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THE ROLE OF BIOTIC AND ABIOTIC FACTORS IN PREVALENCE OF CYPRINIDAE FISHES AND TROUT PARASITES IN THE FISH FARMS OF AZERBAIJAN

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РОЛЬ БИОТИЧЕСКИХ И АБИОТИЧЕСКИХ ФАКТОРОВ В РАСПРОСТРАНЕНИИ ПАРАЗИТОВ КАРПОВЫХ И ФОРЕЛИ В РЫБОВОДНЫХ ХОЗЯЙСТВАХ АЗЕРБАЙДЖАНА

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Abstract. During 2013–2017 years biotic and abiotic of environmental conditions affecting to the extensiveness of invasion by causative agents of carp and trout parasitosis in fish farms in the territory of Azerbaijan Republic were studied. In addition, we studied the seasonal and age dynamics of diseases of the farm fishes. The prevalence of fish parasites infection in hot season (May-July) in comparison with cold month (October) was recorded. Twenty species of parasites from various systematical groups were found: protozoans (4 species); monogenean worms (3 species); cestodes (4 species); trematodes (3 species); nematodes (2 species); acanthocephalans (2 species); crustaceans (2 species). All investigations were conducted by considering of various factors affecting on production of fish. 386 specimens of carp and 415 specimens of trout were examined by the method of full parasitological dissection. We analyzed the physical and chemical conditions of water from the fish pools and other artificial basins in fish farms. In conclusion of our investigation the list of most pathogenic species of cultivated parasites were composed: *Metechinorhyncnus truttae, Acanthocephalus clavulae, Paradilepis scolecina, Proteocephalus torulosus, Rhabdochon agnedini*.

Аннотация. В течение 2013–2017 гг. изучались биотические и абиотические условия окружающей среды, влияющие на экстенсивность инвазии возбудителей паразитозов карпа и форели в рыбоводных хозяйствах на территории Азербайджанской Республики. Кроме того, была изучена сезонная и возрастная динамика болезней сельскохозяйственных рыб. Отмечено преобладание заражения рыб паразитами в жаркое время года (май — июль) по сравнению с холодным месяцем (октябрь). Обнаружено 20 видов паразитов из различных систематических групп: простейшие (4 вида); моногенеи черви (3 вида); цестоды (4 вида); трематоды (3 вида); нематоды (2 вида); скребни (2 вида); ракообразные (2 вида). Все исследования проводились с учетом различных факторов, влияющих на продуктивность рыб. Методом полного паразитологического вскрытия исследовано 386 экз. карпа и 415 экз. форели. Мы проанализировали физико-химическое состояние воды из бассейнов и других искусственных водоемов на рыбоводных фермах. Составлен список наиболее патогенных видов паразитов рыб в рыбоводных хозяйствах: *Metechinorhyncnus truttae, Acanthocephalus clavulae, Paradilepis scolecina, Proteocephalus torulosus, Rhabdochona gnedini*.

Keywords: fish culture, ecological factors, environment, extensiveness of invasion, parasites, fishes, systematics.

Ключевые слова: рыбоводство, экологические факторы, окружающая среда, экстенсивность инвазии, паразиты, рыбы, систематика.

Introduction

The great attention has been paid to increasing fish stocks in Azerbaijan in recent years. In addition, the government and business structures is carrying out effective work in the field of fish breeding. Unfortunately, environmental pollution provoked some dangerous diseases in fish farms. Taking into account the above-mentioned facts, the epizootic situation in carp and salmon farms in presented investigation was determined [1].

Considering the negative impact of environmental factors on fish products, we decided to describe the parasite fauna of cyprinids and salmonids, study the causes of diseases and take effective control measures. The studies were carried out in fish farms; we took into account the biology of the parasites, the age and sex of the fish. Depending on the epizootic situation the habitat conditions of the parasites was considered. In addition, we described the species composition of fish parasites and some peculiarities in distribution of diseases.

Because of our research, we found the following facts: the biotic and abiotic factors can influence on epizootic situation in the trout farms in dependence of the climatic conditions (temperature, physicochemical parameters of water, seasons, fish stocking density, age, etc.) and specific economic situation [2].

