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# HEALTH PROFILE OF SOME FRESHWATER FISHES COLLECTED FROM DANUBE RIVER SECTOR (KM 169-197) IN RELATION TO WATER QUALITY INDICATORS

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***Abstract***

*Evaluating the fish parasitic fauna should constitute a major concern, especially in the climate change context because the parasites have a significant impact both on the natural fish population and the farm yield, economic viability, or sustainability. In this context, this study aimed to present the influence of water quality parameters upon the distribution and variety of parasites of 14 freshwater species, belonging to 5 systematic families: Cyprinidae, Percidae, Siluridae, Clupeidae, Esocidae. Parasitofauna analyses were performed through classic methods and the results were expressed as the prevalence of parasitic fauna and their intensity grades. Although the experimental groups have a similar environment, they present a distinct parasitofauna which shows a strong influence of the environmental factors upon its development. Adequate knowledge and periodic monitoring of the prevalence of parasites on the fish populations can have multiple implications and can be used as an indicator of anthropogenic impacts on other aquatic environments.*

***Key words****: ectoparasites, endoparasites, water's physical-chemical factors, wild fish.*

## INTRODUCTION

The Danube River covers a large hydrographical basin, being the second biggest river in Europe which passes over seven European countries.

A significant part of the lower sector flows either close by or into Romanian territory where it forms a large delta before getting to the Black Sea. Even though the Danube present both ecological and economical importance, providing a valuable habitat for numerous species, various aspects need a profound insight.

The functional integrity of riverine ecosystems and the sustainable management of their natural resources are frequently threatened, especially in heavily polluted areas that are subjected to numerous anthropogenic impacts (Zaharieva et al., 2021).

Diminishing the effect of pollution on organisms and ecosystems constitute nowadays one of the key topics to improve the quality of life in developed countries. Induced changes in aquatic ecosystems as a consequence of human activity and its influence on organisms can have important effects on the abundance and quality of natural resources and therefore on the economic development since they can alter both biodiversity and the functioning of ecosystems and their carrying capacity (Chunchukova et al., 2020; Mocanu et al., 2021).

Knowledge of species composition changes at different time scales is crucial for understanding the dynamics of riverine communities (Sinclair & Byron, 2006). Due to the lack of a previous historic data baseline on ecosystems functioning, try-outs to evaluate human impact on the ecosystems are often extremely difficult to be successfully applied.

An environmental factor in the riverine ecosystems, which can bring a large amount of important information, is represented by the study of diseases. Illnesses/infections play an important role in the evolution of fish populations, especially commercial ones (Miller et al., 2014).

A disease state is defined as a complex of manifestations found in different relationships with one or more pathogens, from the moment of contact with the host until the disappearance of the consequences (Casadevall et al., 2000).

The manifestation of the disease in a population is generally established after the state of stress, which reduces the resistance of organisms and promotes the onset of infectious, parasitic, or other diseases (Bagge et al., 2004).

Environmental disturbance can have a positive, negative, or neutral effect on the fish and also on their parasites, depending on the type of ecological factor fluctuation and parasite taxa (Sures, 2006, 2008).

A regular parasite phase may incorporate the fish definitive host and several intermediate invertebrate hosts and for the parasite to survive all hosts must co-occur in a stable population structure. Changes in environmental conditions that affect any of the hosts, directly and indirectly, will have a significant effect on the prevalence and intensity of the infection, and on the diversity of parasites that infect the fish (Hudson et al., 2006; Lafferty et al., 2008). In this sense, parasite communities of fish have been used as comprehensive marks of ecosystem health, parasites being also used as a source of information that can provide data about fish stock separation, fish recruitment migrations, fish diet, or fish behavior, in relation to environmental pollution (D'Amelio & Gerasi, 1997; Overstreet, 1997; Marcogliese, 2003). That is why, for a complete fish health profile a report of the hydrochemical parameters (e.g. temperature, salinity, nutrient and oxygen concentrations should be given (Araújo et al., 1999; Marshall and Elliott, 1998; Snigirov et al., 2012; Thiel et al., 1995).

Therefore, in our study, we aimed to analyze the structure of fish's parasitofauna, from the Danube - Brăila region as a health profile tool, in relation to the environmental factors affecting their habitat.

