www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 14: 367-378 (2014) DOI: 10.4194/1303-2712-v14_2_07

Monogenean Fish Parasites, Their Host Preferences and Seasonal Distributions in the Lower Kızılırmak Delta (Turkey)

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Received 17 January 2014
Accepted 12 April 2014

Abstract

This comprehensive research study was conducted to determine the monogenean fauna of 16 fish species belonging to Cyprinidae, Mugilidae, Gobiidae, Percidae, Cyprinodontidae, Gasterosteidae, Cobitidae, Atherinidae, Poecilidae and Sygnidae in Lower Kızılırmak Delta located by the coasts of the Black Sea in the northern part of Turkey. A total of 1049 fish specimens were collected during the period between December 2010 and November 2011. *Gyrodactylus proterorhini, G. cyprini, G. arcuatus, Dactylogyrus extensus, D. chalcalburni, D. difformis, Ancyrocephalus paradoxus, Ligophorus mediterraneus, L. cephali, Solostamenides mugilis* and *Paradiplozoan homoion* were identified to the specific level while one *Gyrodactylus* and one *Salsuginus* species were identified only to the generic level. Some monogeneans were found to be specific to some host families, especially *Ligophorus* for Mugilidae and *Dactylogyrus* for Cyprinidae. Prevalence (%) and intensity indices were determined and discussed for each monogenean species and/or genus on respective hosts. All the monogenean species were recorded for the first time in the Lower Kızılırmak Delta. *Gyrodactylus cyprini* and *Ancyrocephalus paradoxus* represented new parasite records for Turkey.

Keywords: Monogenean parasites, prevalence, Kızılırmak delta.

Aşağı Kızılırmak Deltasındaki (Türkiye) Monogenea Balık Parazitleri, Konak Tercihleri ve Mevsimsel Dağılımları

Özet

Bu kapsamlı araştırma, Türkiye'nin kuzeyinde Karadeniz kıyısında bulunan Aşağı Kızılırmak Deltasındaki Cyprinidae, Mugilidae, Gobiidae, Percidae, Cyprinodontidae, Gasterosteidae, Cobitidae, Atherinidae, Poecilidae ve Syngnathidae familyalarına ait 16 balık türünün monogenea faunasını belirlemek amacıyla yapıldı. Toplam 1049 adet balık bireyi Aralık 2010 ve Kasım 2011 tarihleri arasında yakalandı. *Gyrodactylus proterorhini, G. cyprini, G. arcuatus, Dactylogyrus extensus, D. chalcalburni, D. difformis, Ancyrocephalus paradoxus, Ligophorus mediterraneus, L. cephali, Solostamenides mugilis, Paradiplozoan homoion* tür bazında tanımlanırken, bir *Gyrodactylus* ve bir *Salsuginus* ise cins bazında tanımlandı. Bazı monogenea türlerinin, özellikle *Ligophorus* türlerinin Mugillidae ve *Dactylogyrus* türlerinin Cyprinidae aileleri için spesifik olduğu belirlendi. İncelenen balıklarda tespit edilen her bir monogenean tür ve/veya cins için enfestasyon oranları (%) ve enfestasyon parametreleri hesaplandı ve ilgili konak türlerindeki bulunuşları tartışıldı. Bu araştırmada tanımlanan tüm monogenea türleri Aşağı Kızılırmak Deltası için ilk bildirimlerdir. *Gyrodactylus cyprini* ve *Ancyrocephalus paradoxus* ise Türkiye parazit faunası için yenidir.

Anahtar Kelimeler: Monogenean parazit, enfeksiyon oranı, Kızılırmak deltası.

Introduction

The Class Monogenea is one of the largest groups of Platyhelminthes. They mostly parasitise fish and frogs and sporadically other aquatic animals throughout freshwater and marine habitats. Monogeneans are composed of two major groups, the monopisthocotyleans and the polyopisthocotyleans. Members of Gyrodactylidae, Dactylogyridae and Ancyrocephalidae are the most reported parasites in wild and cultured fish. Their life cycle involves only one host and they mostly spread by way of egg releasing and free-swimming infective larvae. As opposed to most monogeneans, members of *Gyrodactylidaeare viviparous*. Thus, gyrodactylid transmission primarily relies on host to host contact,

although parasites may also invade new hosts by drifting with water currents or clinging to the surface of the water and differences in water quality directly affect their infection processes (Poulin, 1992; Cable *et al*., 2002).

Worms of the class Monogenea are important and numerous ectoparasites of fish which exhibit a relatively high degree of host specificity, with most fish species being infected by one or more specific parasites (Williams and Jones, 1994). This would lead to the prediction that there are well over 23,250 monogenean species; however, less than 4,000 species have been described worldwide (Chisholm and Whittingtonn, 1998). To date, there have been many studies on monogenean parasites in Turkey (Özer *et al*., 2004; Özer and Öztürk, 2005; Öztürk and Altunel, 2006; Soylu and Emre, 2007; Soylu, 2009; Koyun, 2011; Koyun and Altunel, 2011; Öztürk, 2011; Akmırza, 2013). On the other hand, there is no parasitological study of fishes in Lower Kızılırmak Delta in Turkey. The aim of this research study is to identify parasite species at this peculiar part of Turkey, to detect any parasite switches between host species, to reveal their seasonal occurrences and interactions between some water quality parameters.