The emergence and spread of the disease in fish is caused by contamination of persisting stages in the life cycle of pathogens; by poor-quality nourishment and improper fodders; due to disproportion in the chemical and physical composition of water; in dependence of fish stocking density, etc. This complex of factors affects fish, and create a stress condition, which would be lead to illness. We can define it as the following equation:

$$S + ff + sf = x,$$

S — host; sum of ff — factors, including the parasitological factor, sf — stress; x — disease.

Considering above-mentioned facts, specialists on fish pathology always check the degree of pollution of basins, measure the pH and amount of dissolved oxygen in the water, control of nourishment and the quantity and quality of feedstuffs; but they also must take the necessary preventive measures to detect diseases and parasitic fish infection.

Material and Methods

About 150 fish specimens (100 carp specimens and 50 trout specimens), collecting from the fish farm were examined. Parasitological investigation was conducted by using the method of full parasitological dissection [3]. All fishes were observed for the presence of protozoan pathogens, monogenean worms, cestodes, trematodes, acanthocephalans and parasitic crustaceans.

For identification of ectoparasites scrapings were taken from the oral cavity of fishes. These scrapings were observed under the magnifying glass (20×) and brightfield research microscope MBI-3 (70×). The thin smears of peripheral blood were air-dried, fixed by absolute methyl alcohol and stained by Romanovsky-Giemsa. Investigations were carried out depending on the seasonal factors, considering ecological factors of habitat in fish farms.

On the assumption of many diseases are directly related to changes in water parameters, the physicochemical properties of water samples taken from water basins were analyzed at the

Environmental Pollution Monitoring Center of the Ministry of Ecology and Natural Resources, the Sanitary Laboratory of the Center for Hygiene and Epidemiology. The results of analyzes are presented in Tables1–2.

Table 1.

THE PHYSICOCHEMICAL PARAMETERS OF LAKE WATERS IN THE FISH FARMS OF TOVUZ

№	*Key components*	*Units*	*Quantity of components*
			Sample №1
	Date of sample collection		*06.06.13*
1	Color, visual	—	Colorless
2	Odor, by organoleptic method	—	Odor-free
3	Turbidity	FTU (NTU)	0
4	Transparence	cm	30
5	Power of hydrogen, pH	—	6.9
6	Electrical conductivity	$\times 10^{-3}$ cm/cm	0.525
7	Dissolved oxygen	mg/l%	4.8–55.4
8	Hardness of water	mg-eq/l	4.4
9	Ions of calcium, Ca^{2+}	mg/l	67.4
10	Ions of magnesium, Mg^{2+}	mg/l	12.2
11	Ions of chloride, Cl^{-}	mg/l	23.0
12	Ions of sulphate, SO_4^{2-}	mg/l	53.8
13	Ions of bicarbonate, HCO_3^{-}	mg/l	268.5
14	Ions of carbonate, CO_3^{2-}	mg/l	0
15	Ions of $Na^{+} + K^{+}$	mg/l	42.5
16	Total, ions $\sum$	mg/l	467.4
17	Ions of nitrite, NO_2^{-}	mg/l	0.02
18	Ions of nitrate, NO_3^{-}	mg/l	1.3
19	Ions of ammonium, NH_4^{+}	mg/l	0.3
20	Ions of phosphate, PO_4^{3-}	mg/l	0.07

Table 2.

THE RESULTS OF PHYSICOCHEMICAL ANALYSES INWATER BASINS OF THE FISH FARMS OF RIVER TROUT OF ZAGATALA REGION

№	*Key components*	*Units*	*Quantity of components*	*Maximum Allowable Concentration (MAC)*
	Date of sample collection		*06.06.13*	
1.	Transparency	cm	29	>30
2.	Turbidity	FTU	3,20	0
3.	Electrical conductivity	S/cm	0.240×10^{-3}	—
4.	Color by organoleptic method		Colorless	“
5.	Power of hydrogen, pH		7.58	6.0–9.0
6.	Hardness of water	mg-eq /1	2.03	7.0
7.	Ions of calcium, Ca^{2+}	mg/1	35.04	180.0
8.	Ions of magnesium, Mg^{2+}	mg/1	3.52	200.0
9.	Ions of chloride, Cl^{-}	mg/1	9.75	350.0
10.	Ions of sulphate, SO_4^{2-}	mg/1	57.62	500.0
11.	Ions of nitrite, NO_2^{-}	mg/1	0.02	3.3
12.	Ions of nitrate, NO_3^{-}	mg/1	5.57	45.0
13.	Ions of ammonium, NH_4^{+}	mg/1	0.07	0.5

Results and Discussion

The problems considering in this article have both theoretical and applied significance. Thus, it is impossible to provide prevention and control measures for parasites cause various infections without detail information about the seasonal extensiveness of invasion amongst populations of juvenile and adult fishes in artificial basins in fish hatcheries.

