Metazoan Parasite Faunas of Three Gobiid Species (Actinopterygii: Gobiidae) Inhabiting the Lower Kızılırmak Delta in Samsun: A Comparative Study

Samsun'da Aşağı Kızılırmak Deltasında Yaşayan Üç Kaya Balığının (Actinopterygii: Gobiidae) Karşılaştırmalı Metazoan Parazit Faunası

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ABSTRACT

Objective: The aim of the present study was to investigate and compare metazoan parasite faunas of three gobiid fishes, *Neogobius fluviatilis*, *Proterorhinus marmoratus*, and *Pomatoschistus marmoratus,* inhabiting the Lower Kızılırmak Delta.
Methods: Fish specimens were caught using fishing nets and electroshock device. The fishes were transferred to the laboratory and examined under a dissecting microscope for metazoan parasites using conventional methods. The isolated parasites were fixed with 70% ethyl alcohol. The Czekanowski–Sørensen Index (ICS) was used for comparing the metazoan faunas of the three gobiid fishes.
Results: Overall, 13 metazoan parasite species comprising 2 monogeneans (*Gyrodactylus proterorhini* and *Gyrodactylus* sp.), 6 digenean metacercariae (T*ylodelphys clavata, Diplostomum spathaceum, Apatemon gracilis, Posthodiplostomum* sp., *Ascocotyle* sp., and *Echinostoma* sp.), 1 cestoda (*Bothriocephalus acheilognathi*), 3 nematodes (*Spiroxys contortus, Eustrongylides excisus*, and *Contraceacum rudolphii*), and 1 arthropoda *Ergasilus* (sieboldin) were observed. The maximum parasite diversity was found in *N. fluviatilis*; *Po. marmoratus* had significantly fewer parasitic species (4). Total parasite abundance was significantly high in *Pr. marmoratus*, which was infected with 9 parasite species. A closer resemblance was observed in the parasite faunas of *N. fluviatilis* and *Pr. marmoratus* (ICS=80.0%).
Conclusions: To the best of our knowledge, this is the first study on metazoan parasite faunas of *N. fluviatilis*, *Pr. marmoratus*, and *Po. marmoratus* in Turkey.
Keywords: Black Sea, gobiid fishes, Lower Kızılırmak Delta, metazoan parasites, Turkey
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ÖZ

Amaç: Bu çalışmanın amacı, Aşağı Kızılırmak Deltasında yaşayan 3 kaya balığının, *Neogobius fluviatilis*, *Proterorhinus marmoratus* ve *Pomatoschistus* marmoratus metazoan parazit faunalarını araştırmak ve karşılaştırmaktır.
Yöntemler: Kaya balıkları, balık ağları ve elektroşok cihazıyla yakalandı. Balıklar laboratuvara nakledildi ve metazoan parazitleri için klasik yöntemlerle disseke mikroskop altında incelendi. İzole edilen parazitler %70 etil alkol ile tespit edildi. Üç kaya balığının metazoan faunalarını karşılaştırmak için Czekanowski-Sorensen indeksi (Ics) kullanıldı.
Bulgular: 2 monogenea *Gyrodactylus proterorhini* ve *Gyrodactylus* sp., 6 digenea (metaserker) *Tylodelphys clavata*, *Diplostomum spathaceum*, *Apatemon gracilis*, *Posthodiplostomum* sp., *Ascocotyle* sp., ve *Echinostoma* sp., bir sestod, B*othriocephalus acheilognathi*, üç nematod *Spiroxys contortus*, *Eustrongylides excisus*, *Contraceacum rudolphii* ve bir arthropod *Ergasilus sieboldii* olmak üzere toplamda 13 metazoan parazit türü belirlendi. Maksimum parazit tür çeşitliliği *N. fluviatilis*'de bulundu. *Pomatoschistus marmoratus*'un tür sayısı (4) daha azdı. Toplam parazit bolluğu 9 parazit türü ile infekte Proterorhinus marmoratus'da belirgin olarak daha yüksekti. *N. fluviatilis* ve *Pr. marmoratus*'un parazit faunalarında benzerlik gözlemlendi (Ics: %80,0).
Sonuç: Bu çalışma, *N. fluviatilis*, *Pr. marmoratus* ve *Po. marmoratus*'un metazoan parazit faunaları üzerine Türkiye'de ilk rapordur.
Anahtar sözcükler: Karadeniz, kaya balıkları, Aşağı Kızılırmak Deltası, metazoan parazit, Türkiye
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INTRODUCTION

