Endohelminth fauna of teleost fishes from coasts of Şile region of the Black sea

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Summary
A total of 508 fish specimens belonging to 19 species collected in the coast of Şile region of the Black sea were examined to detect the presence of endohelminths. Of this, 357 (70.27%) were found to be infected with parasites. 15 distinct helminths species were recovered including four species of nematodes, seven digenean species, one species of cestodes and three species of acanthocephalans. It was also determined that the species of nematode Hysterothylacium aduncum was the most common parasite and the most diverse endohelminth fauna was found in Gobius niger and Solea vulgaris, with five species. Furthermore, it should be noted that Capillaria gracilis is reported for the first time from the Turkish coasts. The infection rates, hosts, and parasites are listed in this paper.

Keywords: Acanthocephala; Cestoda; Digenea; Nematoda; Teleosts; Şile

Introduction
Fish are aquaculture resources with a significant economic value, and present essential nutrients amongst the foods of animal origin (Öztürk, 2005). Fish constantly live amongst parasites in the waters of their natural environment (Taşçi & Topçu, 1990). These parasites not only reduce the nutritional value of the fish, but also hamper their growth, reproduction, and feeding capabilities (Özan & Kır, 2005). While the majority of the parasites involved with fish present no danger to humans, it is also known that the ones harmful for humans tend to have more than one development stage (Adams et al., 1997). Aquatic environments are continuously exposed to different types of waste materials, and such pollution is known to cause an increase in the prevalence of diseases and anomalies encountered in fish populations (Turgut & Özgül, 2009). Since the pollution in these environments is most often of chemical nature, the fish and other animals that act as hosts for the parasites are weakened and lose immune resistance, which in turn causes gaps in the ecological nutritional chain (Oğuz, 1996). The fact that researches focused on fish diseases has gained increased attention and importance in recent years also makes it necessary to gain more insight into the parasitic fauna of fish (Demirtaş, 2011). This study was, therefore, performed to determine the endohelminth fauna of the fish caught from the coastal areas of the Şile region of the Black Sea.

Materials and Methods
The Study Area
This study was performed between February 2010 and December 2013 in the Şile district of İstanbul province. Şile (Fig.1) is located towards the northwest of the country, along the northeast edges of the Marmara Region, facing the Black Sea coasts of the Kocaeli Peninsula. The Black Sea is a semi-closed inland sea with an average depth of 1300 m and a total surface area of 420,000 km². The Black Sea is also the world’s largest anoxic sea, with an oxy-
generated upper layer of approximately 100 – 150 meter depth, while the lower layers are anoxic and contains hydrogen sulfide (Güngör & Çağatay, 2010).

**Fish Material and Sample collection**

The fishers of the coasts of Şile usually hunt shoreline fish. A total of 508 fish distributed over 19 species was obtained from these fishers between February 2010 and December 2013. Fish were collected either alive or as fresh dead and transported to the land inside canisters filled with seawater. The dissections of the fish were performed in the port of Şile, and one specimen from each species was reserved to perform species identification. Fish species were identified using the guidelines established by Slastenko (1955), Geldiay (1969), and Can & Bilecenoğlu (2005). Mid-caudal lengths of the fish were measured and recorded, and the interior organs of the fish were removed by inserting a thin-point scissor into the anus and cutting towards the anterior of the fish body. To make it easier to identify any parasitic presence, the specimens were placed into a petri dish containing physiological saline. The parasites were first searched macroscopically within the body cavity and in interior organs, and any visible parasites were collected into watch-glass using pasteur pipettes to be preserved in physiological saline.