Materials and Methods

Fish specimens were collected from fish lakes in Lower Kızılırmak Delta located by theBlack Sea in Turkey (41°38' N; 36°04' E) (Figure 1). This Delta covers an area of 50,000 ha, which includes freshwater marshes, swamps and seven lakes and lagoons (Ulu, Uzun, Cernek, Liman, Karaboğaz, Tatlı and Gıcı). Fish samples were collected with the aid of an electro-schock device and fishing net from December 2010 to November 2011. Totally, 16 fish species belonging to 10 families were investigated (Table 1). Skin, fins and gills were examined for monogenean parasites under a dissecting microscope. Individual worms were counted alive and then fixed and preserved in 70% alcohol, mounted in glycerine jelly or in ammonium picrate-glycerine under sufficient coverslip pressure to flatten the parasite specimens. Photomicrographs were taken using Olympus BX53 microscope attached with an Olympus DP25 digital camera. For Scanning Electron Microscopy (SEM), some samples of several monogenean species were hydrated, placed in 1% osmium tetroxide overnight, dehydrated in ethanol, air dried and mounted on stubs with double-sided adhesive tape and sputter coated with gold-palladium and examined in Jeol JSM-6510LV at an accelerating voltage of 10 kV. The taxonomic classification and identification of the parasites observed were done on the basis of Bychovskaya-Pavlovskaya *et al*. (1962), Gusev (1985), Sarabeev *et al*. (2005), Dmitrieva *et al*. (2009a, 2009b), Dzika *et al*. (2009). Infection prevalence and mean intensity were calculated in accordance with Bush *et al*. (1997). Water temperature (°C), salinity (ppt), oxygen (mg/L) and nitrate (mg/L) levels were measured using a YSI-Proplus digital water analyser at the sampling sites. Kruskal-Wallis test (Non-parametric ANOVA) was performed to compare differences in the mean intensity values recorded in different seasons. The analyses were carried out using the computer programme GraphPad Instat 3.0 and P-values less than 0.05 was considered to be significant.

Results and Discussion

The current study is the first to report on the monogenean parasite fauna of fishes from Lower Kızılırmak Delta. A total of 1328 fish specimens from 16 fish species belonging to Cyprinidae, Mugilidae, Gobiidae, Percidae, Cyprinodontidae, Gasterosteidae, Cobitidae, Atherinidae, Poecilidae and Syngnathidae

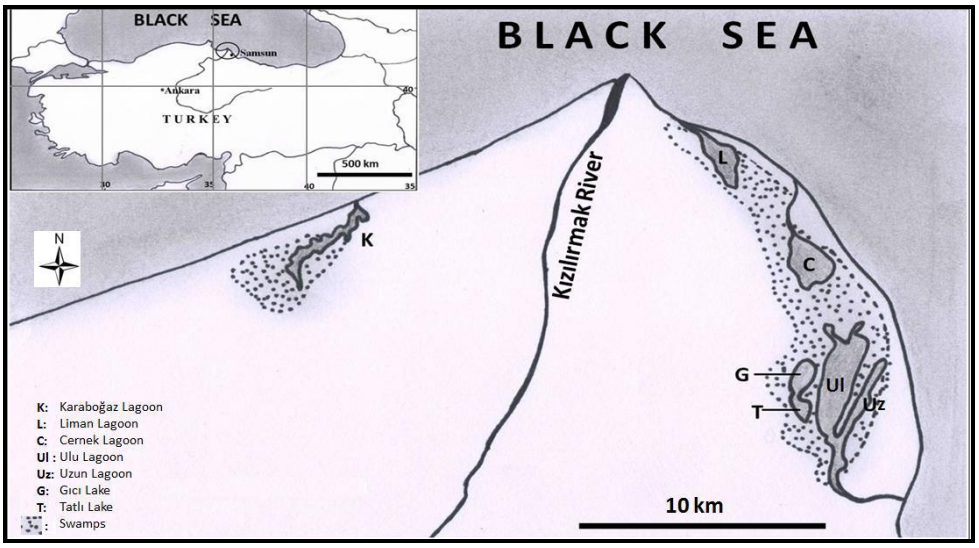

Figure 1. Map of the sampling area.

Table 1. List of identified monogeneanspecies and their host fish found on fishes in Lower Kızılırmak Delta

Host Family	Host	Monogenean species	Specificity
Gobiidae	*Proterorhinus marmoratus* (Pallas, 1814)	*Gyrodactylus proterorhini* Ergens, 1967	Specific
	Neogobius fluviatilis (Pallas, 1814)	*Gyrodactylus proterorhini* Ergens, 1967	Specific
	Pomatoschistus marmoratus (Risso, 1810)	*Gyrodactylus proterorhini* Ergens, 1967	New host record
Cyprinidae	*Cyprinus carpio* L., 1758	*Gyrodactylus cyprini* Diarova, 1964	Specific
		Dactylogyrus extensus Müller et Van Cleave, 1932	Specific
		Dactylogyrus chalcalburni Dogiel & Bychowsky, 1934	New host record
	Vimba vimba (L., 1758)	*Dactylogyrus extensus* Müller et Van Cleave, 1932	New host record
		Dactylogyrus chalcalburni Dogiel & Bychowsky, 1934	New host record
		Paradiplozoan homoion (Bychowsky & Nagabina, 1959)	Specific
	Scardinius erythropthalmus (L., 1758)	*Dactylogyrus difformis* Wagener, 1857	Specific
		Paradiplozoan homoion (Bychowsky & Nagabina, 1959)	New host record
	Carassius gibelio (Bloch, 1782)	No monogenean species were detected	
Mugilidae	*Mugil cephalus* L., 1758	*Ligophorus mediterraneus* Sarabeev, Balbuena et Euzet, 2005	Specific
	Liza aurata (Risso, 1810)	*Ligophorus cephali* Rubtsova, Balbuena, Sarabeev, Blasco-Costa et Euzet, 2006	Specific
		Solostamenides mugilis (Vogt, 1878)	Specific
Percidae	*Sander lucioperca* (L., 1758)	*Ancyrocephalus paradoxus* Creplin, 1839	Specific
Gasterosteidae	*Gasterosteus aculeatus* L., 1758	*Gyrodactylus arcuatus* Bychowsky, 1933	Specific
Cyprinidontidae	*Aphanius danfordii* (Boulenger, 1890)	*Gyrodactylus* sp.	-
		Salsiginus sp.	-
Poeciliidae	*Gambusia affinis* (Baird and Girard, 1853)	No monogenean species were detected	
Atherinidae	*Atherina boyeri* Risso 1810	No monogenean species were detected	
Cobitidae	*Cobitis taenia* L., 1758	No monogenean species were detected	
Syngnathidae	*Syngnathusacus* L., 1758	No monogenean species were detected	