The family Gobiidae is one of the largest taxons of fish and vertebrate animals. It comprises >2000 species with >200 genera. They are abundant worldwide in every kind of environment, including tropical to temperate marine, estuarine, and freshwater (1). A total of 5 out of 27 species of this family, which inhabited the Black Sea (2), *Neogobius*, *Proterorhinus*, and *Pomatoschistus* are the most common genera of the family. *Neogobius fluviatilis* and *Proterorhinus marmoratus* are native species in the Ponto–Caspian basin. Their native habitats include the coastal zones of the Black Sea, Caspian Sea, Azov Sea, and Marmara Sea (3-5). *Pomatoschistus marmoratus* is a species of the Mediterranean Basin and is widespread in the Eastern Atlantic, Mediterranean, Black Sea, Azov Sea, and Suez Canal (3, 6). The gobiid fishes play important roles in the ecosystem. Regarding food chains, the gobies are secondary consumers and are themselves prey for larger fish, sea birds, and seals. Their availability for predators implies that they are important transmitters of parasites, which complete their life cycle in several hosts (7). Gobiids may be definitive, intermediate, or paratenic hosts of parasites such as digeneans, cestodes, and nematodes. Owing to their ecological tolerance, small sizes, habitation, and diversity, gobiids are appropriate fishes to study the course of colonization by parasites (8).

Several studies are available about the helminths of lagoons and estuaries in the northwestern Black Sea (9-21). Although there is considerable information available on the parasite fauna of gobiids mainly from the northern coasts of the Black Sea, only few studies have reported on those of the gobiids that reside close to Turkish coasts (22-24). In Turkey, there is so far only one published study on the metazoan parasite fauna of *Neogobius melanostomus*, which is not a gobiid species investigated in the present study (23). Moreover, no published study has reported on the metazoan parasites of *N. fluviatilis*, *Pr. marmoratus*, and *Po. marmoratus* from the southern coast of the Black Sea so far. Thus, more studies are required to determine the metazoan parasite fauna of various gobiid species.

The aim of the present study was to investigate and compare the metazoan parasite faunas that occur on *N. fluviatilis*, *Pr. marmoratus*, and *Po. marmoratus* from the Lower Kızılırmak Delta located on the southern coastal zones of the Black Sea. The results are comparable with those of a few previous studies, which investigated in different coastal zones from the Black Sea. The results of the present study present new data about parasite–host relationship.

METHODS

The three gobiid species were fished from the Lower Kızılırmak Delta, which is located on the border of Samsun city (41°38'38.84" N and 36°04'09.89" E) and lies at the sea level. The specimens of these fishes were caught using fishing nets and electroshock device. Sampling was conducted over a 1-year period. A total of 221 specimens of the three gobiid species, *N. fluviatilis* (160), *Pr. marmoratus* (45), and *Po. marmoratus* (16), were investigated for the presence of helminths. The fishes were measured and weighed, and their external and internal organs were carefully examined.

Parasitological Indices and Statistical Analysis

The prevalence, mean intensity, and abundance for metazoan parasites from monkey goby *N. fluviatilis*, tubenose goby *Pr. mar-*

Table 1. Component community of parasites of three gobiid fishes from the Lower Kızılırmak Delta (bold data for homogeneity)

	***Neogobius fluviatilis* (n=160)**			***Proterorhinus marmoratus* (n=45)**			***Pomatoschistus marmoratus* (n=16)**		
Host species	**P**	**MI±SE**	**A**	**P**	**MI±SE**	**A**	**P**	**MI±SE**	**A**
Gyrodactylus proterorhini	9.4	2.7±0.6	0.25	28.9	15.2±3.9	**4.40**	12.5	2.5±05	0.31
Gyrodactylus sp.	–	–	–	–	–	–	6.25	26.0±0.0	1.63
Ascocotyle sp. met.	4.4	1.3±0.2	0.06	–	–	–	–	–	–
Echinostoma sp. met.	60.0	16.7±2.1	**10.03**	37.8	15.4±5.3	**5.82**	25	1.3±0.3	0.31
Tylodelphys clavata met.	15.0	3.5±1.8	1.19	28.9	4.8±1.4	1.38	18.8	1.0±0.0	0.19
Diplostomum spathaceum met.	18.8	6.6±1.4	1.24	13.3	2.0±0.6	0.27	–	–	–
Apatemon gracilis met.	3.8	5.0±2.1	0.19	46.7	63.9±16.2	**29.84**	–	–	–
Posthodiplostomum sp. met.	6.3	5.7±2.3	0.36	17.8	38.9±12.6	**6.91**	–	–	–
Bothriocephalus acheilognathi pl.	5.0	1.4±0.3	0.07	17.8	1.3±0.2	0.22	–	–	–
Spiroxys contortus L3	2.5	1.4±0.4	0.04	–	–	–	–	–	–
Eustrongylides excisus L3	2.5	1.6±0.6	0.05	–	–	–	–	–	–
Contraceacum rudolphii L3	–	–	–	8.9	1.8±0.5	0.16	–	–	–
Ergasilus sieboldi	8.8	1.3±1.2	0.31	2.2	1.0±0.00	0.02	–	–	–
Total	75	18.4±2.1[ab]	13.78	77.8	63.0±15.4[b]	49.02	43.8	6.0±4.0[a]	2.63

