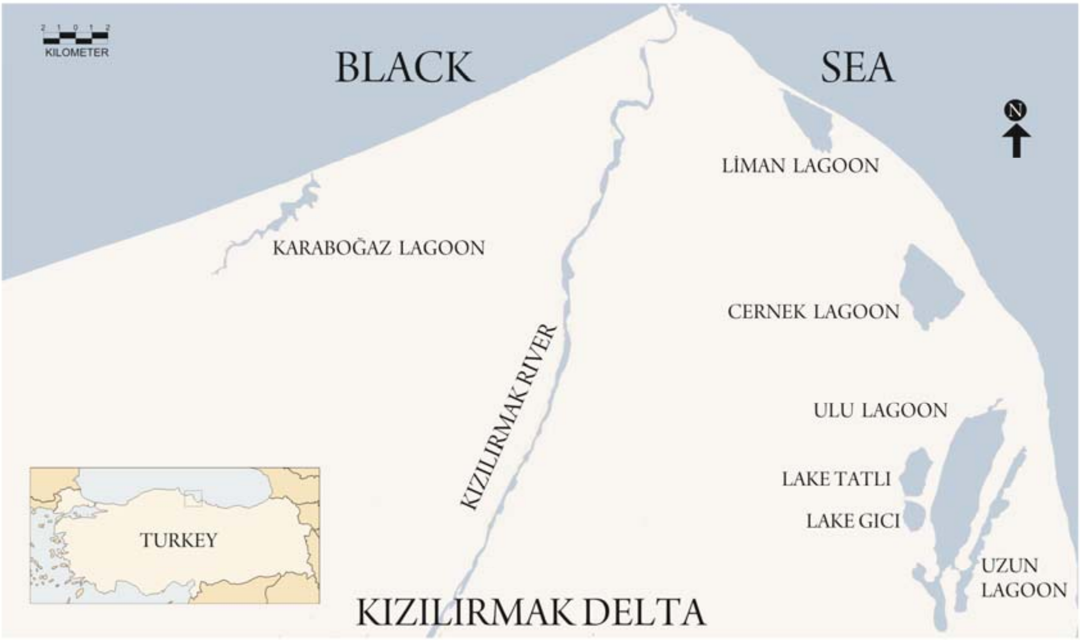

Fig. 1. Sampling sites of Karaboğaz and Liman Lagoons in Kızılırmak Delta

were subsequently examined for ecto- and endoparasites under a dissecting microscope. The examination included the skin, fins, gills, eyes (lens and vitreous humour), body cavity and visceral organs (stomach, intestine, liver, swim-bladder, hearth and gonads). Parasites recovered were fixed and preserved using methods commonly applied. For SEM imaging, worms were dehydrated in a graded ethanol series, placed in hexamethyldisilazane and allowed to dry. They were mounted on stubs and coated with gold and then SEM micrographs were taken using a Jeol JSM-6510LV scanning electron microscope at an accelerating voltage of 10 kV.

Infection prevalence (%) and mean intensity follow the recommendations of Bush *et al*. (1997). The prevalence (%) was calculated as the percentage of the total number of fish infected out of the total number of fish examined. The mean intensity was calculated as the average number of parasites in the total number of infected fish. The prevalence and mean intensity values of *Trichodina* (*T. puytoraci* and *T. lepsii*) and *Ligophorus* species (*L. cephali*

Table 2. Parasite species identified and their overall infection prevalence (%), mean intensity and abundance values in Kızılırmak Delta throughout the sampling period (n:46)

Parasite species	Microhabitat	Prevalence (%)	Mean Intensity ± S.E.	Abundance ± S.E.
Trichodina-group				
Trichodina puytoraci (Lom, 1962)	gills, skin	56.52	81.11 ± 36.56	45.85 ± 21.34
Trichodina lepsii (Lom, 1962)	skin, gills			
Ligophorus-group				
Ligophorus cephali (Ruptsova et Euzet, 2006)	gills	97.83	88.93 ± 17.41	87.00 ± 17.13
Ligophorus mediterraneus (Sarabeev, Balbuena, Euzet, 2005)	gills			
Microcotyle mugilis (Vogt, 1878)	gills	8.70	2.75 ± 1.44	0.24 ± 0.16
Ascocotyle (Phagicola) longa Ransom, 1920	gills, hearth	6.52	6.00 ± 3.05	0.39 ± 0.27
Tylodelphys clavata (Nordmann, 1832)	humour vitrous	4.35	1.00 ± 0.00	0.04 ± 0.03
Haplosplanchnus pachysomus (Eysenhardt, 1829) Loss,1902)	intestine	39.13	128.72 ± 37.77	50.37 ± 17.28
Neoechinorhyncus agilis **(**Rudolphi, 1819)	intestine	47.83	6.14 ± 1.58	2.93 ± 0.87
Ergasilus lizae (Krøyer, 1863)	gills	50.00	6.87 ± 1.72	3.43 ± 0.99
Overall		**100.00**	**190.09 ± 43.15**	**190.09 ± 43.15**