## MATERIALS AND METHODS

Our research was conducted during the three seasons along the year: spring (April-May), summer (June-August), autumn (September-November) in 2021, on the Danube River sector (Brăila station) (Figure 1). The sampling sites were randomly taken within the 169-197 km of the river and the fishing activity was carried out with the help of a fishing net wall. Seasonally there were randomly selected between 15-30 samples from each species for ichtyopatological analysis. During the entire activity, there were collected water samples and diverse specimens belonging to 14 fish species: *Abramis brama* (Linnaeus, 1758), *Alosa immaculata* (Bennett,1835), *Aspius aspius* (Linnaeus, 1758), *Barbus barbus* (Linnaeus, 1758), *Carassius auratus gibelio* (Bloch, 1782), *Cyprinus carpio* (Linnaeus, 1758), *Esox lucius* (Linnaeus, 1758), *Hypophthalmichthys molitrix* (Valenciennes, 1844), *Perca fluviatilis* (Linnaeus, 1758), *Rutilus rutilus* (Linnaeus, 1758), *Sander lucioperca* (Linnaeus, 1758), *Scardinius erythrophtamus* (Linnaeus, 1758), *Silurus glanis* (Linnaeus, 1758), *Vimba vimba* (Linnaeus, 1758) (Table 1). After catching, the fish were immediately frozen at -20°C and transported to the Institute of Research and Development for Aquatic Ecology, Fishing and Aquaculture Galați where examinations were completed. After the standard measurements (total length – TL, body weight – BW) each fish was analyzed for endo- and ectoparasites. According to the parasite category, each fish was consequently dissected and analyzed for parasites using standard parasitological techniques (Docan et al., 2021). The gills, skin, eyes, intestine, muscle and liver were examined using a Zeiss microscope. Further, parasites were taxonomically classified using identification keys (Bauer, 1987; Dykova, 1989; Lom & Moravec, 1994; Munteanu & Bogatu 2003). Morphological parameters of all collected fishes are shown in Table 1. The parasitic infection was described in terms of prevalence (number of infected hosts/number of examined hosts, as a percentage) and mean intensity (total number of parasites/number of infected hosts). The water quality parameters were analyzed in the laboratory except for the temperature (which was measured on the field with a portable multiparameter). The obtained values were reported at the Order of the Ministry of Environment and Waters Management 161/2006 about surface water quality classification to establish water body ecological status.

*Statistical analysis*. Data were analyzed using SPSS program version 21. One-way ANOVA and Duncan's multiple range tests were used to compare the differences between the experimental groups (p=0.05). If differences among seasons were recorded, a Duncan test was performed. A p-value lower than 0.05 was considered statistically significant.


Figure.1. Fishing area – Brăila region (169 and 197 km)

Table 1. Morphological parameters of the examined fish

| Fish species | Body mass (g) | | Total length (cm) | |
|---|---|---|---|---|
| | Average±S.D. | Body range | Average±S.D. | Body range |
| *Abramis brama* | 358.16±85.53 | 201-515 | 30.43±3.05 | 23.2-34.6 |
| *Alosa immaculata* | 259.63±49.31 | 170-350 | 31.11±2.09 | 26-35 |
| *Aspius aspius* | 2040±850.61 | 1100-2770 | 59±7.39 | 50-68 |
| *Barbus barbus* | 937.37±308.84 | 475-1685 | 44.38±4.15 | 38-52.5 |
| *Carasus auratus gibelio* | 809.3±613.86 | 200-3200 | 34.11±9.33 | 21.6-60 |
| *Cyprinus carpio* | 1962.6±923.02 | 215-5250 | 50.57±7.92 | 28.2-72 |
| *Esox lucius* | 870±346.41 | 320-1430 | 48.6±6.69 | 37-61 |
| *H. molitrix* | 4382.5±2233.8 | 2400-6430 | 66.75±10.88 | 57-78.5 |
| *Perca fluviatilis* | 333.3±158.41 | 115-630 | 26.3±3.94 | 20-33 |
| *Rutilus rutilus* | 3567.5±3739.97 | 175-8300 | 25.1±1.39 | 22.6-27.5 |
| *Sander lucioperca* | 1241.67±452.79 | 235-2373 | 49.37±5.88 | 32.2-60.5 |
| *S. erythrophthamus* | 225.56±58.48 | 142-360 | 24.78±9.8 | 21.3-28.5 |
| *Silurus glanis* | 1935.63±1056.6 | 835-5780 | 64.5±10.43 | 35-90 |
| *Vimba vimba* | 342.68±67.64 | 155-490 | 30.98±1.68 | 29.5-37 |

## RESULTS AND DISCUSSIONS

*Water analysis*

The Danube River is a fluctuating aquatic ecosystem, that is why for high accuracy of physicochemical characterization, the water samples were collected every month being analyzed using the same laboratory methods.

