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Observations on Helminth Parasites in Endemic and Native Fish from Susurluk Basin, Türkiye Using a Genetic- Molecular Approach: With New Host and Geographical Records

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ABSTRACT: In this study, a total of 50 individuals of three endemic fish species, namely *Chondrostoma angorense* (n=13), *Oxyoemacheilus simavicus* (n= 9) and *Oxyoemacheilus angorae* (n= 12), and one native fish species, *Silurus glanis* (n=16) were examined for helminth parasites between February 2021 and December -2021 from Nilüfer stream and Simav stream, in the northwest Anatolian region of Turkey. A total of 5881 parasite species of five helminths were found in four of the fish species consisting of 2 monogenean: *Paradiplozoon homoion* (in *C. angorense*) and *Ancylo-discoides vistulensis* (in *S. glanis*), one digenean: *Clinostomum complanatum* metacercariae (in *C.angorense*), 2 nematodes: *Contra-caecum rudolphii* B (in *C.angorense*, *O. simavicus* and *O. angorae*) and *Eustrongylides excicus* larvae (in *S. glanis*). *A. vistulensis* was found to be the highest number compared the remaining parasite species. The present work reported for the first time the occurrence of *P. homoion*, *C. complanatum* metacercariae and *C. rudolphii* B in *C.angorense*, and *C. rudolphii* B in *O. simavicus* and *O. angorae*. This depicted new host records and geographical distribution for those five helminth parasites.

Keywords: Susurluk basin; endemic and native fish; helminth parasites

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INTRODUCTION

According to recent findings, a total of 409 freshwater fish species are recognized within the political boundaries of Turkey, and 194 of these fish species are endemic to Turkey (Çiçek et al., 2018). As far as we know, there are no studies or it is known that there are limited numbers of studies on the ichthyoparasitological investigation of various freshwater fish species still widespread in our country today. To increase the number of studies in this field, scientific studies investigating fish species in terms of ichthyoparasitology started in the 1960s and gained momentum in the 2000s. Despite the increase in the number of studies in this field in recent years, according to the latest findings (Özer, 2021), the number of parasite species reported from freshwater fishes is only 186. This number is quite low when compared to the number of species recorded in studies conducted in this area in neighboring countries of Turkey. Moreover, the number of studies investigating endemic fish species, represented by 194 species distributed in inland waters of Turkey, in terms of ichthyoparasitological is also very low. Exactly confirming the above information, to the authors' knowledge and available references, there are no records of ichthyohelminthological studies for *O. simavicus* and only one ichthyohelminthological study is available on *C. angorensis* (Innal et al., 2020).

The present study aimed to (i) characterize the community of helminthic parasites from endemic and native fish species collected from two localities of Susurluk basin, Turkey using a genetic-molecular approach (ii) improve the epidemiological data, geographical distribution, and host range of helminthic parasite in Turkish waters.

MATERIALS AND METHODS

Sampling and parasitological analysis

A total of 50 individuals from three endemic *Chondrostoma angorensis*, *Oxyoemacheilus simavicus*, *Oxyoemacheilus angorae* (n= 12), and one native, *Silurus glanis* fish species were collected for the presence of helminth parasites. The fish were collected by electrofishing and transported to the laboratory in ventilated plastic tanks from the following localities in Susurluk basin, Turkey. *Chondrostoma angorensis* (n=13); *Silurus glanis* (n=16) Susurluk stream, (39° 48 ' 973''K, 28° 10' 714''D) and *Oxyoemacheilus simavicus* (n= 9); *Oxyoemacheilus angorae* (n= 12) Nilüfer stream (40°10'44.8''N

28°58'13.0''E), Bursa. The sampling localities of fish species are shown in Figure 1.

The fish were measured (total body length, TL, 5 mm accuracy) and weighed (total body weight, TW, in g) before inspection for parasites. For the collection of parasites, the external body, oral cavity, gills, branchial cavity, body cavity, stomach, small intestine, large intestine, pyloric caeca, mesenteries, gonads, heart, branchial artery, swim bladder, kidneys, liver, spleen of the fish were carefully examined using a stereomicroscope (SMZ 745 Nikon and SZ61 Olympus). Monogenea specimens were removed and were made permanent with a mixture of glycerine-ammonium picrate (Malmberg et al., 1957; Bylund et al.,1980). Trematodes were fixed in 4 % formalin solution and stained with acetocarmine stain, rinsed dehydrated, cleared in Xylene, and mounted in Canada balsam. Nematodes were fixed in hot 4 % formalin, cleared, and mounted in lactophenol without staining. The identifications of all specimens were performed according to the diagnostic morphological keys of Gussev (Gussev,1985, 1987;Bychovskaya - Pavlovskaya, 1962 ; Markevic, 1951; Yamaguti,1985a,b,c; Khotenovskiy,1985; Moravec, 1994; Dawes,1968; Hoffman 1999; Gibson et al.,2002; Khalil et al.,1994). and available references using an optical microscope. The levels of prevalence, mean intensity, and mean abundance of infection as defined by Bush et al. (1997) were calculated. Standard statistical computation (standart deviation) was carried out using Microsoft Excel (Office 2000). Finally, the collected nematode larvae were washed in saline solution, fixed in 70% ethanol, and delivered to the Laboratory of Parasitology, Department of Public Health and Infection Diseases of "Sapienza-University in Rome", for molecular identification. The photomicrographs of all parasite specimens were taken using a photographic

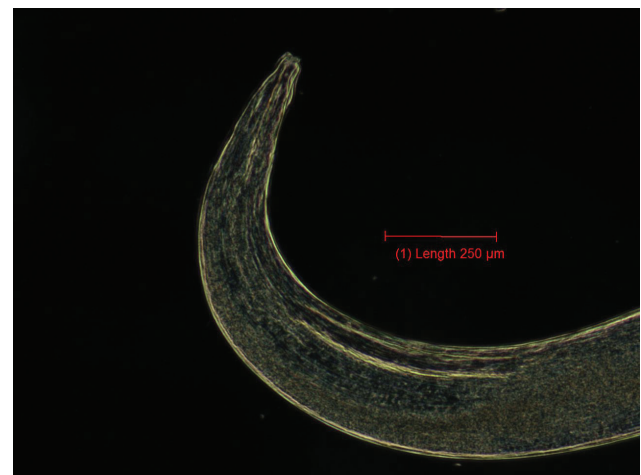


Figure 1. *Contracaecum rudolphii*-B anterior

camera-mounted Leica DMR microscope with phase contrast and BX-50 Olympus with a research microscope.