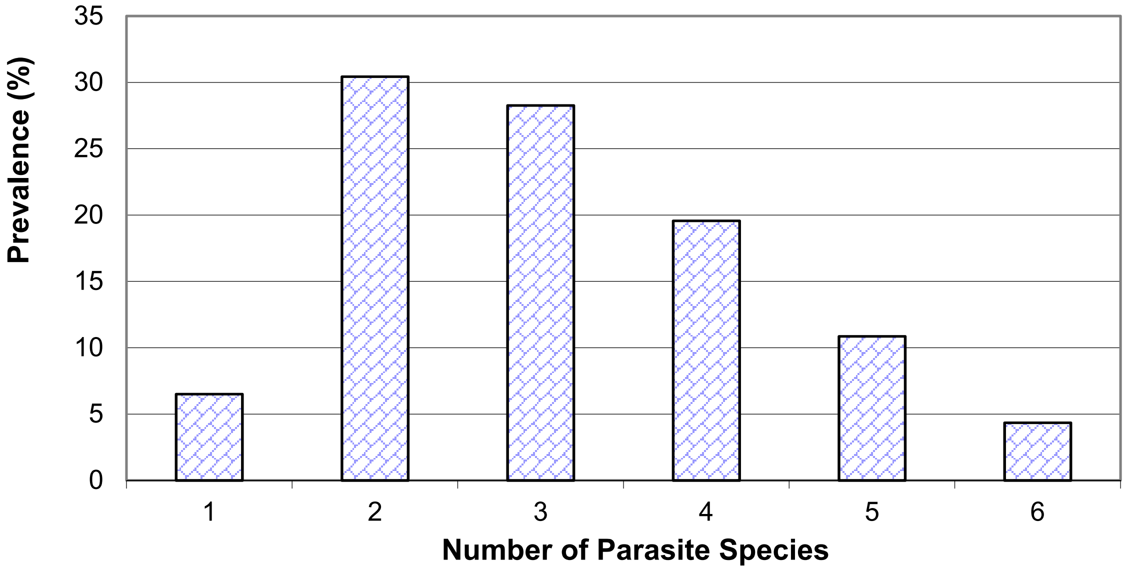

Fig. 2. Infection prevalences (%) with respect to the number of parasite species detected in the golden grey mullet throughout the investigation period

and *L. mediterraneus*) were given for pooled data as group rather than by species.

Physico-chemical parameters (temperature (C), dissolved oxygen (mg/lt), salinity (ppt) and nitrate (ppt)) values were measured by YSI professional plus water quality instrument.

Results

The current study is the first to report on the parasite fauna of golden grey mullet captured from Lower Kızılırmak Delta in Turkey and among its kind in the world in terms of being a delta. A total of 10 parasite species was identified: 6 ectoparasites and 4 endoparasites (Table 2, Plate 1). If the number of parasite species in the individual host (infra community) is regarded, it is apparent that the majority of golden grey mullet hosts were infected with mostly by two and, secondly, by three parasite species (Fig. 2). It must be noted that, as was explained in M&M section, *Trichodina puytoraci* and *T. lepsii* along with *Ligophorus cephali* and *L. mediterraneus* were designed as groups only. *Trichodina puytoraci* and *Ligophorus cephali* dominated over their counterparts in the fish specimens examined and there was a rate of 75 : 1 in favour of above mentioned species. Ectoparasitic species of *Trichodina, Ligophorus* and *Ergasilus* were commonly found together parasitizing their hosts and only one or two digenean species contributed at the same time as the indication of parasite community numbers in Fig. 2.

Data on the parasite list with indications of infection prevalence, mean intensity and abundance values are presented in Table 2. Overall infection prevalence was 100 %, and both the mean intensity and abundance values were equal as 190.09 ± 43.15 parasites per infected/examined fish. The overall maximum infection prevalence was determined for *Ligophorus*-group (97.83 %), followed by *Trichodina*-group (56.52 %), *E. lizae* (50 %), *N. agilis* (47.83 %) and *H. pachysomus* (39.13 %) throughout the investigation period (Table 2). On the other hand, the overall maximum mean intensity value was for *H. pachysomus* (128.72 ± 37.77), followed by *Ligophorus*-group (88.93 ± 17.41) and *Trichodina*-group (81.11 ± 36.56) (Table 2). *Microcotyle mugilis, Ascocotyle (Phagicola) longa* and *T. clavata* were rare throughout this survey study.