were investigated for monogenean parasites. No parasites were found in the members of Cobitidae, Atherinidae, Poecilidae and Sygnathidae. A total of 13 monogenean species were identified (see Table 1). The data on monogenean parasite list with their hosts is presented in Table 1 and representatives of the monogenean species are illustrated in Figure 2 and Figure 5. The monogenean parasite species detected in this study were found to be fish family or fish species specific, especially *Ligophorus* for Mugilidae, *Dactylogyrus* for Cyprinidae and *Gyrodactylus proterorhini* for Gobiidae (Table 1). Cyprinid fishes had the highest number of five species. Overall prevalence and mean intensities value of identified monogeneans from respective fish species are presented in Table 2.

Gyrodactylidae Species

Four *Gyrodactylus* species were identified (Table 2, Figure 2); *Gyrodactylus proterorhini* in three gobiid fish species, *G. arcuatus* in *Gasterosteus aculeatus*, *G. cyprini* in *Cyprinus carpio* and *Gyrodactylus* sp. in *Aphanius danfordii*, all were species-specific.

Gyrodactylus proterorhini is a common parasite of gobiids inhabiting the littoral zone of the Black and Azov Seas and their estuaries. This species was initially reported to be specific for only *Proterorhinus marmoratus* (Ergens, 1967). Later on, *Zosterisessor ophiocephalus*, *Gobius cobitis*, *G. niger*, *Neogobius melanostomus* and *N. fluviatilis* have also been reported as hosts of *G. proterorhini* (Naydenova, 1974; Dmitrieva and Gerasev, 1997; Ondrácková *et al*., 2005; Özer, 2007; Kvach and Oğuz, 2009; Francová *et al*., 2011; Mierzejewska *et al*., 2011). Considering *Proterorhinus marmoratus*, a Ponto-Caspian relict, is the main host of this parasite species, we can speculate of its first occurrence on *Pomatoschistus marmoratus* in the present study is an example of the host-switching of native species of parasites on the relatively "new" host of Mediterranean origin.

In the present study, *Gyrodactylus arcuatus* was the only *Gyrodactylus* species found infesting *Gasterosteus aculeatus*, with a prevalence of 37.9% and mean intensity level of 10.09±4.63 in summer when 29 fish samples were collected (Table 3). Rokicki and Vojtkova (1994) and Özer *et al*. (2004) reported high prevalence values of 80% and 80.2% for *G. arcuatus* on the three-spined stickleback in Poland and Turkey, respectively, whereas, Morozinska-Gogol (1999) reported an infestation range between 4.3% and 38.7% from Southern Baltic for this parasite species.

*Gyrodactylus cyprini*is a relatively little known species, a parasite specific to *C. carpio* (Prost, 1980; Dzika *et al*., 2009). This species was found only in season among fish samples collected all seasons (Table 3). As far as we are aware of, there is no