The mean values (per season) of the analyzed parameters are summarized in Table 2.

With few exceptions, the majority of the parameters place the water quality into II - III classes of the Order no. 161/2006 emitted by the Ministry of Environment and Water Management regarding the classification of surface water quality. Generally, the reaction of the water was favorable for the living aquatic organisms and primarily fish. The values recorded for pH were constantly high during all seasons, slightly exceeding the recommended range for fish life (i.e. 6,4-8,5 upH).

The values recorded for pH did not show major oscillations which proves a relatively constant composition of water over time. The organic substances detected during the autumn season exceeded the maximum allowed limits, according to the literature (i.e. 30-55 mg $KMnO_4$/l) (Roccaro et al., 2007). Being an active aquatic ecosystem, these variations of organic substances are normal, being subjected to a complex of biotic and abiotic factors. Regarding the phosphates, the obtained values from all the samples surpass the detection limit. The statistical analysis applied to all parameters revealed different trends.

Table 2. Synthetic table with the average values of the main physicochemical parameters of water

| Water parameters | U.M. | Spring | | Summer | | Autumn | |
|---|---|---|---|---|---|---|---|
| | | Mean | ±S.D. | Mean | ±S.D. | Mean | ±S.D. |
| Temperature | ºC | 13.81 | 4.49 | 24.79 | 3.79 | 17.83 | 4.71 |
| pH | upH | 8.49 | 0.22 | 8.65 | 0.38 | 8.85 | 0.15 |
| Organic matter | mg $KMnO_4$/l | 26.23 | 1.87 | 34.74 | 10.81 | 59.45 | 9.32 |
| Chemical oxygen consumption | mg $O_2$/l | 6.63 | 0.48 | 8.79 | 2.74 | 13.51 | 4.52 |
| Calcium ($Ca^{2+}$) | mg/l | 56.11 | 17.01 | 58.78 | 8.34 | 57.62 | 3.54 |
| Magnesium ($Mg^{2+}$) | mg/l | 26.73 | 13.75 | 12.96 | 1.40 | 20.38 | 11.63 |
| Water hardness | ºD | 14.02 | 0.79 | 10.84 | 0.87 | 15.43 | 5.95 |
| Nitrites ($NO_2^-$) | mg/l | 0.015 | 0.01 | 0.030 | 0.013 | 0.02 | 0.01 |
| Nitrates ($NO^-_3$) | mg/l | 1.83 | 0.18 | 1.64 | 0.18 | 1.25 | 0.29 |
| Chlorides ($Cl^-$) | mg/l | 20.74 | 6.77 | 10.99 | 1.62 | 11.17 | 2.26 |
| Ammonium ($NH_4^+$) | mg/l | 0.09 | 0.11 | 2.19 | 0.21 | 0.15 | 0.10 |
| Ammonia ($NH_3^-$) | mg/l | 0.11 | 0.03 | 0.16 | 0.01 | 0.03 | 0.01 |
| Phosphates (P-$PO_4$) | mg/l | > detection limit | | | | | |

To measure specific differences between pairs of values, Duncan post-hoc test was applied (p=0.05). The results varied, as follows: temperatures were separated into three distinct groups, organic matter was separated into two groups - spring-summer and autumn, chemical oxygen consumption varied significantly among all seasons (three groups), magnesium ions were divided into 2 groups – spring and summer-autumn, water hardness and nitrites displayed the same pattern (spring-autumn group and summer group), nitrates were lower in the autumn than in the spring and summer, chlorides were higher in the spring than the other two seasons, the ammonium was lower in the spring and autumn versus summer and the ammonia was higher in the autumn than in the rest of the year.

*Fish*

The aim of this study was the investigation the parasitofauna of the fish community as a reflection of the health profile. The fish are part of the commercial species, being caught in 2021 from the Danube river, in the Brăila sector. The majority of species are Cyprinids, followed by Percids, Clupeids, Esocids and Silurids with important economic values.