Water parameters temperature (C), dissolved oxygen (mg/lt), salinity (ppt) and nitrate (mg/lt) values were measured from Liman and Karaboğaz Lagoons were presented in Table 3.

Table 3. Water temperature (ºC), dissolved oxygen (mg/lt), salinity (ppt) and nitrate (mg/lt) values measured from sampling sites according to seasons in sampled lagoons

Lagoon/Seasons	Spring (March-May)				Autumn (September-October)			
	T	DO	S	NO_3	T	DO	S	NO_3
Liman Lagoon	18.0	10.7	2.35	2.25	13.0	10.8	1.51	0.2
Karaboğaz Lagoon	21.3	7.7	2.80	2.38	14.2	9.5	1.50	0.6

T – Temperature (ºC); DO – Dissolved oxygen (mg/lt); S – Salinity (ppt); NO_3 – Nitrate (mg/lt)

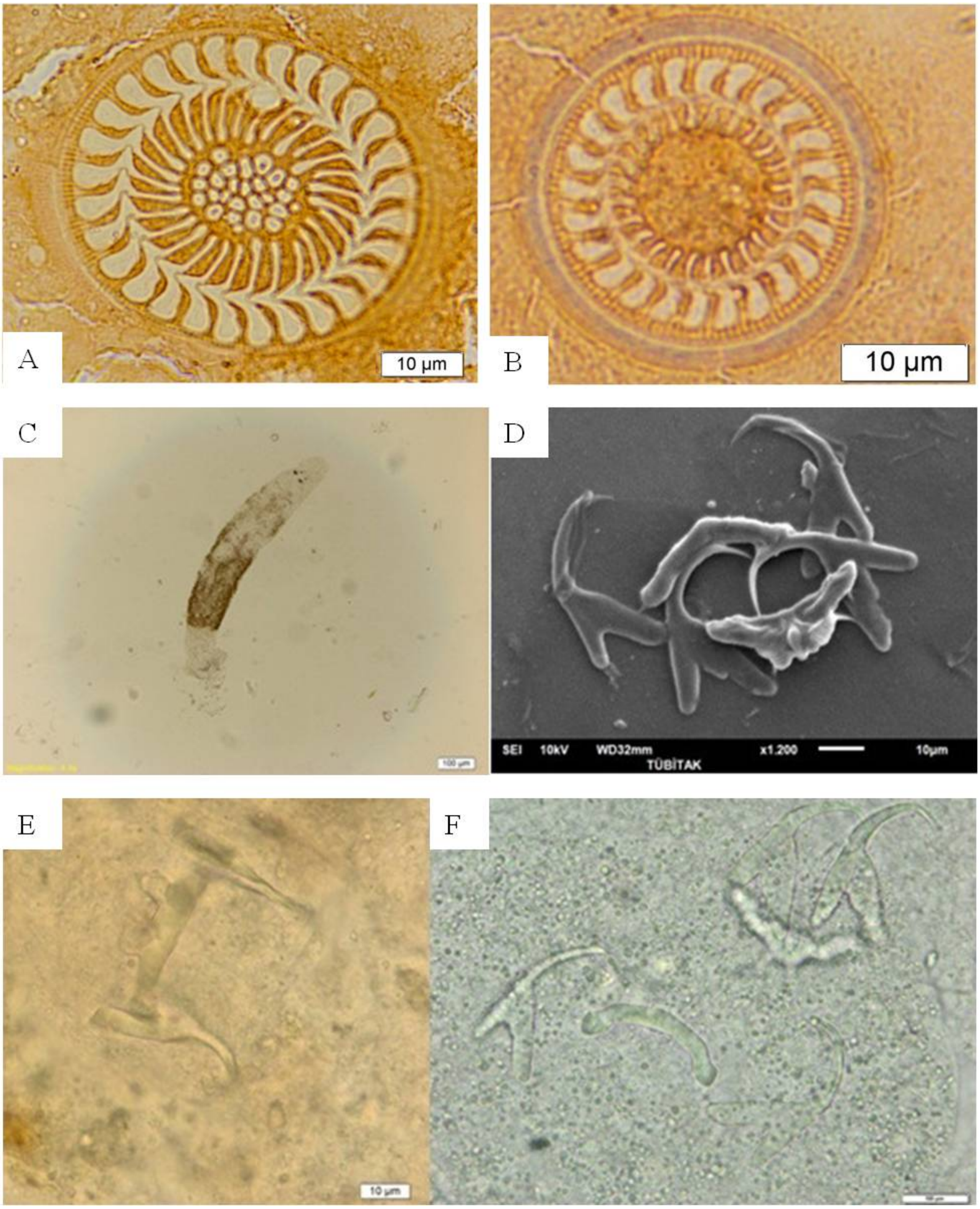

Plate I. Parasite species identified in *Liza aurata*. A – *Trichodina puytoraci*; B – *Trichodina lepsii*; C, D – *Ligophorus cephali*; E, F – *Ligophorus mediterraneus*; Scale bars: A, B, D, E – 10 µm; C, F – 100 µm

Discussion

A wide variety of parasite species including two trichodinids, three monogeneans, three digenean trematodes, one acanthocephalan and one copepod species were identified in *Liza aurata* during the present study. The number of parasite species (10) identified here is similar to that reported by Merella and Garippa (2001) and Ragias *et al*. (2005) but, far more than that of Dmitrieva and Gaevskaya (2001), Özer and Öztürk (2004), Mariniello *et al*. (2004), Sarabeev and Balbuena (2004), Blasco-Costa *et al*. (2006), Blasco-Costa *et al.* (2009) (see table 1). In the infra community level, most of the fish were found to be parasitized by 2 species as was dominated by *Trichodina, Ligophorus* and *Ergasilus*, all being ectoparasites on the gills of host fish. Ectoparasites are known to be affected heavily by