The digestive tracts of the fish were cut from the stomach to the intestines. The contents of the intestines were investigated, and the intestinal epithelium was scraped to search for the presence of any parasites. Livers were cut into small pieces, which were then grounded for microscopic evaluation. Air and gall bladders of the fish were punctured and searched for any parasites. The samples were evaluated under a binocular stereomicroscope, and any nematodes detected were collected into plastic tubes containing 70 % alcohol. The number and location of the parasites within the body were recorded along with the date, the fish species, and the parasite type and count in a sticker used as a label for the tubes, which were then stored until the slides were prepared. Other parasites, meanwhile, were placed between slide glasses and fixed using the A.F.A (Acetic acid + formaldehyde + alcohol) solution, then kept in jars containing 70 % alcohol until their permanent slides were prepared. The permanent slides of the nematodes were prepared by placing them between the glass and cover slides and covering them with glycerine-gelatine. For the other parasite groups, the permanent mounts were prepared as suggested by Baylis (1922), Wardle (1932), Pantin (1960), Cable (1976), Bylund et al. (1980), and Pritchard & Kruse (1982). Parasite species were identified through the guidelines of Dawes (1947), Yorke & Maplestone (1962),
| Parasite Type           | Host                          | EFC | IFC | PCH | P % | MI | MA  |
|------------------------|-------------------------------|-----|-----|-----|-----|----|-----|
| CESTODA                |                               |     |     |     |     |    |     |
| Progrilleta dasyatis   | Chelidonichthys lucerna       | 2   | 2   | 4   | 100 | 2  | 2   |
|                        | Gaidropsarus mediterraneus     | 19  | 11  | 28  | 58  | 2.6| 1.47|
|                        | Gobius niger                   | 32  | 11  | 29  | 34.4| 2.6| 0.9 |
|                        | Mullus sumuleetus              | 54  | 9   | 18  | 17  | 2  | 0.33|
|                        | Scorpaena porcus              | 46  | 2   | 2   | 4.3 | 1  | 0.04|
|                        |                               |     |     |     |     |    |     |
|                        | Helicometra fasciata          |     |     |     |     |    |     |
|                        | Caspialosa pontica            | 32  | 7   | 12  | 22  | 1.7| 0.4 |
|                        | Gobius niger                  | 32  | 3   | 7   | 9.4 | 2.3| 0.2 |
|                        | Platichthys flesus            | 1   | 1   | 41  | 100 | 41 | 41  |
|                        | Scorpaena porcus              | 46  | 27  | 150 | 59  | 5.56| 3.26|
|                        | Solea vulgaris                | 8   | 2   | 13  | 25  | 6.5| 1.63|
|                        |                               |     |     |     |     |    |     |
|                        | Helicometra insolata          |     |     |     |     |    |     |
|                        | Solea vulgaris                | 8   | 1   | 10  | 12.5| 10 | 1.25|
|                        | Symphodus tinca               | 1   | 1   | 4   | 100 | 4  | 4   |
|                        |                               |     |     |     |     |    |     |
|                        | Anisocladium fallax           |     |     |     |     |    |     |
|                        | Anisocladium gracile          |     |     |     |     |    |     |
|                        | Anisocelleum capitellatum     |     |     |     |     |    |     |
|                        | Prodistomum polonii           |     |     |     |     |    |     |
|                        | Monascus filiformis           |     |     |     |     |    |     |
|                        |                               |     |     |     |     |    |     |
|                        | NEMATODA                      |     |     |     |     |    |     |
|                        | Hysterothyacium aduncum       |     |     |     |     |    |     |
|                        | Caspialosa pontica            | 32  | 23  | 180 | 72  | 8  | 5.4 |
|                        | Chelidonichthys lucerna       | 2   | 2   | 8   | 100 | 4  | 4   |
|                        | Engraulis encrasiculus        | 33  | 17  | 115 | 52  | 7  | 4   |
|                        | Gaidropsarus mediterraneus     | 19  | 10  | 103 | 53  | 10.3| 5.4 |
|                        | Gobius niger                  | 32  | 25  | 268 | 78.1| 11 | 8.4 |
|                        | Merlangius merlangus euxinus  | 107 | 79  | 922 | 74  | 12 | 9   |
|                        | Mullus sumuleetus             | 54  | 13  | 23  | 24  | 1.8| 0.43|
|                        | Sarda sarda                   | 6   | 3   | 27  | 50  | 9  | 4.5 |
|                        | Sciaena umbra                 | 2   | 1   | 3   | 50  | 3  | 1.5 |
|                        | Scorpaena porcus              | 46  | 19  | 115 | 41.3| 6.05| 2.5 |
|                        | Solea vulgaris                | 8   | 2   | 57  | 25  | 28.5| 7.1 |
|                        | Spicara smaris                | 32  | 25  | 369 | 78.1| 14.8| 11.5|
|                        | Symphodus tinca               | 1   | 1   | 2   | 100 | 2  | 2   |
|                        | Trachinus draco               | 11  | 10  | 30  | 91  | 3  | 2.3 |
|                        | Trachurus mediterraneus       | 68  | 49  | 631 | 72.1| 13 | 9.3 |
|                        | Uranosocus scaber             | 44  | 28  | 369 | 64  | 13.2| 8.4 |
|                        |                               |     |     |     |     |    |     |
|                        | ACANTHOCEPHALA                |     |     |     |     |    |     |
|                        | Philometra sp.                |     |     |     |     |    |     |
|                        | Trachinus draco               | 11  | 1   | 8   | 9.1 | 8  | 0.73|
|                        | Trachurus mediterraneus       | 68  | 1   | 4   | 1.5 | 4  | 0.06|
|                        | Solea vulgaris                | 8   | 2   | 10  | 25  | 29 | 7.1 |
|                        | Symphodus tinca               | 1   | 1   | 13  | 100 | 13 | 13  |
|                        | Gobius niger                  | 32  | 2   | 13  | 6.3 | 7  | 0.4 |
|                        | Mullus sumuleetus             | 54  | 1   | 18  | 1.9 | 18 | 0.33|