Molecular Analyses

The samples fixed in alcohol were first washed in PBS and distilled water before the DNA extraction. The total DNA of each single larvae was extracted using the Quick-gDNA™ Miniprep Kit (ZYMO RESEARCH) following the standard manufacturer recommended protocol. The mitochondrial cytochrome C oxidase subunit II (cox2) gene was amplified using the primers 211F (5-TTTTCTAGTTATATAGATTGRTTYAT-3) and 210R (5- CACCAACTCTTAAAAT-TATC-3) (Nadler and Hudspeth 2000). Polymerase chain reaction (PCR) was carried out according to the previously described procedures Mattiucci et al. (2008). PCR amplicons were sent to an external laboratory for sequencing (Bio-Fab Research, Rome, Italy). Contiguous sequences were assembled and edited using MEGA X v. 11. (Kumar, 2018). Sequence identity was checked using the Nucleotide Basic Local Alignment Search Tool (BLASTn) (Morgulis et al., 2008).

Additionally, to confirm the morphological identification of diplozoid species, the molecular analysis was performed as previously described by Aydogdu et al. (2020 a , 2020 b). And Sequence data was published to GenkBank (Genbank accession number: OP559061)

RESULTS

Of the 50 fishes, representing 3 endemic and one native species were examined. Thirty-seven fish individuals were found to be infected with one or more parasite species. A total of 5881 parasites of 5 species

were identified in the fishes consisting of 2 monogeneans: *Paradiplozoon homoion* (in *C. angorensis*) and *Ancylo-discoides vistulensis* (in *S. glanis*), one digenean: *C. complanatum* metacercariae (in *C. angorensis*), 2 nematodes: *Contra-caecum rudolphii* B (in *C. angorae*, *O. angorae* and *O. simavicus*) and *Eustrongylides excicus* larvae (in *S. glanis*). The prevalence, mean intensity, abundance, range, and total parasite number of these parasites are shown in Table 1.

The Ankara nase, *Chondrostoma angorensis*, averaged 70.2g (\pm 53.8g, range 36.1-215.8g) in weight and averaged 20.4 cm (\pm 3.5cm, range 17.1-28.6 cm) in total length. Among the 13 examined *C. Angorensis*, all individuals were found to be infected with one or more parasite species. The most prevalent and abundant parasite species were *C. Rudolphii* B (Figure 1- 2) in this fish. All fish studied were

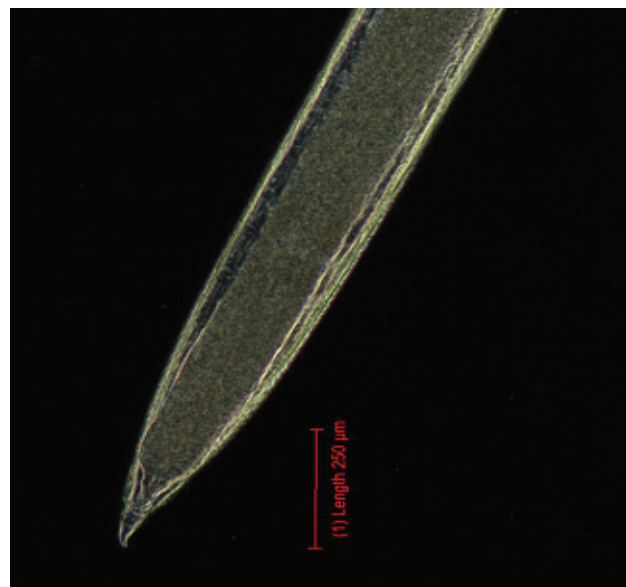


Figure 2. *Contra-caecum rudolphii*-B posterior

Table 1. Distribution of infection value of helminth parasites in endemic and native fish from Susurluk basin, Turkey

Host and parasite species	Prevalence (%)	Mean intensity \pm SD	Mean abundance	Range	Total Parasite no
<i>Chondrostoma angoranse</i> (n=13)					
<i>Paradiplozoon homoion</i>	61.5	4.2 \pm 4.4	2.6	1-11	34
<i>Clinostomum complanatum</i> metacercariae	53.8	1.5 \pm 0.5	0.8	1-2	11
<i>Contra-caecum rudolphii</i> -B	100	10.9 \pm 8.3	10.9	3-28	142
<i>Oxynoemacheilus simavicus</i> (n= 9)					
<i>Contra-caecum rudolphii</i> -B	33.3	2 \pm 1.7	0.3	1-4	6
<i>Oxynoemacheilus angorae</i> (n= 12)					
<i>Contra-caecum rudolphii</i> -B	41,6	1,6 \pm 0.8	0,6	1-3	8
<i>Silurus glanis</i> (n=16)					
<i>Ancylo-discoides vistulensis</i>	100	355,8 \pm 280.6	355,8	22-1214	5694
<i>Eustrongylides excicus</i> larvae	56,2	5,1 \pm 4.1	2,8	1-15	46