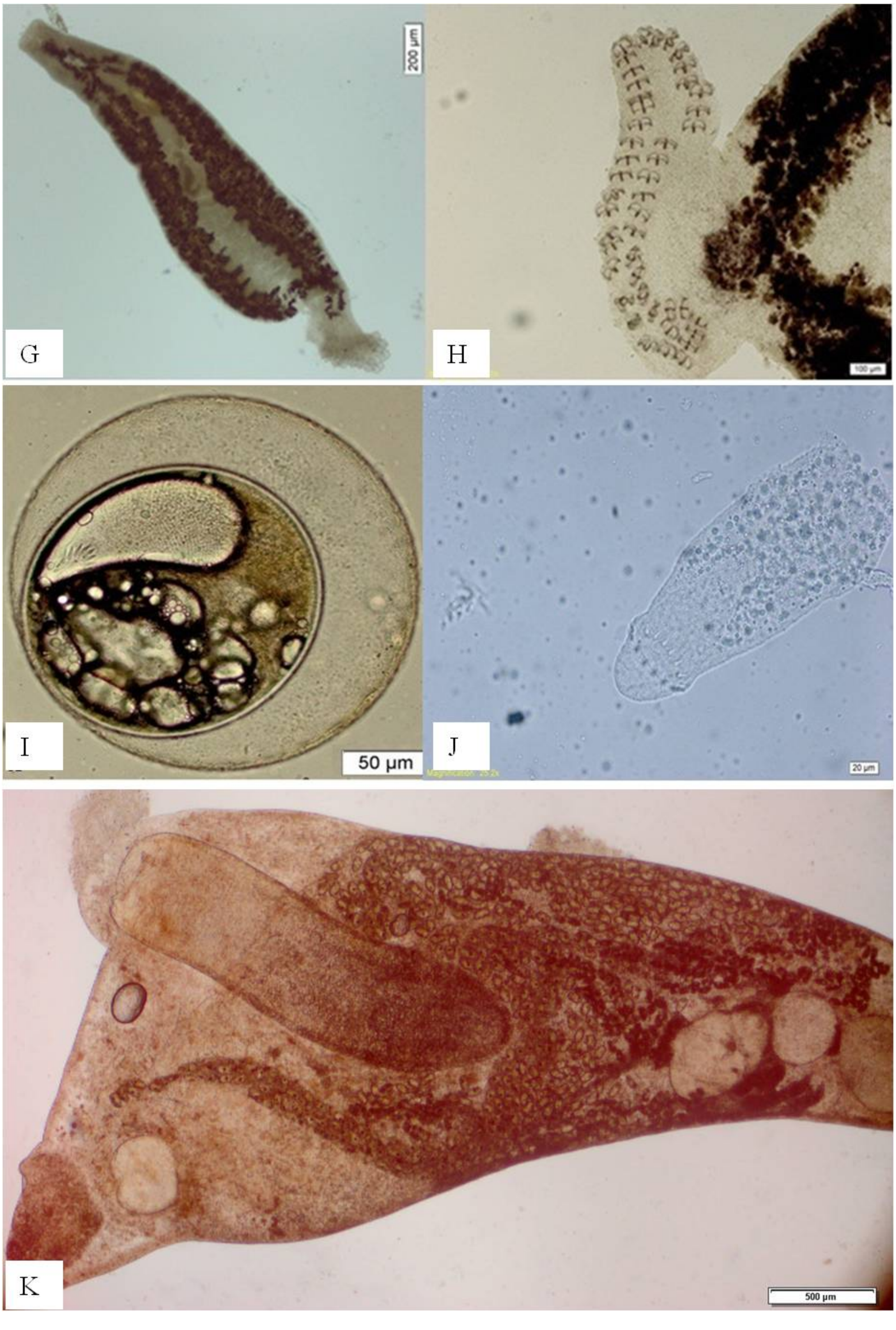

Plate I. – second part. G, H – *Microcotyle mugilis*; I, J – *Ascocotyle (Phagicola) longa*; K – *Haplosplanchus pachysomus*;
Scale bars: G – 200 µm; H – 100 µm; I – 50 µm; J – 20 µm; K – 500 µm

differing water conditions. On the other hand, digeneans and acanthocephalans need intermediate hosts to complete their life cycle and their infection process is fairly stable when compared to those of ectoparasites of fish.

Trichodinids are probably the most commonly encountered protozoan parasites on wild and cultured fishes in marine as well as freshwater environments (Urawa, 1992). Host specificity in trichodinids appears variable, *Trichodina puytoraci* and *T. lepsii* have been reported from mugilids including *Liza aurata* in different environment by several authors (see Table 1). Monogeneans are well-known typical external parasites of mugilid fishes. Because all mugi-