EFC: Evaluated Fish Count, IFC: Infected Fish Count, PCH: Parasite Count in Host, P: Prevalence, MI: Mean Intensity, MA: Mean Abundance
Schell (1970), Fagerholm (1982), Khalil et al. (1994), Gibson et al. (2002), Jones et al. (2005), Yamaguthi (1955a), Yamaguthi (1955b), Yamaguthi (1955c). The prevalence, mean intensity, and mean abundance values for all parasite species were calculated as suggested by Bush et al. (1997).

**Ethical Approval and/or Informed Consent**

For this study formal consent is not required.

**Results**

As the endohelminths of a total of 508 fish belonging to 19 different species were inspected as part of the study, 15 different helminth species were encountered. 357 out of the 508 fish inspected (70.27 %) were found to be infected with parasites, and a total of 3813 parasites were detected amongst all the fish. 313 of the fish (61.6 %) were found to be infected with nematodes, 75 (14.76 %) were infected with Digeneans, 35 (6.88 %) were infected with Cestoda and 18 (3.54 %) were infected with Acanthocephala group of parasites. A total of 3288 Nematodes, 398 Digeneans, 81 Cestodes, and 46 Acanthocephalans were determined throughout the specimens (Table 1).

The only Cestoda encountered as part of the study was the *Progriollotia dasyatidis*, which belongs to the Progrillotiidae family. The species identified for the Digenean group are as follows: *Helicometra fasciata* and *Helicometra insolata* species belonging to the Opecoelidae family, *Anisocladium fallax*, *Anisocladium gracile*, and *Anisoscoelium capitellatum* belonging to the Acanthostomidae family, *Prodistomum polonii* of the Lepocreadiidae family, and *Monascus filiformis* of the Fellodistomidae family. As for nematodes, the species identified consisted of *Hysterothylacium aduncum* of the Anisakidae family, *Philometra sp.* of the Philometridae family, *Cucullanellus minutus* of the Cucullanidae family, and *Capillaria gracilis* of the Capillaridae family. Finally, the species identified for the Acanthocephala consisted of *Acanthocephaloides irregularis* of the Arhythmacanthidae family, *Neoechinorhynchus agilis* of the Neoechinorhynchidae family, and *Solearhynchus kustylewi* of the Echinorhynchidae family (Table 1). Amongst these, *Capillaria gracilis* was identified for the first time in Turkey as part of the present study (Fig. 2).

Considering the relationship with the inspected fish species and corresponding parasite species, the highest number of species of parasites was found in *Gobius niger* and *Solea vulgaris* fish species, each of which were infected with 5 different types of parasites. *Scorpaena porcus*, *Mullus surmuletus*, and *Uranoscopus scaber* were infected with four different species of parasites, *Gaidropsarus mediterraneus*, *Symphodus tinca*, and *Trachurus mediterraneus* were infected with three different species of parasites, *Caspialosa pontica*, *Chelidonichthys lucerna*, and *Trachinus draco* were infected with two different species of parasites, and *Engraulis encrasicolus*, *Liza aurata*, *Merlangius merlangus euxinus*, *Platichthys flesus*, *Sarda sarda*, *Sciaena umbra*, and *Spicara smaris* were found to be infected with only one type of parasite. The highest prevalence for the parasite species encountered as part of this study was that of *H. aduncum* with 84.5 %. *H. aduncum* was also the parasite species that infected the highest number of different species of fish (16 species). *P. dasyatidis* and *H. fasciata* share the second most prevalent distribution with 26.3 %.* A. fallax*, *A. gracile*, *A. capitellatum*, *M. filiformis*, *P. polonii*, *N. agilis* and *S. kustylewi* each share 5.3 % prevalence and they were each encountered only in a single species of fish.