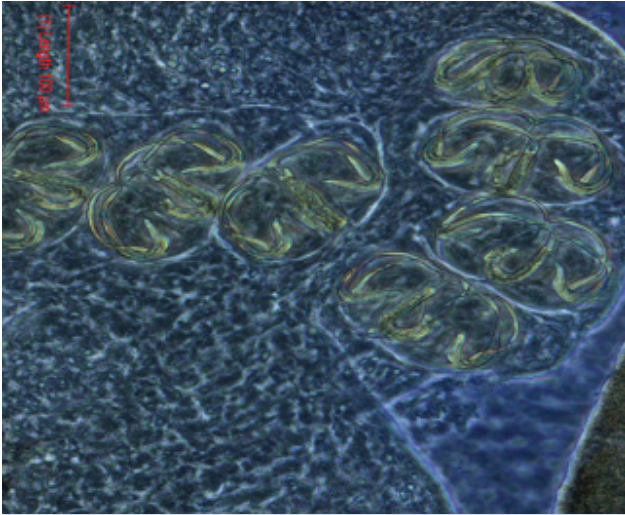


Figure 3. *Paradiplozoon homoion* haptor and clamps



Figure 4. *Clinostomum complanatum* metacercariae total view

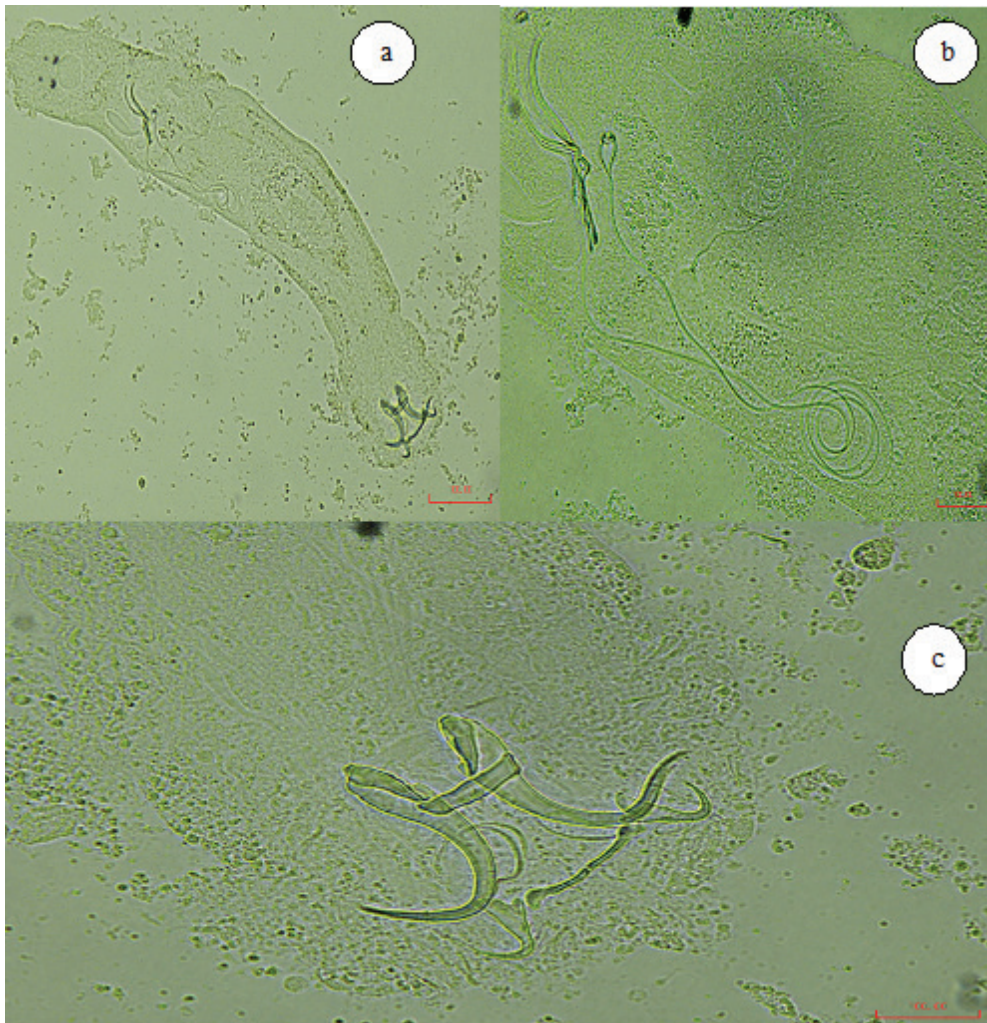


Figure 5. *Ancylo-discoides vistulensis* a) Total view b) copulation organ c) haptor