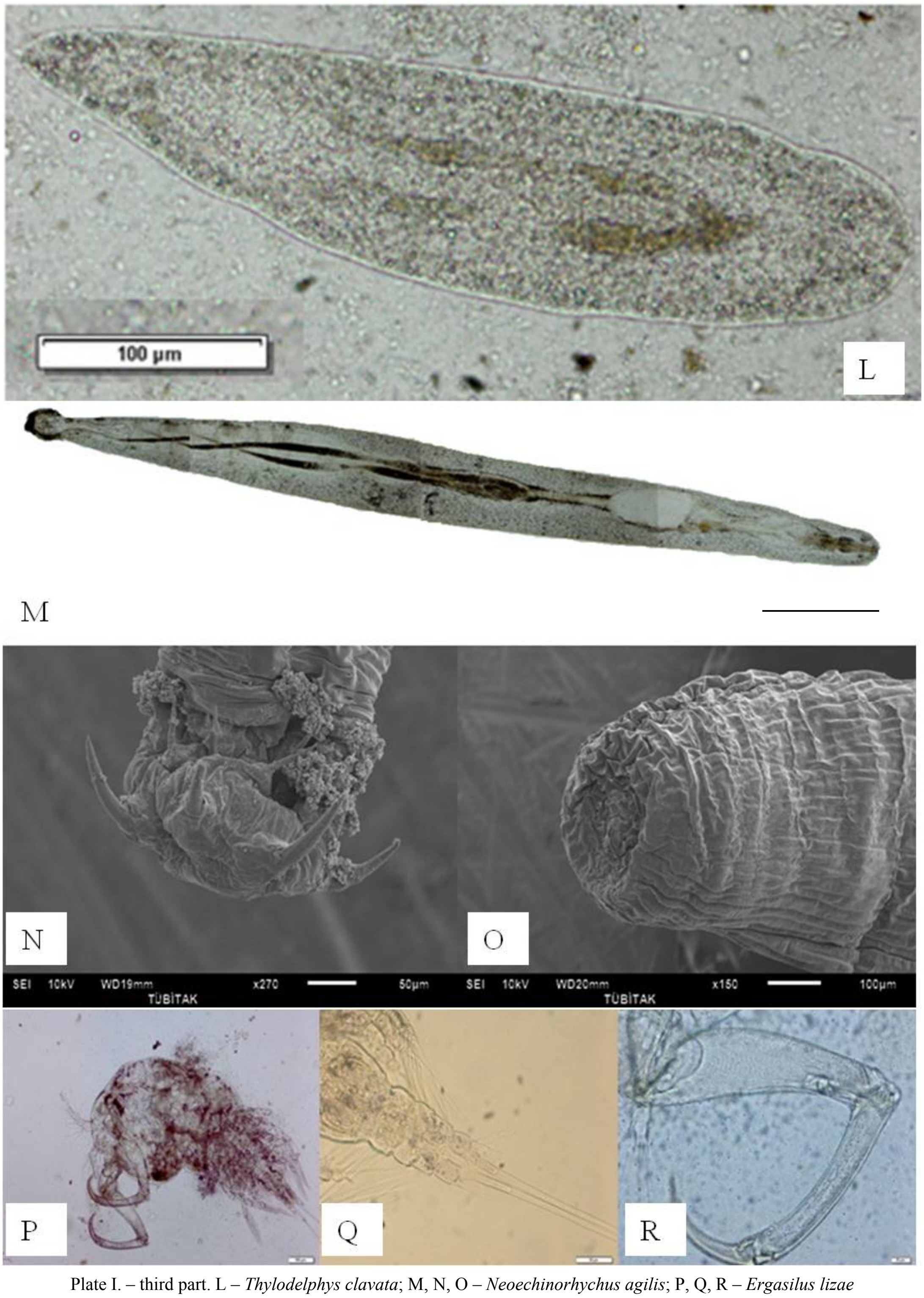

Plate I. – third part. L – *Thylodelphys clavata*; M, N, O – *Neoechinorhychus agilis*; P, Q, R – *Ergasilus lizae*
Scale bars: M – 500 µm; L, O, P – 100 µm; N, Q – 50 µm; R – 20 µm

lids 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. Here in the present study, two species of *Ligophorus* and one species of *Microcotyle* were identified. Twelve species of *Ligophorus* are strictly specific to mugilids; including *Ligophorus cephali* and *L. mediterraneus* on *Mugil cephalus* (Sarabeev *et al*., 2005; Dmitrieva *et al*., 2012). There are several reports of only *Microcotyle mugilis* parasitizing golden grey mullet, and there is no report on *Ligophorus cephali* and *L. mediterraneus* on this fish species at present (see Table 1). Here, in the present study, both species were found on *Liza aurata* for the first time. The known geographical and host range of *L. mediterraneus* has been expanded by Rubtsova *et al*. (2006) on *M. cephalus* in the Black and Azov Seas. *Ligophorus cephali* has also been reported to be specific to *M. cephalus* in different sampling areas (Rubtsova *et al*., 2006; Dmitrieva *et al*., 2009a,b; Dmitrieva *et al*., 2012). Both, *Ligophorus cephali* and *L. mediterraneus* are the first records for Turkish parasitic fauna in fish as well. *Microcotyle mugilis,* previously being reported in Turkey, was the other monogenean described in the present study and elsewhere (see Table 1). There is no record on the presence of digenean trematodes *Ascocotyle (Phagicola) longa* and *Thylodelphys clavata* in *L. aurata* and they are identified in this fish species for the first time in the present study, too. On the other hand, *Haplosplanchnus pachysomus, Neoechinorhynchus agilis* and *Ergasilus lizae* have been reported in *L. aurata* several times (see Table 1).