**Discussion**

Until 2005, a total of 114 parasitic helminths (87 Platyhelminthes, 16 Nemathelminthes, 9 Acanthocephala, 2 Annelida) were reported in the first checklist that could be considered a report for the marine fish of Turkey, recorded as observed from 65 marine fish (Öktener, 2005). Various other researchers (Oğuz, 1996; Keser,
For the Cestoda, the Progrillotidae family was first determined for the seas surrounding Turkey in a Gobius niger (Oguz & Bray, 2008), and was later reported to be present in Gobius niger, Uranoscopus scaber, Gaidropsarus mediterraneus, Ophidian rochei and Mullus barbatus (Tepe et al., 2014). In the present study, the only species encountered for the Progrillotidae family was Progrillotia dasyatis, which was identified in Gobius niger, Mullus surmuletus, Gaidropsarus mediterraneus, Chelidonicthys lucerner, and Scorpaena porcus fish species.

**Helicometra fasciata** is known to have a high host infection spread and was reported first for Turkey in the Sea of Marmara Gaidropsarus mediterraneus, Gobius gobistes, Scorpina scrofa, Symphodus tinca, Trachurus mediterraneus, and was reported first for Turkey in the Sea of Marmara (Oguz & Bray, 2008), and was later reported to be present in Gobius niger, Uranoscopus scaber, Gaidropsarus mediterraneus, Ophidian rochei and Mullus barbatus (Tepe et al., 2014). In the present study, the only species encountered for the Progrillotidae family was Progrillotia dasyatis, which was identified in Gobius niger, Mullus surmuletus, Gaidropsarus mediterraneus, Chelidonicthys lucerner, and Scorpaena porcus fish species.

**Anisocelium capitellatum** is a parasite that infects the gall bladder of Uranoscopus scaber and was detected in Turkey the first time in the Marmara Sea, around the shores of Mudanya by Oğuz (1995). Tepe (2011) and Tepe et al. (2014) have also reported the parasite to be present around the shores of the Eastern Black Sea. In the present study which focused on the shorelines of Şile, 18 out of the 44 Uranoscopus scabers inspected were found to contain the parasite (41 %), and the mean intensity was determined as 4.1. Prodistomum poloni which was previously only encountered in the intestines of Trachurus mediterraneus, was reportedly present in the Trachurus trachurus of the Dardanelle Strait of Turkey by Keser et al. (2007). In the present study, this species was found to have a prevalence of 9 %, and mean intensity and abundance of 0.18.

Another Digenean species, Monascus filiformis, has previously been reported in Turkey in the shores of Mudanya, infecting the Symphodus tinca fish (Oguz & Bray, 2006). This species of parasites was also reported for the Trachurus trachurus of the Sea of Marmara (Keser et al., 2007). In the present study, Monascus filiformis was encountered only in a single fish (2 % prevalence) of Mullus surmuletus.

Hysterothylacium aduncum was first encountered in Turkey in Trachurus mediterraneus and Engraulis encrasicolus and Sprattus sprattus (Öktemer, 2005). Doğanay (1994) and Ismen & Bingel (1999) have reported the parasite in Merlangius merlangus of the Turkish coasts of the Black Sea. Furthermore, some of the anchovies obtained from the fish market of Eskişehir was reported to be infected with Contracaecum sp. (Yetim, 1985). The parasite was also encountered in Merluccius merluccius, Gobius niger, and Trachurus trachurus caught in the Sea of Marmara (Oğuz, 1995; Keser et al., 2007), in Scomber japonicas of the Aegean Sea (Akmirza, 1997), in the Trachurus trachurus obtained from Erzurum fish market (Özkan et al., 2010), and later in Pagellus erythrinus and Lophius piscatorius caught nearby the Gökçeada Island (Akmirza, 2013). In this study, H. aduncum was determined to be present with a very high prevalence (84.5 %), and was found to have infected Caspialosa pontica, Chelidonicthys lucerner, Engraulis encrasicolus, Gaidropsarus mediterraneus, Gobius niger, Merlangius merlangus euxinus, Mullus surmuletus, Sarda sarda, Sciaena umbra, Scorpaena porcus, Solea vulgaris, Spicara smaris, Symphodus tinca, Trachinus draco, Trachurus meditteraneus, and Uranoscopus scaber. The mean intensity of the parasite was the highest in Solea vulgaris with 28.5, and the mean abundance was the highest in Spicara smaris 11.5.