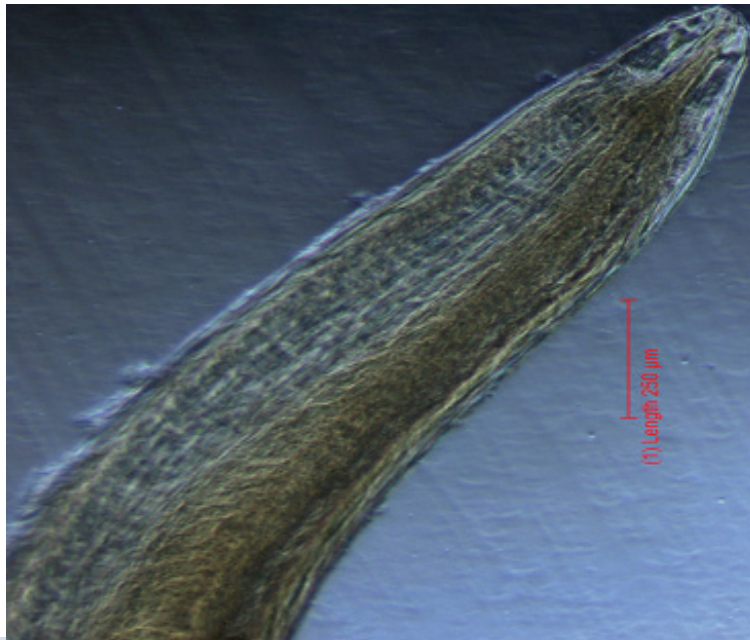


Figure 6. *Eustrongylides excicus* larvae anterior



Figure 7. *Eustrongylides excicus* larvae posterior

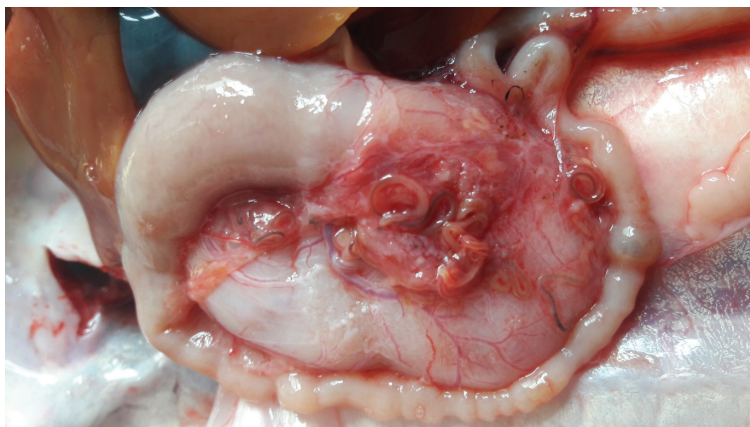


Figure 8. *Eustrongylides excicus* larvae in *Silurus glanis*

found to be infected with this nematode species and a total of 142 specimens were recorded in the host fish (Table 1). The second dominant parasite was *P. Homoion* (Figure 3). Eight of 13 fish were infected with this parasite (61.5 % prevalence). A total of 34 parasites were found in 8 host fish individuals (Table 1). A total of 11 specimens of *C. complanatum* metacercariae (Figure 4) were infected 7 of 13 fish examined with prevalence, mean intensity, and mean abundance of infection of 53.8 %, 1.5, and 0.8, respectively (Table 1). The Simav loach, *Oxynoemacheilus simavicus*, averaged 1.5g (\pm 0.3g, range 1.2 -2.3g) in weight and averaged 6.3cm (\pm 0.3cm, range 5.5 -6.7 cm) in total length. According to Table 1, a total of 6 parasitic individuals belonging to a nematode species, *Contracaecum rudolphii* B (Figure 1-2) were obtained from the host fish. We described this nematode species based on morphology and molecular analysis. These parasites were found to be localized in the abdominal cavity of the fish, with prevalence, mean intensity and mean abundance of 33.3%, 1 parasite/fish, and 0.3, respectively (Table 1).

The Angora loach, *Oxynoemacheilus angorae*, averaged 1.8g (\pm 0.7g, range 0.8 -3.1g) in weight and averaged 5.7cm (\pm 0.8cm, range 4.2-6.7 cm) in total length. As shown in Table 1, of the 12 fishes examined, only one species of nematodes were found in the abdominal cavity of 5 individuals of the host fish. Our detailed studies on morphological identification of the species identified as *Contracaecum rudolphii* B (Figure 1- 2) and we also confirmed with molecular analysis, as in the previous nematode species (in *O. simavicus*). Five fish individuals were infected with 8 parasite specimens. Infection variables were recorded as follows: prevalence 41.6%, mean intensity 1.6 parasite/fish, and mean abundance 0.6 (Table 1).

The wels catfish, *Silurus glanis*, averaged 140.3g (\pm 100.1g, range 51 -320g) in weight, and averaged 25.5cm (\pm 7.5cm, range 16- 39.5 cm) in total length. A total of 5680 parasite individuals belonging to 2 helminth parasite species were recovered from the wels catfish.

Of these, *A. vistulensis* (Figure 5a,b,c) was found to be the most abundant compared to the remaining parasite species. A total of 5634 specimens of *A. vistulensis* were found in all 16 individuals of *S. glanis* examined (Table 1). The other parasite species in this fish is *E. excisus* larvae (Figure 6,7,8). A total of 46 specimens of this nematode species were found

in the abdominal cavity of the host fish. The prevalence level of *E. excisus* larvae (Figure 6,7,8) was 56.2% and the mean intensity value was 5.1 parasite/fish (Table 1).

DISCUSSION

In this study, helminth parasites in three endemic fish and one native species from Susurluk basin, Turkey were investigated. Five helminth species were identified from these fishes; *Paradiplozoon homoion* (in *C. angorensis*) and *Ancylo-discoides vistulensis* (in *S. glanis*) in the gills; *Clinostomum complanatum* metacercariae (in *C. angorensis*) in the gills and gill cavities; *Contracaecum rudolphii* B (in *C. angorensis*, *O. simavicus*, and *O. angorae*) and *Eustrongylides excisus* larvae (in *S. glanis*) in the abdominal cavity of the host fishes.

In the present study, two parasites, *P. homoion* and *C. rudolphii* B were identified using morphological and anatomic assessment, which confirmed molecular characterization. This study contributes to increasing the number of ichthyohelminthological studies on endemic fish and expanding our understanding of helminth diversity in *S. glanis* collecting data from a previously untouched locality in a different geographic region of Turkey. In addition to these findings, three endemic fish species are new hosts for helminth parasites recorded in them. At the same time, this study is the first ichthyohelminthological data for *S. glanis* living in Susurluk stream, Susurluk basin, Turkey. Therefore, the present study adds new data to the host range and the geographical distribution of parasite species recorded in this study.

The results show that *C. angorensis* was found infecting with the highest number of helminth parasites (5). Moreover *S. glanis*, was found with a moderate number of parasites (2). *O. simavicus* and *O. Angorae* were found with the smallest number of parasite species.