Studies on the trichodinids in Turkey have increased considerably in the recent years. Özer and Erdem (1998; 1999), Özer (2000; 2003a; 2003b; 2007), Öztürk and Özer (2008) conducted comprehensive studies on several trichodina species, namely *T. acuta, T. mutabilis, T. nigra, T. domerguei, T. jadranica, T. modesta* and *T. tenuidens* in different environments as well as host species. *Trichodina puytoraci* and *T. lepsii* have been studied only once and were reported for the first time by Özer and Öztürk (2004). Infection prevalence (56.52 %) and mean intensity value (81.11 ± 36.56) determined in the present study for *Trichodina*-group were quite higher than that of Özer and Öztürk (2004) who reported infection prevalence of 40.6 % and mean intensity value of 5.46 ± 1.07 *Trichodina puytoraci* per infected fish in a small stream connected to the Black Sea in Sinop. It must be noted that *T. lepsii* was dominant species in the present study while *T. puytoraci* was only species in the above mentioned study. Environmental factors in different levels at both sampling sites might have affected in favour of one species than the other. Higher level of intensity value in Kızılırmak Delta might reflect the promoting potential of this sampling area for trichodinid infections. Yemmen *et al*. (2012) reported an infection prevalence value of *T. lepsii* from *L. aurata* as 6 %, only from saline Ghar El Mehl Lagoon in Tunisia. The infection prevalence was highest in brackish Kızılırmak Delta and lowest in saline Ghar El Mehl Lagoon in Tunisia, with that of a slightly brackish small stream in Sinop in between. These infection indices provided above show a clear effect of salinity on this parasite species.