n: number of examined fish; P: prevalence (%); MI: mean intensity; SE: standard error; A: abundance; met.: metacercaria; pl.: plerocercoid; L3: L3 stage

Table 2. Infracommunity index

	Neogobius fluviatilis	*Proterorhinus marmoratus*	*Pomatoschistus marmoratus*
Gyrodactylus proterorhini	0.07	0.14	0.30
Gyrodactylus sp.			0.09
Ascocotyle sp. met.	0.03		
Echinostoma sp. met.	0.44	0.24	0.40
Tylodelphys clavata met.	0.11	0.14	0.30
Diplostomum spathaceum met.	0.14	0.07	
Apatemon gracilis met.	0.03	0.23	
Posthodiplostomum sp. met.	0.05	0.09	
Bothriocephalus acheilognathi pl.	0.04	0.09	
Spiroxys contortus L3	0.02		
Eustrongylides excisus L3	0.02		
Contraceacum rudolphii L3		0.04	
Ergasilus sieboldi	0.06	0.01	
Mean infracommunity	1.82	2.02	1.43
Species richness	11	9	4
Shannon Index	1.06	1.30	0.99
Species evenness	0.44	0.56	0.72

(ICI>0.30). met.: metacercaria; pl.: plerocercoid, L3: L3 stage; ICI: infracommunity index

moratus, and marbled goby *Po. Marmoratus* were determined according to Bush et al. (25). The standard error for mean intensity is provided. The Czekanowski–Sørensen Index (ICS, %) was used to compare the helminth faunas (26). The significance of the host–parasite relationship was determined according to the abundance values. The scales used for species were >2 for core species, 0.6-2 for secondary species, 0.2-0.6 for satellite species, and 0.2 for rare species (27). The tendency to participate in the infracommunity was evaluated in terms of the infracommunity index with >0.30 as the highest value. The mean infracommunity was characterized as the mean number of parasite species per host individual (28). The species evenness was calculated according to the formula provided by Zander et al. (7). The evenness values > 0.6 represented a greater part of the homogeneity with >0.7 being a high homogeneity. All statistical tests were carried out using GraphPad Instat 3.0 for Windows 2000 (Software, San Diego, CA, USA) software ($p<0.05$: statistically significant).

RESULTS

In total, the following 13 metazoan parasite species were found: 2 monogenea (*Gyrodactylus proterorhini* and *Gyrodactylus* sp.) 6 digenean metacercariae (*Tylodelphys clavata*, *Diplostomum spathaceum*, *Apatemon gracilis*, *Posthodiplostomum* sp., *Ascocotyle* sp., and *Echinostoma* sp.), 1 cestoda (*Bothriocephalus acheilognathi*), 3 nematodes (*Spiroxys contortus*, *Eustrongylides excisus*, and *Contraceacum rudolphii*), and 1 arthropoda *Ergasilus* (*sieboldi*). The monkey goby has the richest parasite fauna with 11 parasite species. Although the monkey goby was infected with 11 parasite species has the richest parasite fauna, the marbled goby was infected with only 4 parasite species. The highest prevalence and abundance values (77.8% and 49.02) were found in tubenose goby infected with 9 parasite species (Table 1).

Table 3. Czekanowski-Sørensen Index (%) in helminth fauna of various gobiid species in the study area

	Nf	Pr	Po
Neogobius fluviatilis (Nf)	100.0	-	-
Proterorhinus marmoratus (Pr)	80.0	100	-
Pomatoschistus marmoratus (Po)	40.0	46.0	100

The monogenean *Gyrodactylus proterorhini* and the digenean metacercariae *Tylodelphys clavata* and *Echinostoma* sp. were determined in three gobiid fishes. *Contraceacum rudolphii* occurred only in tubenose goby; *Spiroxys contortus* and *Eustrongylides excisus* were found only in monkey goby, and *Gyrodactylus* sp. occurred only in marbled goby (Table 1). Four species, *G. proterorhini*, *Apatemon gracilis*, *Posthodiplostomum* sp., and *Echinostoma* sp., played core roles in the metazoan parasite faunas of gobies from the Lower Kızılırmak Delta. *G. proterorhini*, *A. gracilis*, and *Posthodiplostomum* sp. were essential in the tubenose goby parasite fauna and *Echinostoma* sp. in the monkey and tubenose goby parasite faunas. Moreover, *Echinostoma* sp. was core in all cases except in marbled goby (Table 1).