Parasitological examination of the fish species from the Danube River (Brăila), showed the presence of twelve species of parasites: one specie from the Ciliates group - *Trichodina* spp., four parasite species of class Monogenea - *Dactylogyrus vastator* (Nybelin, 1924), *Diplozoon paradoxus* (Nordmann, 1832), *Gyrodactylus* sp., *Mazocraes alosae* (Hermann, 1782), two parasite species of class Trematoda: *Diplostomum spathaceum* (Rudolphi, 1819) and *Neascus cuticola* (von Nordmann, 1832) Hughes, 1927, three species of class Nematoda - *Contracaecum aduncum* (Rudolphi, 1802), *Eustrongylides excisus* (Jägerskiöld, 1909) and *Hepaticola* sp., one parasite species of class Acanthocephala: *Pomphorhynchus laevis* (Zoega in Müller, 1776) and one parasite species of class Cestoda: *Ligula intestinalis* (Linnaeus, 1758) (Tables 3, 4). Regarding the infection with Trichodina spp. there was found a seasonal variability at the prevalence and mean intensity parameters (Duncan post-hoc test, $p<0.05$), with higher values during the colder seasons (spring and autumn). Our results align with our studies which states that trichodiniasis infection is more frequent at low temperatures, being favored by the accumulation of organic matter and mal-nutrition or poorly developed fish (Rumokoy et al., 2018). The freshwater ecosystem of the Danube River displays a significantly larger number of taxa in the parasite communities, especially worms (Kirin et al., 2013, Munteanu & Bogatu, 2008). Fluctuation of the monogeneans had different patterns between the seasons (Table 3). The most frequent are monogeneans which are either oviparous or viviparous with a single host, spreading being uninterrupted (Munteanu & Bogatu, 2008).

Table 3. Prevalence and intensity of fish's parasites from the Danube River, Brăila station

| Systematic group | Parasite | Host | Site | Seasons | N | P (%) | MI |
|---|---|---|---|---|---|---|---|
| Protozoa/Ciliata | *Trichodina* sp. | *Carasus auratus gibelio* | G | Spring | 30 | 53.57 | 13.67 |
| | | | | Summer | 28 | 33.33 | 10.77 |
| | | | | Autumn | 27 | 36.67 | 11.13 |
| | | *Sander lucioperca* | G | Spring | 17 | 47.06 | 6.35 |
| | | | | Summer | 24 | 38.18 | 12 |
| | | | | Autumn | 21 | 54.17 | 10.33 |
| | | *Rutilus rutilus* | G | Spring | 26 | 50 | 8.76 |
| | | | | Summer | 23 | 43.43 | 8.63 |
| | | | | Autumn | 28 | 47.83 | 7.15 |
| Monogenea | *Dactylogirus vastator* | *Carasus auratus gibelio* | G | Spring | 30 | 33.33 | 9.12 |
| | | | | Summer | 28 | 53.57 | 9.25 |
| | | | | Autumn | 27 | 51.85 | 10 |
| | | *Cyprinus carpio* | G | Spring | 29 | 37.93 | 8 |
| | | | | Summer | 30 | 56.67 | 6.5 |
| | | | | Autumn | 30 | 46.67 | 5.25 |
| | | *Abramis brama* | G | Spring | 30 | 43.33 | 5.66 |
| | | | | Summer | 28 | 57.14 | 6.75 |
| | | | | Autumn | 30 | 50 | 5.5 |
| | *Diplozoon paradoxus* | *Abramis brama* | G | Spring | 30 | 50 | 7.6 |
| | | | | Summer | 28 | 50 | 5.9 |
| | | | | Autumn | 30 | 36.67 | 4.53 |
| | | *Rutilus rutilus* | G | Spring | 26 | 53.85 | 3.99 |
| | | | | Summer | 23 | 56.52 | 4.87 |
| | | | | Autumn | 28 | 57.14 | 9.25 |
| | | *Scardinius erythrophthamus* | G | Spring | 25 | 32 | 14.3 |
| | | | | Summer | 22 | 45.45 | 8.8 |
| | | | | Autumn | 27 | 33.33 | 6.5 |
| | *Gyrodactylus* sp. | *Vimba vimba* | G | Spring | 23 | 47,62 | 4.75 |
| | | | | Summer | 27 | 65.22 | 5.25 |
| | | | | Autumn | 21 | 48.15 | 4.66 |
| | | *Cyprinus carpio* | G | Spring | 29 | 40 | 4.8 |
| | | | | Summer | 30 | 55.17 | 8,25 |
| | | | | Autumn | 30 | 46.67 | 6,12 |
| | *Mazocraes alosae* | *Alosa immaculata* | G | Spring | 15 | 53.33 | 10.3 |
| | | | | Summer | 23 | 65.22 | 13.1 |
| | | | | Autumn | 15 | 46.67 | 11.2 |
| Acantocephala | *Pomphorhynchus laevis* | *Silurus glanis* | I | Spring | 18 | 44.44 | 5,3 |
| | | | | Summer | 24 | 46,3 | 6 |
| | | | | Autumn | 15 | 46.67 | 4,7 |
| | | *Barbus barbus* | I | Spring | 19 | 42.11 | 6.21 |
| | | | | Summer | 23 | 47.83 | 7.72 |
| | | | | Autumn | 27 | 33.33 | 5.25 |