Monogenean parasites *P. homoion* and digenean parasites *C. complanatum* metacercariae were only found in *C. angorensis*. A total of 34 specimens of *P. homoion* were recovered from 8 of 34 *C. angorensis* examined with prevalence and mean intensity of 61.53% and 4.2 respectively. It is also the most recorded species of *Paradiplozoon* in Turkey. *P. homoion* was previously reported five times from various freshwater fish species in the Marmara region conducted in our current study (Öztürk, 2005; Aydogdu,

2009; Aydogdu et al. 2020 a, b) found that prevalence and mean intensity values were 6;9.57%, 3.5, respectively in *Alburnoides manyasensis*. This prevalence and mean intensity values were nearly similar as compared to the finding of our current study.

As for *C. complanatum* metacercariae, a total of 11 specimens of this parasite were recorded from 7 of 13 individuals of *C. angorensis*. This species has been previously reported from different fish species in a wide geographical area of Turkey: namely *Rhodeus amarus*, *Cyprinus carpio*, *Alburnus* sp., *Chondrostoma* sp., *Varicorhinus* sp., *Luciobarbus escherichi*, *Capoeta tinca*, *Scardininus erythrophthalmus*, *Sander lucioperca*, *Lepomis gibbosus*, *Perca fluviatilis*, *Rutilus rutilus*, and *Squalius cephalus* with prevalence values varying from 7.7 % to 53.8 % (Burgu et al.1988; Öge and Sarimehmetoglu 1996; Dávidová, 2011;Çolak,2013;Soylu 2013;Şimşek 2018;Aydogdu,2020a). From these authors, Soylu [33] reported a 53.8% prevalence of *C. complanatum* metacercariae infecting *P. fluviatilis* from Lake Gala, the same as the value of our study.

In this study, the infection prevalence value of *C. rudolphii*-B varied according to the host fish species. The highest prevalence value of this species was recorded in *C. angorensis*. (100%) (Table 1), As for the infection value among *Oxyneomacheilus* spp, *O. angorae* is more infected by this species (41.6%) than *O. simavicus* (33.3%)(Table 1). According to the available literature, nematode species of the genus *Contracaecum* have been reported from various freshwater fish species living in different habitats in Turkey (Aydogdu,2002; Aydogdu,2008; Aydogdu,2011; Tekin-Özan,2005; Koyun and Altunel, 2007; Selver et al., 2009), nonetheless, neither of the parasite species was identified at a species level. To date, only one of the parasite species of this genus recorded in Turkey has been identified at the species level. It was determined as *C. rudolphi* by Innal et al. (2020) with morphological and anatomical features approaches. They reported this parasite species in *Carassius gibelio* from Karataş Lake, Burdur, Turkey. They determined a prevalence of 2.6% and a mean intensity of 27 parasites per fish in their study.

In the present study, the prevalence of *C. rudolphii*-B varied from 100% in *C. angorensis* from Susurluk stream, 41.6 % in *O. angorae*, and (33.3% in *O. simavicus* from Nilüfer stream. Surprisingly, contrary to their findings, we found that *C. rudolphii* B was heavily infected in individuals of three endemic

fish. In addition to these findings, this study presents the first report on the molecular characterization of *C. rudolphii* B from Turkey. Moreover, this study reports new host records and new localities were added for the distribution of this parasite species.

A. vistulensis was found to be the most prevalent and the most abundant compared to the remaining parasite in the understudy. *A. vistulensis* is a specific and very common parasite in European catfish, *S. glanis* living in different habitats in Europe and Asia. This parasite species has been previously reported from *Silurus glanis* distributed in different habitats across Turkey. namely from Serban Dam Lake, Sapanca Lake (Soylu, 1991; Soylu,2009); Terkos Lake (Soylu,2005);Almus Dam Lake (Turgut 2005);Durusu Lake (Soylu,2009), Siğirci Lake (Çolak, 2013) ;Sakarya River (Akmirza and Yardimci ,2014) and Büyükçekmece Dam Lake (Yardımcı et al.2018). *A. vistulensis* was recorded from *S. glanis* spreading in the wetlands of the same region where our current study was conducted in some of the above-mentioned studies. As to prevalence values of the infection of this species in *S. glanis* in Marmara Region: For example, this value was recorded at 42.6%, 25 % from Durusu Lake, Büyükçekmece Dam Lake, respectively. But we recorded prevalence values in Susurluk stream much higher (100%) than Durusu Lake and Büyükçekmece Dam Lake.

In the present study, *E. excisus* larvae were found in the abdominal cavity of *S. glanis* (Figure -1). This nematode species is a common parasite for several species of freshwater fishes distributed in different habitats across Turkey. This parasite has been previously reported in various fish species living in different habitats in Marmara Region and other regions from Turkey (Öztürk,2001; Öztürk,2002; Soylu 2005; Karatoy and Soylu, 2006; Aydogdu 2011; Çolak, 2013; Soylu, 2013; Akcimen, 2014,; Metin, 2014; Demir and Karakişi, 2016; Yardımcı et al., 2018; Innal et al., 2019). Among the above-mentioned authors, only two, Soylu (2005) and Yardimci et al. (2018) reported this parasite species in *S. galnis*. Soylu (2005) recorded this parasite species (10 samples) in *S. galnis* in Lake Durusu, but did not report any value for the prevalence of infection, while Yardimci et al. (2018) recorded 100 % the prevalence value in *S. glanis* from Büyükçekmece Dam Lake. Surprisingly, in our study, the prevalence of infection for this species was not close to or similar to the infection rates recorded in different fish species in most of the studies

listed above while it was close to the prevalence value (46.2%) of infection of this species in *Perca fluviatilis* in only one study listed above (Çolak, 2013).