The species composition of metazoan faunas of the three gobiid species differed, and the parasite species richness was variable among the gobiid fishes. The metazoan parasite fauna of the marbled goby, which is of Mediterranean origin, differed markedly from those of the monkey and tubenose gobies (Table 1). The homogeneity of the parasite component faunas was low in monkey and tubenose gobies, but it was high in marbled goby (Table 2). The mean infracommunity index (ICI) of the monkey goby was higher than that of the marbled goby. The ICI of the tubenose goby differed from that of the monkey and marbled gobies (Table 2). A high Czekanowski–Sorensen index, indicating a close similarity, was observed in the metazoan parasite fauna of the monkey and tubenose gobies (*Ics*=80.0%) (Table 3).

DISCUSSION

Data on parasites of various gobiid fishes found in the Black Sea coast are previously reported (12-17, 20, 21, 29-31). These studies include the parasites of the three gobiid species (*N. fluviatilis*, *Pr. marmoratus*, and *Po. marmoratus*) and 34 metazoan parasite species (Table 4). We found 13 parasite species; 6 species were reported on in a previous study, but 7 species, including *Gyrodactylus* sp., *Bothriocephalus acheilognathi*, *Echinostoma*

Table 4. List of the metazoan parasites reported from three gobiid fishes in different geographical localities in the Black Sea region

	Neogobius fluviatilis	***Proterorhinus marmoratus***	***Pomatoschistus marmoratus***
Gyrodactylus proterorhini	[43], Present study	[43], [20], [21], Present study	Present study
Gyrodactylus leopardinus			[30]
Gyrodactylus sp.			Present study
Ascocotyle sp. met.	Present study		
Echinostoma sp. met.	Present study	Present study	Present study
Tylodelphys clavata met.	[31] Present study,	Present study	Present study
Diplostomum spathaceum	[21], [31] Present study	Present study	
Apatemon gracilis met.	[31] Present study	Present study	
Posthodiplostomum sp. met.	Present study	Present study	
Cryptocotyle concavum met.	[12], [13], [14], [16], [21], [32], [43]	[10], [15], [16], [17], [20], [21]	[10], [15], [16], [29], [21]
Cryptocotyle lingua met.	[12], [13], [16], [21], [43],	[16], [17], [20], [21]	[15], [16], [21], [29]
Pygidiopsis genata met.	[12], [13], [16], [21], [31]	[20], [21]	[21], [29]
Acanthostomum imbutiformis	[10], [21], [31], [43],	[20], [21]	[15], [16], [21], [29]
Stephanostomum bicoranatum		[43]	
Monascus filiformis	[43]	[43]	
Pronopyrmna ventricosa	[43]	[43]	[31]
Pronopyrmna petrowi	[43]	[43]	
Magnibursatus skrjabini		[20], [21]	
Asymphylodora imitans	[31]		
Asymphylodora pontica	[21]		[15], [16], [21], [29]
Aphalloides coelomicola			[15], [16], [21], [29]
Galactosomum lacteum	[43]		
Paratimonia gobii			[15], [16], [21], [29]
Nicolla skrjabini	[16], [31]		
Holostephaluscobitis met.	[31]		
Ichthyocotylurus variegatus	[31]		
Rhipidocotyle companula met.	[31]		
Maritrema subdolum met.	[10]		
Proteocephalus gobiorum	[12], [16], [31]	[20]	
Proteocephalus torulosus	[31]		
Ligula pavlovskii	[13], [14], [16]		
Bothriocephalus gregarius			[16], [29]
Bothriocephalus acheilognathi pl.	Present study	Present study	
Agamonema sp. L3	[31]		
Contraceacum rudolphii L3	[21]	[21], Present study	
Contraceacum microcephalum			[29]
Eustrongylides excisus L3	[14], [16], [31],		
Present study			
Dichelyne minutus	[12], [14], [16], [21], [31]	[15], [16], [17], [20], [21]	[15], [16], [29], [21]
Cucullanus heterochrous	[43]		
Streptocara crassicauda	[31]	[20]	
Raphidascaris acus	[14], [16], [31]		
Pseudocapillaria tomentosa	[13]		
Spiroxys contortus	Present study		
Acanthocephaloides propinquus	[12], [13], [16], [31]	[12], [16], [17], [20]	[16], [29]
Telosentis exiguus	[10], [12], [16]	[20]	[16]
Ergasilus sieboldi	Present study		
Thersitina gasterostei	[43]		