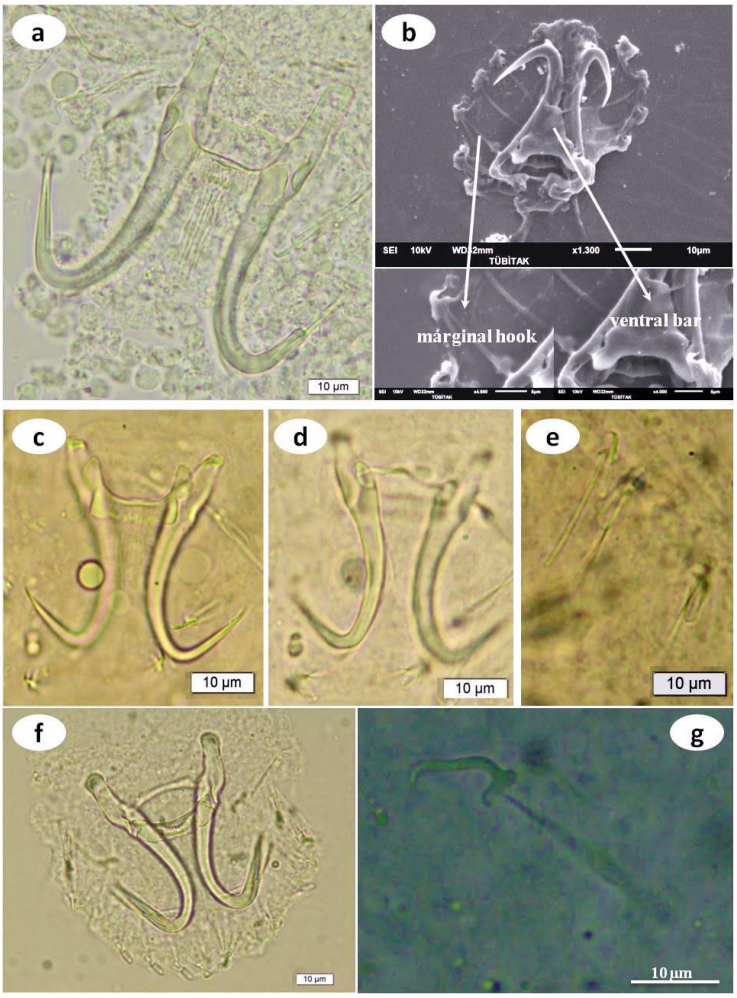

Figure 2. Photomicrographs of gyrodactylid species **a.** Haptor of *Gyrodactylus proterorhini*, **b.** Haptor of *G. proterorhini* (SEM), **c.** Vental bar and median hooks of *G. arcuatus*, **d.** Dorsal bar and median hooksof *G. arcuatus*, **e.** Marginal hooks of *G. arcuatus*, **f.** Haptor of *Gyrodactylus* sp. **g.** Marginal hook of *Gyrodactylus* sp.

Table 2. Prevalance (%) and mean intensity values of monogenean parasite species of fishes in Lower Kızılırmak Delta

Parasites Species	Host	N	Prevalence (%)	Mean Intensity ± SE	Min-Max
Gyrodactylus proterorhini	*Proterorhinus marmoratus*	45	28.9	15.23±3.99	3-53
	Pomatoschistus marmoratus	16	18.8	11.33±8.84	2-29
	Neogobius fluviatilis	161	9.3	2.66±0.57	1-9
Gyrodactylus cyprini	*Cyprinus carpio*	232	0.9	3.50±0.50	3-4
Gyrodactylus arcuatus	*Gasterosteus aculeatus*	29	37.9	10.09±4.63	1-41
Gyrodactylus sp.	*Aphanius danfordii*	125	24.0	4.13±0.86	1-21
Dactylogyrus spp. (*D. extensus* + *D. chalcalburni*)	*Cyprinus carpio*	232	74.1	16.79±1.81	1-194
Dactylogyrus spp. (*D. extensus* + *D. chalcalburni*)	*Vimba vimba*	40	17.5	6.43±1.59	1-11
Dactylogyrus difformis	*Scardinius erythropthalmus*	28	17.9	6.40±3.93	1-22
Ancyrocephalus paradoxus	*Sander lucioperca*	73	28.8	10.33±2.52	1-41
Ligophorus spp. (*L. mediterraneus* +*L. cephali*)	*Mugil cephalus*	254	96.9	252.77±22.23	1-2172
Ligophorus spp. (*L. mediterraneus* +*L. cephali*)	*Liza aurata*	46	97.8	88.93±17.41	1-559
Salsuginus sp.	*Aphanius danfordii*	125	8.8	3.09±0.64	1-7
Solostamenides mugilis	*Mugil cephalus*	254	14.6	3.49±0.58	1-15
	Liza aurata	46	8.7	2.75±1.44	1-7
Paradiplozoan homoion	*Vimba vimba*	40	10.0	10.00±0.00	10
	Scardinius erythropthalmus	28	28.6	8.37±2.50	1-22

N: number of examined fish, SE: Standart Error

published study on this parasite in Turkey. This report is the first on its presence, thus, it represents a new parasite record for Turkish fauna.

Dactylogyridae Species

Three *Dactylogyrus* species, *D. extensus*, *D, chalcalburni* and *D. difformis* were identified from three cyprinid fish species (Table 2, Figure 3). *Dactylogyrus extensus* and *Dactylogyrus chalcalburni* were found on *C. carpio* and *V. vimba. Dactylogyrus extensus* is known as to be specific for *C. carpio* (Markevic, 1951; Bychovskaya-Pavlovskaya *et al*., 1962; Gusev, 1985). This is the first report of existence *D. extensus* on *V. vimba.* To date, some authors have reported *Dactylogyrus chalcalburni* on *Chalcalburnus chalcoides* (Öztürk and Altunel, 2002; Soylu, 2009) and *Alburnoides bipunctatus* (Gussev *et al*., 1993). Thus, *C. carpio* and *V. vimba* are new host records for *Dactylogyrus chalcalburni* in the present study. On the other hand, *Dactylogyrus difformis* was found only on *Scardinius erythropthalmus* in this study anditis one of the most common parasites of *S. erythropthalmus* (Selver and Aydoğdu, 2006; Aydoğdu *et al*., 2008; Demirtaş and Altındağ, 2011).

Dactylogyrus chalcalburni and *D. extensus* were found together on the same host and the former being more common in general. Therefore, the prevalence and mean intensity values of *D. extensus* and *D. chalcalburni* were given as *Dactylogyrus* spp. for pooled data rather than by each individual species (Table 2). The prevalence values of *Dactylogyrus* spp. were 74.1%, on *C. carpio* and 17.5% on *V. vimba* in this study. Kutlu and Öztürk (2006) and Çolak (2013) reported high prevalence values of 91.5% and 85.7%, respectively for *D. extensus* on *C. carpio* in Turkey, whereas, Soylu and Emre (2007) reported lower infestation value of 23.6% on same the host. Our data are our results being in between. In the present study, *D. difformis* has a prevalence 17.9% anda mean intensity of 6.40±3.93 individuals per infested *S. erythropthalmus.* The present data are lower than those reported by Öztürk and Altunel (2006) Aydoğdu *et al*. (2008) and Demirtaş and Altındağ (2011) which were 28.1%, 40% and 83% respectively. These differences could be resulted from both different host size and environmental factors in different geographical areas where fishes were collected by