Studies on monogenean parasites of *Liza aurata* are very limited (see Table 1) and only 7 parasite species reported from Mediterranean, Azov and Black Seas so far (Gaevskaya & Dmitrieva 1997; Dmitrieva & Gaevskaya 2001; Mariniello *et al*., 2004; Sarabeev & Balbuena 2004; Merella & Garippa 2001; Ragias *et al*., 2005; Dmitrieva *et al*., 2012). Here in the present study, we have identified *Ligophorus cephali* and *L. mediterraneus* in the gills of *L. aurata* for the first time making the sum of 9 monogenean species reported from this fish species where survive. These 2 species have so far been reported from their type host *Mugil cephalus* from the Mediterranean and Black Seas (Sarabeev *et al*., 2005; Rubtsova *et al*., 2006; Dmitrieva *et al*., 2009a,b). Sarabeev *et al.* (2005) identified *Ligophorus mediterraneus* as a new species and provided infection prevalence (%) and intensity ranges from different environments; 71 % and 2 – 19 worms per fish in Gulf of Valencia in the Mediterranean Sea: 24 % and 6 – 24 worms per fish in Kerch Channel in the Black Sea. *Ligophorus cephali* was identified as a new species by Rubtsova *et al*. (2006) with some data regarding to its infection values. Infection prevalence (%) and intensity ranges for *L. cephali* were 100 %, 7 – 91 worms per fish in Gulf of Valencia; 56 %, 1 – 22 worms per fish in Ebro River Delta in the Mediterranean Sea; 58 %, 1 – 69 worms per fish in Kerch Channel in the Black Sea. In the present study, we determined infection prevalence and mean intensity values for *Ligophorus*-group as 97.83 % and 87.00 ± 17.13 worms per fish, respectively. It must be reminded that a rate of 75 : 1 in favour of *L. cephali* over *L. mediterraneus* was recorded in the present study. Thus, the above mentioned values mainly reflect the infection capability of *L. cephali*. It is obvious that the infection values determined here for *L. cephali* are close to those of reported for the same parasite species from *M. cephalus* in Gulf of Valencia in the Mediterranean Sea possibly reflecting its higher infection capability regardless of geographical and salinity differences where they were found. Our study also provides information about both parasite species being together on the same host and a possible competition in favour of *L. cephali* over *L. mediterraneus*. This possibility, however, warrants more studies on this subject.

Microcotyle mugilis was the other monogenean recorded from *L. aurata* in the present study with infection prevalence of 8.7 % and mean intensity of 2.75 ± 1.44 worms per infected fish. Gaevskaya and Dmitrieva (1997) and Dmitrieva and Gaevskaya (2001) reported this parasite form *L. aurata* in the Black Sea without any infection parameters. However, El-Hafidi *et al*. (1998) provided very similar infection prevalence and mean intensity values (10.13 %, 2.06 worms per infected fish) for *Microcotyle mugilis* in *Mugil cephalus* in Morocco. Oğuz and Bray (2008) also reported very low level of infection values (5.5 %, 1 ± 0 worms per fish) in *Liza ramada* in Sea of Marmara in Turkey. The above mentioned infection values along with ours of this big monogenean species show that this parasite may survive in different habitats (Sea of Marmara, the Mediterranean and Black Seas) with different salinity and temperature with low level infection occurrences.