For this purpose the volume of reservoirs, dependence from the age, density of hosts and seasonal factors for the following parasites of farm fishes were studied: non-specific flagellate parasite species *Ichthyophthirius multifiliis*, the causative agent of ichthyophthiriasis; parasitic infuzoria species *Chiloodonella piscicola*, the causative agent of chilodoneliosis; monogenean worm *Dactylogyrus extensus*, one of the causative agents of dactylogyrosis of carps; *Gyrodactylus elegans*, the causative agent of gyrodactylosis; and in the end, the *Bothricephalus acheilognathi*, the causative agent of disease of the same name [4–5].

In consideration of inability for detailed study of above-mentioned problems, we decided to provide our research in following scheme.

So, 50 fish samples of carp and trout were studied by full parasitological dissection method. Investigations were conducted during May-July and October–December (25 samples for both periods).

In dependence with seasonal investigations (spring-summer, autumn-winter) 20 species of parasites were recorded: 4 protozoan species (*Costia necatrix, Chiloodonella piscicola*, *Ichthyophthirius multifiliis, Myxosoma cerebralis*); 3 monogenean species (*Dactylogyrus extensus, Gyrodactylus elegans, G. truttae*); 4 species from cestodes (*Bothricephalus acheilognathi, Paradilepis scolecina, Proteocephalus torulosus, Ligula intestinalis*); 3 species of trematodes (*Capillaria tomentosa, Diplostomum chromatophorum, Bunocotyle cingulata*); 2 acanthocephalan species (*Metechinorhyncnus truttae, Acanthocephalus clavulae*); 2 species of crustacean parasites (*Lernaea cyprinacea, Argulus foliaceus*) [6–7].

The key pathogen species (*Ichthyophthirius multifiliis*, *Dactylogyrus extensus*, *Myxosoma cerebralis*, *Paradilepis scolecina*, *Proteocephalus torulosus*, *Rhabdochona gnedini*, *Metechinorhyncnus truttae*, *Acanthocephalus clavulae*) have the potential epidemiological significance for fish farms.

Information about the prevalence of parasites in dependence of season and age of fishes is presented in Figures 1–2. This information is based on our long-term investigations [8].

As can be seen from the presented table, the polymastigine flagellate *Costia necatrix* was observed in two-month-old fishes in the period of May–July (the extensiveness of invasion was equal to 33.3%).

Chilodonella piscicola. Under yearlings of carp had extensiveness and intensity of invasion equal to 10% and 1.3, accordingly. We couldn't find this parasite in autumn season. These parasites were not found in spring-summer months; the extensiveness and intensity of invasion in two-years-old fishes were recorded as 24% and 1–2 parasites per fish, accordingly. Fry trouts had extensiveness and intensity of invasion equal to 6.7 and 1–2 parasites per fish, accordingly.

Trout fries were demonstrated the lower extensiveness and intensity of invasion, 6.7% and 1–2 parasites per fish, accordingly. Two-years-old fries had more high level of extensiveness and intensity of invasion (13.5% and 1–3 parasites per fish, accordingly). Fries and adult fishes were observed during warm and cold seasons.

The extensiveness of invasion of trout by *Ichthyophthirius multifiliis* was equal to 33.3% in May-July. This parasitic ciliate wasn't observed in under yearling fries.

The whirling disease caused by species *Myxosoma serebrale*, the parasitic myxosporean parasite of salmonids had extensiveness of invasion was equal to 80%. The two-years-old fishes were free of this parasite. The extensiveness of invasion of trout by *Costia necatrix* in spring season was equal to 13.7%.