Table 3. Seasonal infection prevalence (%) and mean intensity values of monogenean parasites found in fishes from Lower Kızılırmak Delta

	Parasite Species	Host	Winter	Spring	Summer	Autumn
Gyrodactylıdae	*Gyrodactylus proterorhini*	*Proterorhinus marmoratus*	78.9 9.86±1.28[a]	NF	100 4.00±0.00[*]	87.5 106.76±24.00[b]
		Pomatoschistus marmoratus	NF	27.3 11.33±8.84	NF	0 0
		Neogobius fluviatilis	NF	0 0	4.8 3.00±1.00*	25 2.58±0.69*
	Gyrodactylus arcuatus	*Gasterosteus aculeatus*	NF	NF	37.9 10.09±4.63	NF
	Gyrodactylus cyprini	*Cyprinus carpio*	0 0	1.4 4.00±0.00*	0 0	0 0
	Gyrodactylus sp.	*Aphanius danfordii*	8.2 4.80±1.16[a]	50 5.06±1.42[a]	25 9.00±0.34[a]	33.3 2.50±1.50[a]
Dactylogyrıdae	*D. extensus*	*Cyprinus carpio*	84	76.4	72.9	69.7
	D. chalcalburni		37.00±5.86[a]	19.82±4.28[b]	12.84±2.11[b]	8.85±1.55[b]
	D. extensus	*Vimba vimba*	33.3	15.8	25	25
	D. chalcalburni		7.33±3.18[a]	8.67±1.33[a]	1.00±0.00[*]	3.75±2.50[a]
	D.difformis	*Scardinius erythropthalmus*	100 2.50±0.25*	7.69 22.00±0.00*	27.3 2.00±1.00*	0 0
Ancyrocephalıdae	*L. mediterraneus*	*Mugil cephalus*	93.3	97.5	100	98.4
	L. cephali		479.16±56.79[a]	120.03±18.03[bc]	78.24±17.16[c]	266.18±39.27[a]
	L. mediterraneus	*Liza aurata*	NF	100	NF	93.3
	L. cephali			78.58±15.30[a]		111.86±45.19[a]
	Ancyrocephalus paradoxus	*Sander lucioperca*	53.9 6.71±4.07[a]	20 15.00±0.00[*]	32 15.38±4.82[a]	14.3 7.00±4.76[a]
	Salsiginus sp.	*Aphanius danfordii*	3.3 1.00±0.00[*]	0 0	29.2 4.00±0.82	33.3 2.00±0.00[*]
Solostamenides mugilis (Microcotylidae)		*Mugil cephalus*	9.3 2.86±0.67[a]	20.3 4.19±1.01[a]	18.1 3.86±1.91[a]	11.1 2.14±0.46[a]
		Liza aurata	NF	3.2 1.00±0.00*	NF	20 3.33±1.86
		Vimba vimba	0	21.1	0	0
Paradiplozoan homoion (Diplozooidae)			0	1.75±0.75	0	0
		Scardinius erythropthalmus	0 0	23.1 11.67±5.55[a]	54.6 7.00±1.71[a]	0 0