Digeneans are important fish parasites with fishes serving mainly intermediate hosts. Three species of digeneans, namely *Ascocotyle (Phagicola) longa*, *Haplosplanchnus pachysomus* and *Tylodelphys clavata*, were identified in *L. aurata* in the present study. *Ascocotyle (Phagicola) longa* is a widespread parasite recorded from the Americas, Europe, Africa and the Middle East in different fish species, however, there is no record in *L. aurata* so far. It is considered to be one of the causative agents of heterophyiasis, an emerging fish-borne disease of humans (Scholz *et al*., 2001). The adult parasites are found in the intestine of fish-eating birds and mammals, and the metacercariae are found mainly in mullets (*Mugil* spp.). *Tylodelphys clavata* is a member of Diplostomidae which metacercarial stage parasitize the eye of fish. The economic significance of the eyediseases of cultured fish, is associated with specific effects or non-specific side effects of parasites, including impairment of vision that leads to exophthalmus, cataract and even complete collapse of the eye, which may be the cause of growth inhibition and death of significant portions of cultured fishes (Barzegar *et al*., 2008). *Tylodelphys clavata* has not been reported from *L. aurata* anywhere in the world so far, thus, this is the first report of this parasite species from this host fish. The genus *Haplospanchnus* is one of the well known parasites of Mugilidae and *Haplosplanchus pachysomus* causes limited pathology on hosts (Ragias, 2005). *Haplosplanchnus pachysomus* is the third digenean species found *L. aurata* in the present study and it has been reported from the Black and Azov Seas by Dmitrieva & Gaevskaya (2001) and from Mediterranean Sea by Ragias *et al*. (2005). Infection prevalence (%) and mean intensity values determined for *Ascocotyle (Phagicola) longa* and *Tylodelphys clavata* were very low when compared to *Haplosplanchnus pachysomus* (see table 2). As was mentioned above, *Ascocotyle (Phagicola) longa* and *Tylodelphys clavata* are the new parasite species for *L. aurata* and there is no comparable data for their infective occurrences. On the other hand, infection prevalence (39.13 %) determined in the present study for *Haplosplanchnus pachysomus* was higher than that of Ragias *et al*. (2005) who reported infection prevalence of 24.4 % in the same fish species in Greece. It must be noted that the mean intensity value (128.72 ± 37.77) determined in *L. aurata* was the highest among all identified parasite species in the present study.

Acanthocephalans are 'thorny' or 'spiny headed' worms with aquatic life cycles; fish as final or paratenic hosts and crustaceans as intermediate hosts. Adults feed on the intestinal walls of vertebrates, especially freshwater and marine fishes, in general, they have a limited interest in fish pathology. *Neoechinorhyncus agilis* is the only species found in *L. aurata* with infection prevalence of 47.83 % and mean intensity of 6.14 ± 1.58 worms per fish in the present study. This species was reported from *L. aurata* in the Mediterranean Sea by Merella and Garippa (2001) and Ragias *et al*. (2005) and in the Black and Azov Seas by Dmitrieva and Gaevskaya (2001). Our infection prevalence value was quite higher those of Ragias *et al*. (2005) (4.1 %) and Merella and Garippa (2001) (16 %).

Parasitic copepods are common on cultured and wild marine finfish, including mullets, and there is a vast literature describing their taxonomy and host ranges (see Johnson *et al*., 2004 for detailed host – parasite list). Many of these species have long been recognized to have the potential to affect the growth, fecundity and survival of wild hosts. Ergasilid copepods have been reported from a variety of finfish reared in brackish and marine waters. Outbreaks of disease caused by ergasilids are a major source of copepod-induced mortality in brackish water finfish culture. *Ergasilus lizae* is the only species found in *L. aurata* with infection prevalence of 50 % and mean intensity of 6.87 ± 1.72 parasites per fish in the present study. Heavy infections of *Ergasilus lizae* on the gills have been reported to cause gill damage, morbidity, and in most instances, substantial mortalities in grey mullet (*Mugil cephalus*) cultured in brackish water ponds. This parasite is known to be common on *Mugil planatus* but, there is only one paper on *L. aurata* reporting its life cycle without any infection parameters (Ben Hassein & Raibaut, 1981).

Water parameters measured from Liman and Karaboğaz Lagoons in the lower Kızılırmak Delta were presented in Table 3 to give a brief understanding of parasite – environmental factors relationship and it is thought that especially direct life cycled parasite species have been affected somehow by those water parameters.

In conclusion, a total of 10 parasite species was identified, 6 being ecto- and 4 being endoparasites, in the present study. Trichodinid, monogenean and ergasilid parasites have a simple direct life cycle that is more dangerous than that of digenean and acanthocephalan parasites which have complex life cycle in causing sudden epidemics. Moreover, members of direct life cycled parasites identified had the highest infection prevalence that those of complex life cycled parasites in the present study. Monogeneans are typically external parasites of fishes including teleosts and elasmobranches and are considered among the most host specific parasites of all fish parasites Among three species of digenean parasites, one of them (*Ascocotyle (Phagicola) longa*) has a zoonotic character which pose a threat to human and the other (*Tylodelphys clavata*) has a potential to eye diseases of fish. Besides, mullets are the most commonly found wild fish in close contact with cultured fish, as they feed on cultured fish debris and are often caught inside the cages. Thus, the presence of these parasites in mullets shows parasite transmission to cultured fish and may reflect the problem of enlargement of the host range of parasitic species under artificial conditions.

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