*G = gills, I = intestine, N = total number of examined fish specimens, P% = prevalence, MI = mean intensity*

Investigates on the helminth community revealed 11 species during all the seasons.

*Dactylogirus vastator* was found on gills of common carp (*Cyprinus carpio*), Prussian carp (*Carasus auratus gibelio*) and common bream (*Abramis brama*). The number of parasitic specimens was situated between 4-15 per examined fish. Statistical analysis showed significant differences between the prevalence and mean intensity found in the spring season and summer-autumn seasons (ANOVA, $p<0.05$), the incidence of the virus being temperature-dependant.

Infection with *Diplozoon paradoxus* was found throughout the year in the Cyprinids group, and the prevalence of infection varied, ranging from 32% (found in spring) to around 57%, calculated during the autumn seasons. *Gyrodactylus* monogeneans are viviparous, possessing no specific transmission stage or swimming ability (Chunchukova et al., 2020; Soleng et al., 1999).

Table 4. Prevalence and intensity of fish's parasites from the Danube River, Brăila station

| Systematic group | Parasite | Host | Site | Seasons | N | P (%) | MI |
|---|---|---|---|---|---|---|---|
| Trematoda | *Diplostomum spathaceum* | *Rutilus rutilus* | E | Spring | 26 | 46.15 | 7.3 |
| | | | | Summer | 23 | 52.17 | 4.67 |
| | | | | Autumn | 28 | 42.86 | 5.5 |
| | | *Hypophthalmychtis molitrix* | E | Spring | 29 | 48.28 | 6.33 |
| | | | | Summer | 30 | 53.33 | 6.4 |
| | | | | Autumn | 30 | 56.67 | 6.75 |
| | *Neascus cuticola* | *Rutilus rutilus* | S | Spring | 26 | 61.54 | 7 |
| | | | | Summer | 23 | 63.91 | 5.5 |
| | | | | Autumn | 28 | 64.29 | 5.13 |
| Nematoda | *Hepaticola* sp. | *Cyprinus carpio* | L | Spring | 29 | 51.72 | 5.45 |
| | | | | Summer | 30 | 50 | 4.25 |
| | | | | Autumn | 30 | 53.33 | 4.67 |
| | | *Abramis brama* | L | Spring | 30 | 52.33 | 5.8 |
| | | | | Summer | 28 | 50 | 7.14 |
| | | | | Autumn | 30 | 43.33 | 4.67 |
| | | *Vimba vimba* | L | Spring | 23 | 65.22 | 5.52 |
| | | | | Summer | 27 | 51.85 | 6.65 |
| | | | | Autumn | 21 | 61.9 | 7.44 |
| | *Contracaecum aduncum* | *Alosa immaculata* | I | Spring | 15 | 33.33 | 7.44 |
| | | | | Summer | 23 | 39.13 | 6.98 |
| | | | | Autumn | 15 | 46.67 | 7.67 |
| | *Eustrongylides excisus* | *Perca fluviatilis* | M | Spring | 16 | 37.5 | 6.98 |
| | | | | Summer | 17 | 41.18 | 8.14 |
| | | | | Autumn | 23 | 47.83 | 7.21 |
| | | *Sander lucioperca* | M | Spring | 17 | 52.94 | 6.98 |
| | | | | Summer | 24 | 41.67 | 7.67 |
| | | | | Autumn | 21 | 42.86 | 7.91 |
| | | *Silurus glanis* | M | Spring | 18 | 33.33 | 8.14 |
| | | | | Summer | 24 | 45.83 | 7.21 |
| | | | | Autumn | 15 | 46.67 | 6.74 |
| | | *Esox lucius* | M | Spring | 15 | 40.2 | 6.98 |
| | | | | Summer | 16 | 35.71 | 7.44 |
| | | | | Autumn | 20 | 55.42 | 7.44 |
| | | *Aspius aspius* | M | Spring | 28 | 39.29 | 7.44 |
| | | | | Summer | 26 | 46.15 | 6.98 |
| | | | | Autumn | 29 | 44.83 | 7.67 |
| Cestoda | *Ligula intestinalis* | *Cyprinus carpio* | I | Spring | 29 | 40.27 | 7.21 |
| | | | | Summer | 30 | 43.33 | 6.65 |
| | | | | Autumn | 30 | 41.27 | 7.12 |
| | | *Rutilus rutilus* | I | Spring | 26 | 41.69 | 7.69 |
| | | | | Summer | 23 | 43.52 | 7.46 |
| | | | | Autumn | 28 | 42.1 | 7.39 |