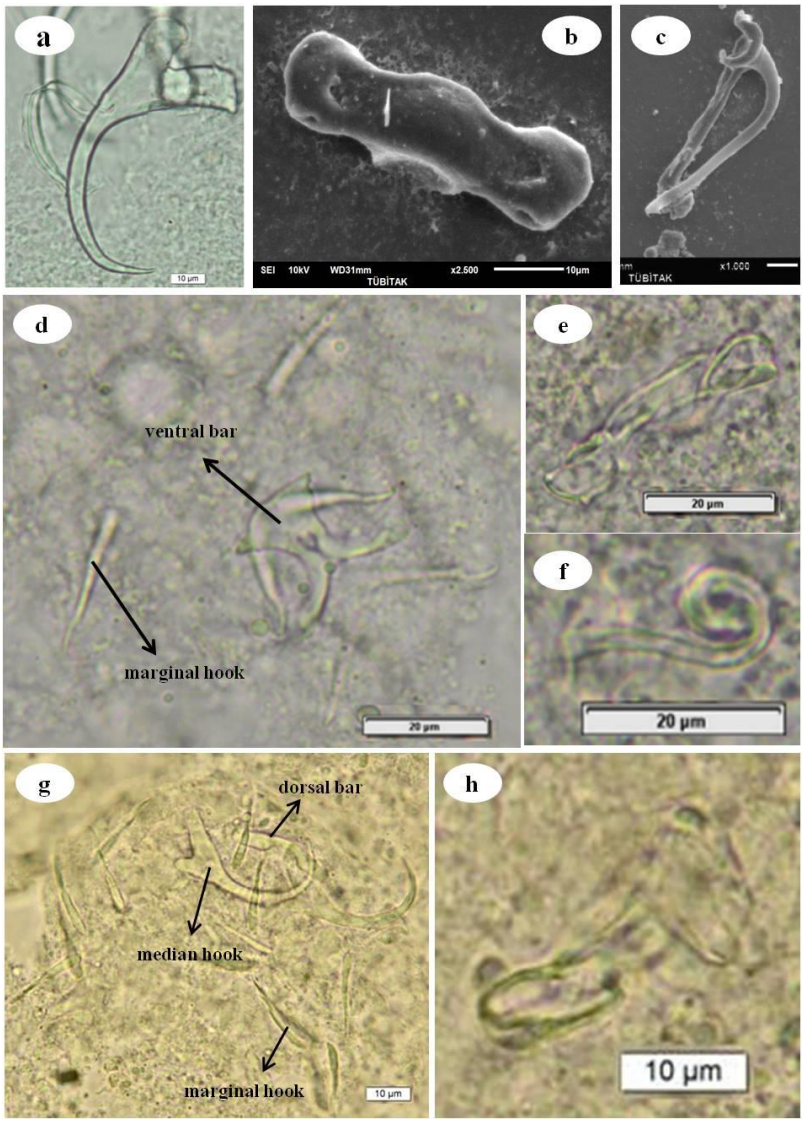

Figure 3. Photomicrographs of dactylogyrid monogenean species **a.** Median hook of *Dactylogyrus extensus*, **b.** Dorsal bar of *D. extensus* (SEM), **c.** Copulatory organ of *D. extensus* (SEM), **d.** Haptorof *Dactylogyrus chalcalburni*, **e.** Male copulatory organ of *D. chalcalburni*, **f.** Vaginal tube of *D. chalcalburni*, **g.** Haptor of *Dactylogyrus difformis*, **h.** Malecopulatory organ of *D. difformis.*

other authors. The host factors like fish size and crowding have a strong influence on infection levels of monogeneans on their fish hosts as was reported for *D. extensus* on cultured and wild carp by Özer and Erdem (1999).

Ancyrocephalidae Species

In the present study, four ancyrocephalid species, *Ligophorus cephali, L. mediterraneus, Ancyrocephalus paradoxus* and *Salsuginus* sp. were identified from 4 fish species (Figure 4, Table 2).

Ligophorus mediterraneus and *L. cephali* were given for pooled data rather than by each *Ligophorus* species. The prevalance and mean intensity levels of the *Ligophorus* spp. (*L. cephali*, *L. mediterraneus*) infesting *M. cephalus* and *L. aurata* are presented Table 2. Rates of infestation values of prevalence and particularly intensity of infestation of *Ligophorus* spp. were fairly high compared to the other monogenean species. In the present study, the highest infestation values of these species was in *M. cephalus* (Table 2). Strict host-specificity is a common phenomenon among monogeneans and the species of some *Ligophorus* are strictly specific to mugilids; including *L. cephali* and *L. mediterraneus* on *M. cephalus*; *L. szidati* and *L. vanbenedenii* on *Liza aurata* (Mariniello *et al*., 2004; Sarabeev *et al*., 2005; Rubtsova *et al*., 2006; Dmitrieva *et al*., 2009b). Öztürk (2013) reported *L. cephali* and *L. mediterraneus* on *L. aurata* captured in another locality nearby to our sampling area. It must be noted that *Ligophorus* spp. which are specific for *L. aurata* were not found during this study, while *Ligophorus* spp. which are specific for *M. cephalus* were found on both mullet species. The prevalence values of