CONCLUSIONS

In this study, a total of 50 individuals of three endemic fish species and one native fish species were examined for helminth parasites between February 2021 and December -2021 from Nilüfer stream and Simav stream, in the northwest Anatolian region of Turkey. 5 parasite species were identified: the monogeneans *Ancylo-discoides vistulensis* and *Paradiplozoon homoion*, a digenean *Clinostomum complanatum* metacercariae and two nematodes, *Contracaecum rudolphii*-B and *Eustrongylides excicus* larvae. The highest parasite community was recorded with monogenean parasite species. *A. vistulensis* was found to be the most prevalent parasite species. This study contributes to increasing the number of ichthyohelminthological studies on endemic fish species and to describe helminth species of *S. glanis* living in different geographic regions off Turkey. *Paradiplozoon homoion*, *Clinostomum complanatum* metacercariae, and *Contracaecum rudolphii* B are reported for the first time parasitising these three endemic species. fish species (*Chondrostoma angorense*, *Oxynoemacheilus simavicus* and *Oxynoemacheilus angorae*) represent new host record for three helminth species adding new knowledge to its geographical distribution and host range. Finally, the present work is the first ichthyohelminthological study for *S. glanis* living in Susurluk stream, Susurluk basin, Turkey.

Declarations

Author' contributions

Nurten Aydogdu, Nesrin Emre and Ali Aydogdu contributed to the conception, coordination and design of the study. Nurten Aydogdu and Ali Aydogdu

collected the samples. Nurten Aydogdu, Nesrin Emre and Ali Aydogdu performed the laboratory activities and organized the database. Nurten Aydogdu, Nesrin Emre and Ali Aydogdu conducted on morphological analysis studies for the identification of helminth parasite species. Nurten Aydogdu and Ali Aydogdu conceived of the study of diplozoid species by molecular analysis, and participated in its design and coordination and helped to confirm the morphological identity of diplozoid species by molecular analysis. Renato Aco-Alburqueque, Simonetta Mattiucci described nematode species, *Contracaecum rudolphii* B based on morphology and molecular analysis. Nurten Aydogdu, Nesrin Emre and Ali Aydogdu conceived of the study, and participated in its design and coordination and helped to draft the manuscript. Renato Aco-Alburqueque and Simonetta Mattiucci critically oversaw the substantial revisions of the manuscript.

Conflicts of interest

All authors have read and agreed to the published version of the manuscript. The authors declare that they have no conflicts of interest. The authors have also nothing to disclose

Compliance with ethical standards

No ethical approval was required, as this study did not involve clinical trials or experimental procedure. During the study, no treatment/experiment was implemented on the live animal. All sampling and laboratorywork on fish have complied with the Republic of Turkey Ministry of Agriculture and Forestry animal welfare laws

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REFERENCES

- Akcimen U, Emre N, Bulut C, Cınar S, Yagcı A (2014) An Investigation on *Eustrongylides excicus* (Jagerskiöld, 1909) parasite in fish of Lake Eğirdir. V. Eastern Anatolian Region Fisheries Symposium May 31-June 02, Elazığ.
- Akmirza A, Yardımcı RE (2014) Fish parasites of the Sakarya River, Turkey. Journal of Academic Documents for Fisheries and Aquaculture 1: 23-29.
- Aydogdu A, Altunel FN (2002) Helminth parasites (Plathelminthes) of common carp (*Cyprinus carpio* L.) in Iznik Lake. Bulletin- European Association of Fish Pathologists 22:343-348.
- Aydogdu A, Emre Y, Emre N, Küçük F (2011) Two new host records for *Pomphorhynchus laevis* (Müller, 1776) (Acanthocephala) recorded from Antalya, Turkey: Small bleak (*Alburnus baliki* Bogutskaya, Küçük & Ünlü, 2000) and Antalya barb (*Capoeta antalyensis* Battalgil, 1944). Turkish Journal Of Zoology 35(6):897-900.
- Aydogdu A, Selver M, Aydın C (2009) Occurrence of Metazoan parasites of the mirror carp (*Cyprinus carpio* L. 1758) in a fish farm, Uluabat, Bursa, Turkey. Pakistan Journal of Zoology 41(4): 322-326. <http://dx.doi.org/10.17582>
- Aydogdu N, Alemdar A, Torcu-Koc H, Erdogan Z (2020a) Susurluk Çayı (Balıkesir)'ndaki Acı Balık, *Rhodeus amarus* (Pallas, 1782) (Teleostei: Cyprinidae)'un Helminth Parazitleri Üzerine Bir Araştırma: Acı