*E= eyes, S= skin, L= liver, I= intestine, M = muscle, N = total number of examined fish specimens, P% = prevalence, MI = mean intensity*

There was observed a clear variance in the transmission proportion between the three seasons, positively correlated with temperature. At an average temperature of 15°C (registered in the spring and autumn), the prevalence and mean intensity of parasites varied between 25-50%, respectively 2-9 parasites/fish, statistically different than the calculated parameters for the summertime, mean temperature 24,79±3,79°C (50-65% prevalence, 3-12 parasites/fish). (Duncan, post-hoc analysis, $p<0.05$). The findings correlate with other studies which state that the intensifying water temperature increases the rate of transmission of *Gyrodactylus* species (Bakke et al., 1991; Bakke et al., 1992; Soleng et al., 1999).

In the case of the last detected monogenean, *Mazocraes alosae* it can be observed the same pattern among the examined fish samples. During the summer, the infection increases substantially compared with the other two seasons. Nevertheless, *Mazocraes alosae* can also be attained earlier, in spring, when about 30–60% of them have eggs, and later through autumn (September–November).

Identified *Pomphorhynchus laevis* parasite didn't have a similar trend in the two examined hosts, *Silurus glanis* and *Barbus barbus*. The mean intensity obtained on both species in autumn was found to be significantly lower compared to summer and spring indices, the calculated data suggesting that the parasite populations in autumn consist mainly of young preadult individuals. On the other hand, the prevalence was similar for the wells catfish during all three seasons (Duncan post-hoc test, $p>0.05$), while the common barbel had a lower prevalence during the autumn, compared to spring-summer seasons (Duncan post-hoc test, $p<0.05$).

The Cestoda parasite, *Ligula intestinalis*, was found only on the Cyprinids species, *Cyprinus carpio* and *Rutilus rutilus*. *Ligula intestinalis* is a widely distributed cestode species with a complex life cycle, which involves a copepod as the first intermediate host, fish as a second intermediate host and an avian definitive host (Chunchukova et al., 2019; Dubinina, 1980).

Prevalence was lowest in spring, slightly increasing in summer, whereas mean intensity was marked by spring peaks (7.21 and 7.69 respectively), in both species. However, there were no substantial seasonal changes for any of the parameters.

Trematoda worms were observed with prevalence indices (P%) situated between 40-60% and mean intensity, MI=49.91±0.94 for *Diplostomum spathaceum* and MI=63.5±1.5 for *Neascus cuticola*. Both detected trematodes have birds as intermediate hosts, which, together with the excrements, discard huge quantities of eggs in the water (Chunchukova et al., 2020).

In the current study, the nematodes were represented by *Hepaticola* species, *Contracaecum aduncum* and *Eustrongylides excisus*. Fish's nematodes development cycle is closely related to aquatic invertebrates groups, therefore their developmental cycles are very different.