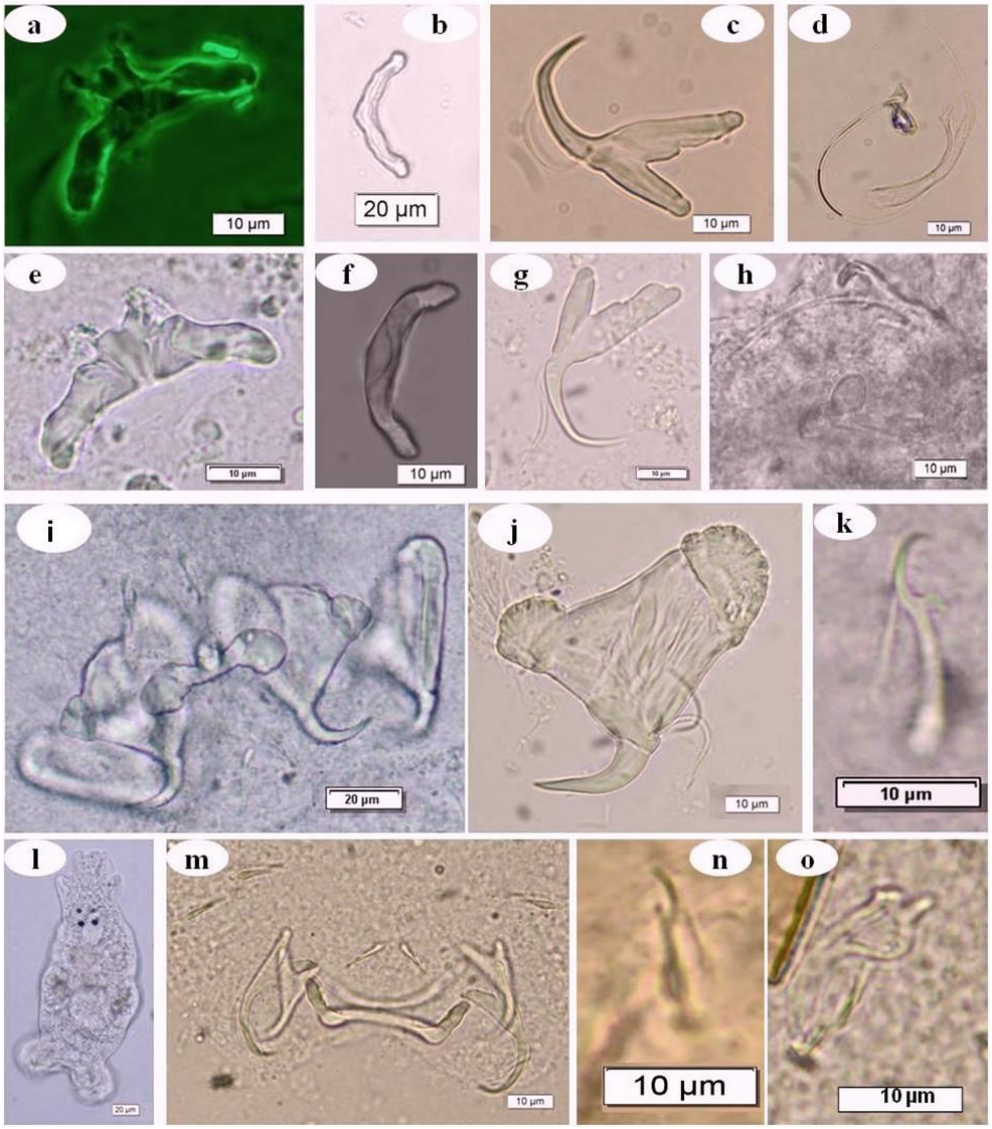

Figure 4. Photomicrographs of ancyrocephalid monogenean species. **a, b, c, d.** *Ligophorus cephali*,**e, f, g, h.** *L. mediterraneus*, **i, j, k.** *Ancyrocephalus paradoxus* and **l, m, n**. *Salsuginus* sp. **a, e.** Ventral bar, **b, f**. Dorsal bar, **c, g, j**. Median hook, **d, h, o.** Male copulatory organ, **i, m.** Haptor, **k, n.** Marginal hook, **l**. *Salsuginus* sp. specimen.

Ligophorus spp. were 96.9%, on *M. cephalus* and 97.8% on *L. aurata* in this study (Table 2). These data were significantly higher than that value reported on juvenile *L. aurata* (18.7%) by Öztürk (2013). This difference could be related to the different fish size and sampling locality.

Ancyrocephalus paradoxus is known to infect the gills of pike perch *Sander lucioperca* (Rolbiecki, 2006; Djikanovic *et al*., 2012). Öztürk *et al*. (2011) reported this parasite for the first time with an prevalence of 31.9% and mean intensity of 12.07±3.26 in a preliminary study in the same locality where this study was conducted. Kritscher (1988) also reported this parasite with a similar prevalence 38.8% on the same host.

Members of *Salsuginus* have been reported from Fundulidae, Poecilidae and Cyrinodontidae (Margolis and Kabata, 1984; Murith and Beverly-Burton, 1984; Mendoza-Franco and Vital-Martinez, 2001; Mendoza-Franco *et al*., 2006). Nevertheless, information on the occurrence of *Salsuginus* on *Aphanius* species is very limited. Öztürk and Özer (2008) reported the same *Salsuginus* sp. on *A. danfordii* at another locality in Sinop with prevalence of 68.1% and mean intensity of 4.23±0.23. In the present study, *Salsuginus* sp. was found to be infesting *A. danfordii*, with a prevalence of 8.8% and mean intensity value of 3.09±0.64, lower in prevalence but similar in mean intensity value with above mentioned authors.

Microcotylidae and Diplozoidae Species

In the present study, *Solostamenides mugilis* (Syn: *Microcotyle mugilis*), a microcotylid monogenean, and *Paradiplozoon homoion*, a diplozoid monogenean, were described (Table 2,