- Balık'ta *Paradiplozoon homoion*' un Türkiye' de İlk Kaydı ve Helmint Parazitlerin Her Biri İçin Yeni Lokalite Kaydı. Türk Tarım ve Doğa Bilimleri Dergisi 2020 7(4), 1049-1056. <https://doi.org/10.30910/turkjans.685761>
- Aydoğdu A, Emence H, İnnal D (2008) Gölbaşı Baraj Gölü (Bursa)'ndeki eğrez balıkları (*Vimba vimba* L. 1758)'nda görülen helmint parazitler. Türkiye Parazit Derg 32(1): 86-90.
- Aydoğdu N, Avenant-Oldewage A, Dos Santos QM, Aydoğdu A (2020b) Prevalence and intensity of *Paradiplozoon homoion* (Monogenea: Diplozoidae) from Manyas spiralin, *Alburnoides manyasensis*, an endemic fish of Turkey: new host and geographical record. Iranian Journal of Fisheries Sciences 19(6): 3301-3309. DOI: 10.22092/ijfs.2020.123007.
- Burgu A, Oğuz T, Körting W, Güralp N (2008) Parasites of freshwater fishes in some areas of central Anatolia. Journal of Etlik Veterinary and Microbiology 3 (6): 143-165.
- Bush AO, Lafferty KD, Lotz JM, Shostak AW (1997) Parasitology meets ecology on its own terms: Margolis et.al. Revisited. The Journal of Parasitology 83:575-583.
- Bychovskaya - Pavlovskaya, Gussev AV, Dubinina MN, Izyumova NA, Simirnova TS, Sokolovskaya I, Shtein GA, Shulman SS, Epshtein VM (1962) Key to parasites of freshwater fishes of the U.S.S.R. Moskova - Leningrad: Izdatel'stvo Akademii Nauk SSR. (In Russian: English Translation - Israel Program for Scientific Translation), Jerusalem.
- Bylund G, Fagerholm HP, Calenius G, Wikgren BJ, Wikström M (1980) Parasites of fish in Finland II. Methods for studying parasite fauna in fish. Act. Acad. Ab., Series B 40: 1-23.
- Çiçek E, Fricke R, Sungur S, Eagderi S (2018) Endemic freshwater fishes of Turkey. Fish Taxa 3 (4), 1- 39.
- Çolak H (2013) Metazoan parasites of fish species from Lake Sığircı (Edirne, Turkey). Turk J Vet. Anim Sci. 37: 200-205.
- Dávidová M, Blažek R, Trichkova T, Koutrakis E, Gaygusuz Ö, Ercan E, Ondračková M (2011) The role of the European bitterling (*Rhodeus amarus*, Cyprinidae) in parasite accumulation and transmission in riverine ecosystems. Aquatic Ecology 45(3): 377-387.
- Dawes B (1968) The Trematoda with special reference to British and other European forms. Londra: Cambridge at the University press.
- Demir S, Karakişi H (2016) Metazoan Parasite Fauna of the Prussian carp, *Carassius gibelio* (Bloch, 1782) (Cyprinidae), from Marmara Lake, Turkey. Acta Zoologica Bulgarica 68(2): 265-268.
- Demir S, Karakişi H (2014) Metazoan Parasites of Nase (*Chondrostoma nasus* L., 1758) from Tahtalı Dam Lake (Izmir Province, Turkey). Biharean Biologist 8(2): 95-97.
- Gibson DI, Jones A, Bray RA (2002) Keys to the Trematoda. Volume 1. CAB. International and Natural History Museum, Wallingford/London, 521 pp.
- Gussev AV, Poddubnaya AV, Abdeeva VV (1987) Key to parasites of the freshwater fishes of the USSR. Fauna, cilt 3, (ed. By ON Bauer) Publ. House Nauka, Leningrad.
- Gussev AV (1985) Monogenea in: Key to parasites of the freshwater fishes of the USSR. Fauna, cilt 2, (ed. By ON Bauer) Publ. House Nauka, Leningrad.
- Hoffman GL (1999) Parasites of North American Freshwater fishes. Comstock Publishing Associates a division of Cornell University Press Ithaca and London, 1- 527pp. inverse intensity evolution between Myxosporidia and Monogenea as a function of the host age. Rev. Elev. Med. Vet. Pays. Trop 57:71-76.
- Innal D, Özdemir F, Stavrescu-Bedivan MM, Ozmen O, Öztürk MO (2020) Occurrence of black spot disease induced by *Posthodiplostomum cuticola* (Nordmann, 1832) (Digenea: Diplostomatidae) in endemic and native fish of Turkey: seven new host records. Journal of the Hellenic Veterinary Medical Society 71(2): 2120-2126.
- Innal D, Stavrescu-Bedivan M, Öztürk MO, Özmen Ö (2020) First record of *Contracaecum rudolphii* Hartwich, 1964 in *Carassius gibelio* (Bloch, 1782) from Turkey. Aquatic Sciences and Engineering 35(1):1-5.
- Innal D, Yıldırım M, Stavrescu -Bediva M, Güçlü SS, Ünal MC, Dogangil B, Özmen Ö (2019) Occurrence and infection dynamics of *Salsuginus* sp. (Monogenea, Ancyrocephalidae) and *Eustrongylides excisus* (Nematoda, Dioctophymatidae) in four endemic *Aphanius* (Cyprinodontidae) species: new host records for Turkish fauna. Acta Biologica Turcica 32(2): 103-109.
- Karakisi H, Demir S (2012) Metazoan parasites of the common carp (*Cyprinus carpio* L., 1758) from Tahtalı Dam Lake (Izmir). Türkiye Parazitoloji Dergisi 36(3): 174.
- Karatoy E, Soyul E (2006) Metazoan parasites of bream (*Abramis brama* Linnaeus, 1758) in Lake Durusu (Terkos). Türkiye parazitoloji dergisi 30(3): 233-238.
- Khalil LF, Jones A, Bray RA (1994) Keys to the Cestode Parasites of Vertebrates. CAB International, p 1- 750.
- Khotenovsky IA (1985) Fauna of the USSR. Monogenea. Suborder Ocotomacrinea Khotenovsky. New Series No. 132. Nauka, Leningrad, 262 pp (in Russian).
- Koyun M, Altunel FN (2007) Metazoan parasites of bleak (*Alburnus alburnus*), crucian carp (*Carassius carassius*) and golden carp (*Carassius auratus*) in Enne Dam Lake, Turkey. International Journal of Zoological Research 3: 94-100. DOI: 10.3923/İJZR. 2007.94.100.
- Koyun M, Ulupınar M, Gül A (2015) Seasonal Distribution of Metazoan Parasites on Kura Barbell (*Barbus lacerta*) in Eastern Anatolia, Turkey. Pakistan J. Zool. 47(5): 1253-1261.
- Kumar S, Stecher G, Li M, Knyaz C, Tamura K. MEGA X (2018) Molecular evolutionary genetics analysis across computing platforms. Mol Biol Evol. 35:1547-9. doi: 10.1093/molbev/msy096
- Malmberg G (1957) Om forekomsten av *Gyrodactylus* pa Svenska fiskar. Sartryk ur Skr utgivna Sodra Sveriges Fisk Arsskr 19-76.
- Markevic AP (1951) Parasitic fauna of freshwater of the fish of the Ukrainian S.S. R.", trans by Rofael N. Kudus 157: 224 pp.
- Mattiucci S, Paoletti M, Webb SC, Sardella N, Timi JT, Berland B, Nascetti G (2008) Genetic relationships among species of *Contracaecum* Railliet & Henry, 1912 and *Phocascaris* Host, 1932 (Nematoda: Anisakidae) from pinnipeds based on mitochondrial *cox2* sequences, and congruence with allozyme data. Parasite 15:408-419.
- Metin S, Didinen Bİ, Boyacı YO, Kubilay A, Emre N, Didinen H, Emre Y (2014) *Eustrongylides excisus* Jägerskiöld, 1909 larvalarının (Nematoda: Dioctophymatidae) Eğirdir Gölü Pikeperç'te (*Sander lucioperca*, L.) bulunması. Süleyman Demirel Üniversitesi Eğirdir Su Ürünleri Fakültesi Dergisi 10 (1): 20-24.
- Moravec F (1994) Parasitic nematodes of freshwater fishes of Europe. Kluwer Academic Publishers, Dordrecht, Boston, London.
- Morgulis A, Coulouris G, Raytselis Y, Madden TL, Agarwala R, Schaffer AA (2008) Database indexing for production MegaBLAST searches. Bioinformatics. 24:1757-64. doi: 10.1093/bioinformatics/btn322
- Ozturk MO, Aydogdu A, Dogan I (2002) The occurrence of helminth fauna in sand goby (*Gobius fluviatilis*, Pallas, 1811) from lake Uluabat, Turkey. Acta veterinaria 52(5-6): 381-391.
- Öge H, Sarimehmetoglu HO (1996) The Metacercaria of *Clinostomum complanatum* (Rudolphi, 1819) in *Barbus plebejus escherichii* (Steindachner, 1897) and *Capoeta tinca* (Heckel, 1843), The Turkish Journal of Parasitology 20 (3-4), 429-437.
- Özer A (2021) Checklist of Marine, Freshwater, and Aquarium Fish Parasites in Turkey. Turkish Marine Research Foundation (TUDAV) Publication No: 62, Istanbul, Turkey 311 p.
- Öztürk MO, Oğuz MC, Altunel FN (2001) Manyas Gölündeki Kaya Balıkları (*Gobius fluviatilis* L.)'nin metazoan parazitleri üzerine bir araştırma ve Türkiye helminth faunası için iki yeni kayıt. Türkiye Parazitoloji Dergisi 25(1): 88-93. (in Turkish with English abstract).
- Öztürk MO (2005) Helminth fauna of two Cyprinid fish species (*Chalcaburnus chalcoides* Guldenstad 1972, *Rutilus rutilus* L.) From Lake Uluabat, Turkey. Hacettepe Journal of Biology and Chemistry 34, 77-91.
- Selver M, Aydoğdu A, Çırak VY (2009) Helminth communities of the roach (*Rutilus rutilus*) from Kocadere stream in Bursa, Turkey: occurrence, intensity, seasonality and their infestations linked to host fish size. Bull. Eur. Ass. Fish Pathol 29(4):131.
- Simsek E, Yildirim A, Yılmaz E, İnci A, Düzlü O, Onder Z, Ciloglu A, Yetişmiş G, Pekmezci GZ (2018) Occurrence and Molecular Characterization of *Clinostomum complanatum* (Trematoda: Clinostomidae) in Freshwater Fishes Caught From Turkey. Parasitology Research 117:2117-2124.