In Turkey, Epinephelus gigas, E. aeneus, E. marginatus, E. costae, and Mycteroperca rubra were reported to be infected with Philometra sp. Furthermore, Epinephelus marginatus and Mycteroperca rubra were reported to contain Philometra lateolabracis,
while some _Pagellus erythrinus_ were reported to be infected with _Philometra filiformis_ (Öktener, 2005). In the Eastern Black Sea, _Uranoscopus scaber_ and _Trachurus mediterraneus_ were reportedly infected with _Philometra globiceps_ (Tepe, 2011; Tepe & Oğuz, 2013). In the present study, the _Philometra_ sp. was found to be present in _Trachinus draco_ and _Trachurus mediterraneus_. The infection prevalence of the parasite was found to be the highest in _Trachinus draco_ with 9.1 %. Another nematode species, _Cucullanellus minutus_, was first reported in Turkey in the Ekinli Lagoon of the Marmara, in _Pleuronectes flesus_ by Oğuz (1989). In our study, _Cucullanellus minutus_ was found to have infected two _Solea vulgaris_ and one _Symphodus tinca_.

There is some information in the literature that _Capillaria_ sp. was determined in angelfish (_Pterophyllum scalare_) (Ürkü & Yardımcı, 2013). While the _Capillaria_ genus displays a widespread distribution on the freshwater fish for the first time by Doğanay et al. (2013). While the _Capillaria_ genus displays a widespread distribution on the freshwater fish for the first time by Doğanay et al. (2013). Still, it was the most prevalent in _Gobius niger_ with 6.3 %. Since this species was never reported for the marine or inland seas of Turkey, this study is the first to report its presence for the Turkey marine.

_Acanthocephaloides irregularis_ of the Acanthocephala group of parasites was first reported from the Sukhýi Lyman Ukrainian shores and the Bay of Odessa, in _Parablennius zvonimiri_, _Ponticola eurycephalus_, _Proterorhinus marmoratus_ and _Symnathus abaster_ fish (Amin et al., 2011). The first recording of the parasite group for Turkey was for the _Scorpaena porcus_ of the Black Sea shores with _Acanthocephaloides propinquus_ infection (Tepe, 2011), which was later revised as _Acanthocephaloides irregularis_ (Tepe & Oğuz, 2013). _Acanthocephaloides irregularis_ was found to be present in _Scorpaena porcus_, _Gaidropsarus mediterraneus_, and _Gobius niger_ fish in this study as well. The highest prevalence of infection was in _Scorpaena porcus_ with 20 %. _Neoechinorhynchus agilis_ was first encountered in _Mugil cephalus_ (Cleave, 1921). In Turkey, this species was reported to be infecting the _Mugil cephalus_, _Liza aurata_, _Liza saliens_, _Liza ramada_ and _Chelon labrosus_ of the Aegean Sea (Altunel, 1982), in _Liza saliens_ of the Dardanelle Strait (Keser et al., 2007), and _Liza aurata_ of the Eastern Black Sea (Tepe & Oğuz, 2013). In our study, _Neoechinorhynchus agilis_ was only determined in the _Liza aurata_ species of fish with 44 % infection prevalence. Another _Acanthocephala_ species, _Solearhynchus costleyewi_, was first reported in Turkey from the Mudanya shores of the Marmara Sea as _Acanthocephaloides soleae_ (Oğuz, 1995), which was later revised as _Paracanthocephaloides costleyewi_ (Oğuz & Kvach, 2006). The same parasite was later identified as _Solearhynchus costleyewi_ (Kvach & Oğuz, 2010). In research performed in the Black Sea, _Acanthocephaloides costleyewi_ was reported as the specific parasite of _Solea nasutus_ (Belofovestova, 2004). In our study, _Solearhynchus costleyewi_ was only found to be present in _Solea vulgaris_ with 12.5 % infection prevalence. Among the reasons for the differences observed in the present study the location where the fish are caught, pollution rate of water, host and intermediate host population, seasonal variations, and methods used can be included.

We hope that this study performed to determine the endohelminth fauna of the fish of the Şile shores of Turkey will present valuable reference opportunities for future studies and will contribute to the insight regarding the diversity of endohelminth of teleost fish of Turkey.

**Conflicts of Interest**

Authors state no conflict of interest.

**Acknowledgment**

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