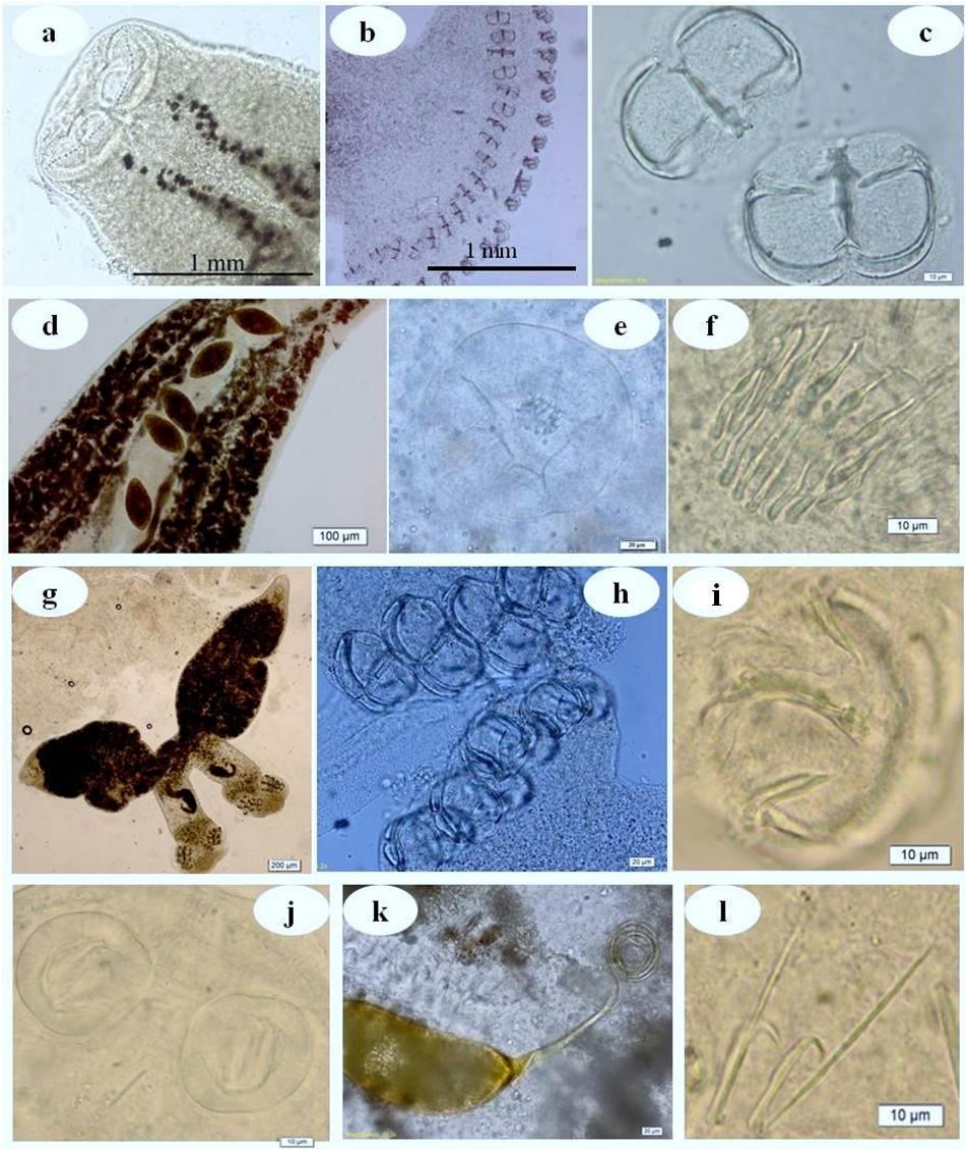

Figure 5. Photomicrographs of microcotylid and diplozoid monogenean parasites. *Solostamenides mugilis* (**a, b, c, d, e, f**) and *Paradiplozoan homoion* **(g, h, i, j, k, l)**. **a. j.** Buccal organ,**b, h**. Opisthaptor, **c, i**. Clamps, **d, k.** eggs, **e.** male copulatory organ, **f.** cirrus, **l.** central hooks.

Figure 5). *S. mugilis* is a common parasite of mugilid fish from the Mediterranean. To date, *S. mugilis* has been reported from *M. cephalus*, *L. haematochielus*, *L. aurata*, *L. ramada*, *C. labrosus* and *L. saliens* (El-Hafidi *et al*., 1998, Ragias *et al*., 2005; Öztürk, 2013). In this study, prevalence values for this parasite were 14.6% on *M. cephalus* and 8.7% on *L. aurata* and our results agree with those reported by the above mentioned authors. *P. homoion*was found in the gills of *V. vimba* and *S. erythropthalmus* (Table 2, Figure 5). Diplozoid parasites, except *P. homoion*, are known to be highly host specific. *P. homoion* has been reported from more than 15 cyprinid fish species (Gelnar *et al*., 1994). However, the number of studies is limited on this parasite species in Turkey (Soylu, 2007; Öztürk, 2011). In this study, as seen can be Table 2, prevalences for this parasite were 10% on *V. vimba* and 28% on *S. erythropthalmus*. It has been reported and by Soylu (2007) on *Pseudophoxinus antalyae* with an infestation of 54.6% and by Öztürk (2011) on *Rutilus rutilus* (5%). This difference between the result of the present study and the previous ones could be related to the differences in host species and to geographic localities which are reflecting different environmental conditions.

The Seasonal Occurrence of Monogenean Parasites

Seasonal prevalence and mean intensity values for each monogenean genus or species on respective hosts were presented in Table 3. Statistical significant differences in mean intensity values of *Dactylogyrus* spp. (on *C. carpio*), *Ligophorus* spp. (on *M.*

cephalus), *G. proterorhini* (on *Proterorhinus marmoratus*) and *Salsuginus* sp. (on *A. danfordii*) were found in relation to seasons (Table 3). The pevalence values were over 93% for *Ligophorus* spp. in all seasons (Table 3). Fuentes and Nasir (1990) reported monthly prevalence values over 54% for *L. mugilinus* on *M. curema*. This difference could be due to the effects of different geographical areas and/or host factors. It must be mentioned that our samplig are is a delta comprising four lake and three lagoons that have different ecological perculiarities in temperature and salinity levels. This clearly affected the occurence of gyrodactylids, for example *Gyrodactylus proterorhini* was found at its highest value on *Proterorhinus marmoratus* collected in desalinated lakes. On the other hand, this parasite was also found in low infection indices on other fish species (*N. fluviatilis* and *Pomatoschistus marmoratus*) collected in summer and autumn seasons when the connection with the Black Sea was broken.

Water temperature is commonly regarded as one of the most important factors determining the existence and abundance of monogenean parasites (Koskivaara *et al*., 1991). While some monogeneanst end to produce more at a higher water temperature, others prefer a cool water temperature (Hanzelova and Zitnan, 1985). Our survey data showed that some monogeneans preferred some seasons while some others occurred throughout the whole year period without any preference indicating that their reproductive potantials are clearly affected by temperature.

In conclusion, a total of 13 monogenean species were identified from 11 fish species from Lower Kızılırmak Delta for the first time. The present study on monogenean fauna yielded new records, all species are new for Lower Kızılırmak Delta and *G. cyprini* along with *A. paradoxus* are now considered as new records for Turkey. In addition, *C. carpio* and *V. vimba* are new hosts records for *Dactylogyrus chalcalburni*, as well as *Vimba vimba* and *Scardinius erythropthalmus* are new hosts for *P. homoion*. In the light of the present data, we can say that the geographical distribution of these parasites is extended. The intensity and infection rates of some monogenean parasites in the above mentioned fish species showed seasonal variations. The findings of this study are expected to contribute to future studies on monogeneans.

Acknowledgements

This study was supported financialy by The Scientific and Technological Research Council (TÜBİTAK) in Turkey with the project number of 110O424. Authors are grateful to this support.

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