Invertebrates play-acting as intermediate hosts, and fish as intermediate, accumulating, or definitive hosts (Kuzmanova et al., 2019). Nematodes are found in freshwater fish under scales, in the digestive tract, or other organs and tissues (Zaharieva et al., 2021).

*Eustrongylides excisus* was a core parasite, being found on five fish species. Its pattern was different among species, statistical analysis highlighting a lower prevalence during the spring, among the following species: *Perca fluviatilis*, *Silurus glanis* and *Aspius aspius* (Duncan post hoc test, $p<0.05$), and during the summer, on the *Sander lucioperca* and *Esox lucius* (Duncan post hoc test, $p<0.05$). *Hepaticola* sp., which were also a core species in the nematode community registered a lower prevalence during the summer (on *Cyprinus carpio* and *Vimba vimba* species) and autumn (*Abramis brama*) with mean intensities situated between 2 and 14 parasites/fish.

The *Contracaecum aduncum* was only found on *Alosa immaculata* with a significantly different prevalence (Duncan post hoc test, $p<0.05$), calculated between seasons. Also, the mean intensity varied between studied exemplars, with parasites ranging from 4 to 12 per fish.

Following the study, the best-represented class is that of Monogeans, with four species of parasites identified during all seasons.

Our results suggest that there is a significant fluctuation of the parasite's fauna among the seasons (Figure 2 a-j), demonstrating the importance of water temperature, as the main factor that draws major changes in the chemical composition of the water, as previously observed by Özer et al. (2004) and Kennedy (2006).

For example, researches conducted on the seasonal incidence of *Gyrodactylus* species show that there is a strict influence of temperature on the prevalence and intensity of infestations which generates a definite seasonal cycle of the parasites (Bakke et al., 1992; Jansen & Bakke, 1991; Mo, 1992; Özer et al., 2004). A significant number of studies have suggested that the prevalence and intensity of monogeneans are seriously influenced by the developmental stage of the fishes, as hosts (Khidr et al., 2012; Özer et al., 2004, 2015; Sailaja et al., 2017). Bakke et al. (1992) state that the role of drifting of detached larval stages of the parasites in the water column depends on a sum of factors. Some parasites separate from their hosts by accident, by active migration, or as a result of a host response (Özer et al., 2004; Scott & Nokes, 1984) and higher temperatures are forcing out accidental dislodgement during transmission (Harris, 1994).


Figures 2 a-j. Parasites found in the Danube River fishes, Brăila region

Seasonal transmission rates were reported for numerous aquatic parasites, with climate conditions playing a major role (Moravec & Scholz, 1994; Nachev et al., 2016). Moravec & Scholz (1994) and Nachev et al. (2016) observed seasonality in the occurrence and maturation of some acanthocephalans detected in barbel, the main conclusions being in accordance with our results.

Some parasites species display a maximum prevalence in spring (Benovics et al., 2018), summer (Wrona et al., 2006), or during the cold seasons (Sultana et al., 1994), being related to fish's activity and thermal's limits. Some fish's activity differs strongly in terms of water temperature, as it decreases progressively with the decrease of water temperature until reaching their thermal limit for activity at a certain temperature (dormancy phase) (Baras, 1995). Consequently, the diminished fish activity and adjusted feeding behavior probably conduct to a diminished infection during colder months, as the final host ceases feeding on intermediate hosts (Kennedy, 2006; Molloy et al., 1995). With increasing temperatures, the fishes start feeding again, but an increase in new parasite infection occurs in late summer when more infected intermediate hosts are available (Finlay et al., 2021).

The presence of parasites can provide information about the state of the environment: the ciliates and nematodes should be sensitive indicators of eutrophication and thermal effluent, while digeneans and acanthocephalans should make good indicators of heavy metals and human disturbances (Docan et al., 2021; Lafferty et al., 2008).

## CONCLUSIONS

Our results provide information about a particular parasite's population upon the fish, as hosts, adding important information regarding their incidence and prevalence. Depending on the parasite's systematic group, the calculated indices displayed a different pattern, showing an affinity for a specific host or organ, signifying that both ecto- and endoparasites are linked to their hosts along with their ecosystem. In this study, the parasites do not seem to affect the health status of their hosts. However, further research is needed, studies that cover larger areas from the species habitats, in order to obtain a parasites full scale seasonal variations table. Also, there is a need for data regarding updated parasites reproductive cycles, their spreading and development and relationship with their hosts.

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