- Soylu E (2005) Metazoan Parasites of Catfish (*Silurus glanis*, Linnaeus, 1758) from Durusu (Terkos) Lake. *Journal of the Black Sea/Mediterranean Environment* 11: 225-237.
- Soylu E (2014) Metazoan parasites of fish species from Lake Gala (Edirne, Turkey). *Ege J. Fish. Aqua. Sci.* 31(4): 187-193.
- Soylu E (2013) Metazoan Parasites of *Perch percafluviatilis* L. From Lake Sığircı, Ipsala, Turkey. *Pakistan J. Zool.* 45 (1): 47-52.
- Soylu E (2009) Monogenean Parasites on the Gills of Some Fish Species from Lakes Sapanca and Durusu, Turkey. *Ege Journal of Fisheries and Aquatic Sciences* 26(4): 247-251.
- Soylu E (1991) Sapanca Gölü'nde bazı balıklarda görülen Monogenean' lar. *İstanbul Üniversitesi Deniz Bilimleri ve Coğrafya Enstitüsü Bülteni* 8: 145- 156. (in Turkish with English abstract)
- Tekin-Özan S, Kir I (2005) An investigation of parasites of goldfish (*Carassius carassius* L., 1758) in Kovada Lake. *Türkiye parazitolojii dergisi* 29(3): 202-203. (in Turkish with English abstract)
- Turgut E (2005) Niksar ve Almus Civarındaki Balık Çiftlikleri ile Doğal Ortamdaki Balık Parazitlerinin Su Kalitesi ve Mevsimlere Bağlı Olarak Değişimi, Araştırma Projesi, Gaziosmanpaşa Üniversitesi, Almus Meslek Yüksekokulu, Tokat.
- Yamaguti S (1985a) *Systema Helminthum*. Vol. I, 'The Digenetic Trematodes of Vertebrates - Part I. New Delhi, India: International Book & Periodicals Supply Service 1-371 pp.
- Yamaguti S (1985b) *Systema Helminthum*. Vol. II. The Cestodes of Vertebrates. New Delhi, India: International Book & Periodicals Supply Service 1-449pp
- Yamaguti S (1985c) *Systema Helminthum*. Vol. III, The Nematodes of Vertebrates - Part I. New York: Interscience Publishers, INC. 250 Fifty Avenue 1-81pp.
- Yamaguti S (1985d) *Systema Helminthum*. Vol. IV, Monogenea and Apisdocotylea. New Delhi, India: International Book & Periodicals Supply Service 1- 699 pp.
- Yardımcı RE, Ürkü Ç, Yardımcı CH (2018) Büyükçekmece Havzası Balıklarının Parazit Faunası Üzerine Bir Ön Araştırma. *Erzincan Üniversitesi Fen Bilim Enstitüsü Derg* 11: 158- 167. doi: 10.18185/erzifbed.410806.