met.: metacercaria; pl.: plerocercoid; L3: L3 stage

sp., *Posthodiplostomum* sp., *Ascocotyle* sp., *S. contortus*, and *Ergasilus sieboldi*, were mentioned from the three examined gobiids for the first time in the Black Sea (Table 4). Parasites such as the trematodes *Pygidiopsis genata* (metacercaria), *Cryptocotyle concavum* met., *Cryptocotyle lingua* met., and *Timoniella imbutiforme* met., nematode *Dichelyne minutus*, and acanthocephalan *Acanthocephaloides propinquus* were previously observed in the three gobiids in various sites of the northwestern Black Sea and Crimean coasts. Overall, these parasite species are typical for the resident gobiids in the Black Sea, but we did not find them during our study. *C. concavum*, *C. lingua*, *P. genata*, *T. imbutiforme*, *D. minutus*, and *A. propinquus* are brackish water and marine parasite species. Moreover, the first intermediate hosts of these parasites are also absent in fresh waters (7, 14). The absence of parasites mentioned in the present study could be explained by low salinity in our study area (approximately 1%).

According to previous studies, five of the listed species, *G. proterorhini*, *A. gracilis*, *T. clavata*, *Diplostomum spathaceum*, and *E. excisus*, have been reported in the monkey goby from different localities of the Black Sea (14, 16, 21, 31, present study) (Table 4). Similarly, *G. proterorhini* and *C. rudolphii* have been previously reported in the tubenose goby (20, 21). *G. proterorhini* is a specific species for gobiids inhabiting the Black and Azov Seas and their estuaries (32). Additionally, *it* is reported in various rivers belonging to the Black Sea drainage within the natural living area of the Ponto–Caspian gobiids (20, 29, 33). To date, *Zosterisessor ophiocephalus*, *Gobius cobitis*, *Gobius niger*, *N. melanostomus*, *N. fluviatilis*, *Neogobius platyrostris*, *Mesogobius batrachocephalus*, and *Neogobius kessleri* have been reported as host of *G. proterorhini* (19, 23, 34-40). To the best of our knowledge, the occurrence of *G. proterorhini* in *Po. marmoratus* is reported for the first time in this study. A new host has been added to the host list of *G. proterorhini*. Until today, three *Gyrodactylus* species that are known to parasitize *Po. Marmoratus* include *G. branchialis* and *G. ostendicus* that are reported from the western Mediterranean Sea (41) and *G. leopardinus* that is reported from the Azov Sea (30, 42).

To date, 47 metazoan parasite species have been mentioned in the Black Sea basin according to data from different authors (Table 4). We found 13 parasite species; 7 of these had already been mentioned in published studies, but 6 species, *Ascocotyle* sp., *Posthodiplostomum* sp., *Echinostoma* sp., *B. acheilognathi*, *S. contortus*, and *E. sieboldi*, were mentioned from three gobiid fishes for the first time. Particularly, tendency to join the infracommunity of *Echinostoma* sp., which is a limnetic parasite species, differs from other parasites in the present study (Table 2). The species composition of the metazoan fauna of gobiid fishes from the Lower Kızılırmak Delta located on the southern coastal zones of the Black Sea differed from those reported from various sites of the northern coastal zone of the Black Sea. The results of the present study indicated that the euryhaline and limnetic species are prevalent in this basin, but the marine and brackish water species are prevalent in its northern part. The gobiid parasite fauna does not show homogeneity in the Black Sea (34). It consists of Ponto–Caspian, Mediterranean, Boreal–Atlantic, and limnetic parasite species that are attributed to the different ranges of euryhalinity of the hosts. Thus, the species composition of the gobiid metazoan fauna in the present study is formed according to the ecology of the host species.

CONCLUSION

The present study comprises current data regarding the metazoan parasite fauna of gobiids in the Lower Kızılırmak Delta from the Black Sea. The data presented in this paper contribute to the list of parasite species that inhabit this basin. In general, the metazoan parasite communities of the three gobiid fishes from the Lower Kızılırmak Delta comprised limnetic species and differed from the other regions of the Black Sea.

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