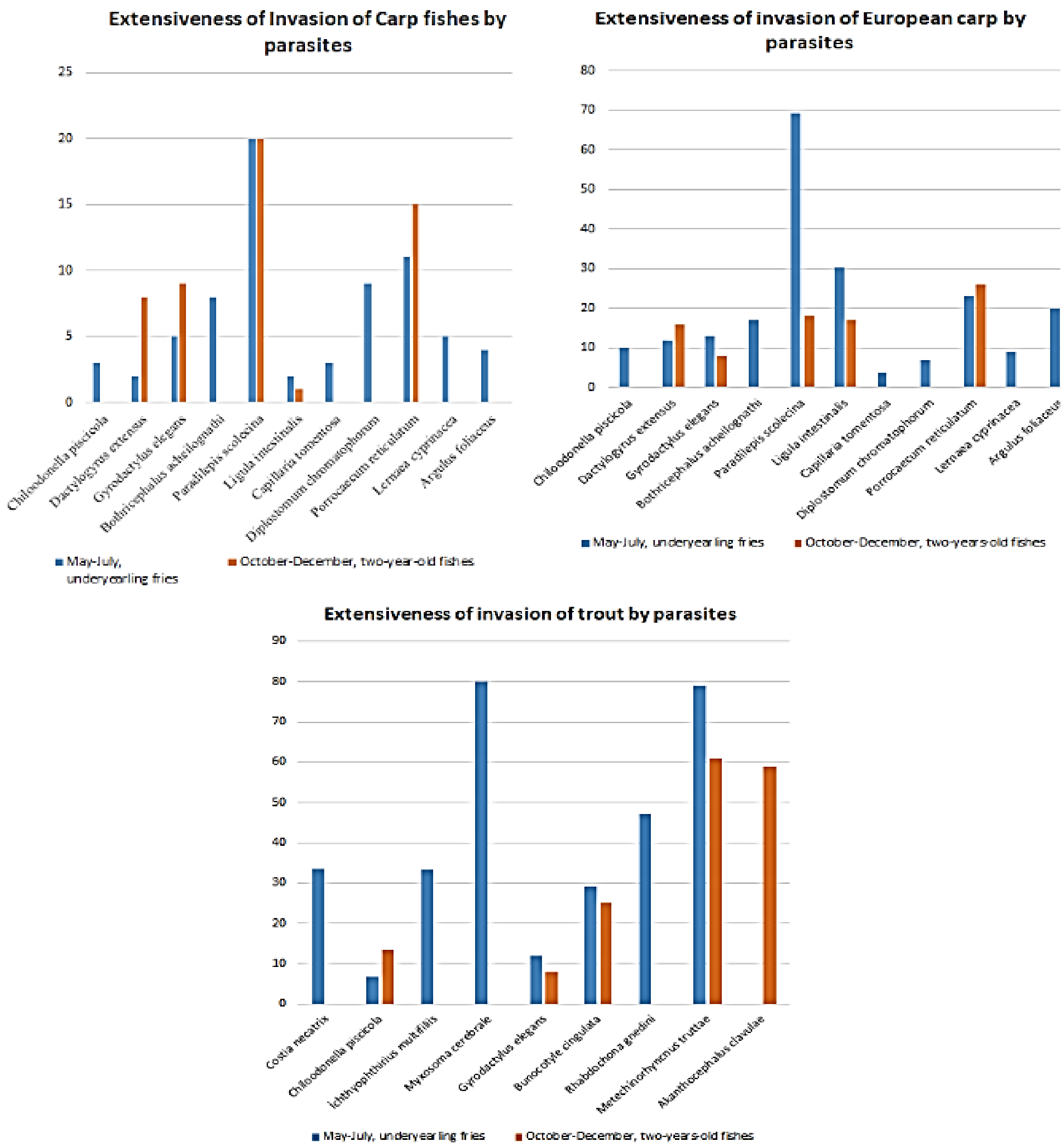

Figure 1. **Extensiveness of invasion of various fishes by parasites depending on season and age**

The extensiveness and intensity of invasion of carp fishes by monogenean species *Dactylogyrus extensus* in spring season were equal to 12% and 1–2 parasites per fish, accordingly. In addition, the above-mentioned parameters of invasion in autumn season were equal 16% and 2–8 parasites per fish, accordingly; the underyearlling carp fishes in spring season were free of parasites. Two-years-old fishes in autumn had extensiveness of invasion equal to 16% and intensity of

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invasion equal to 1–4 parasites per fish [9].

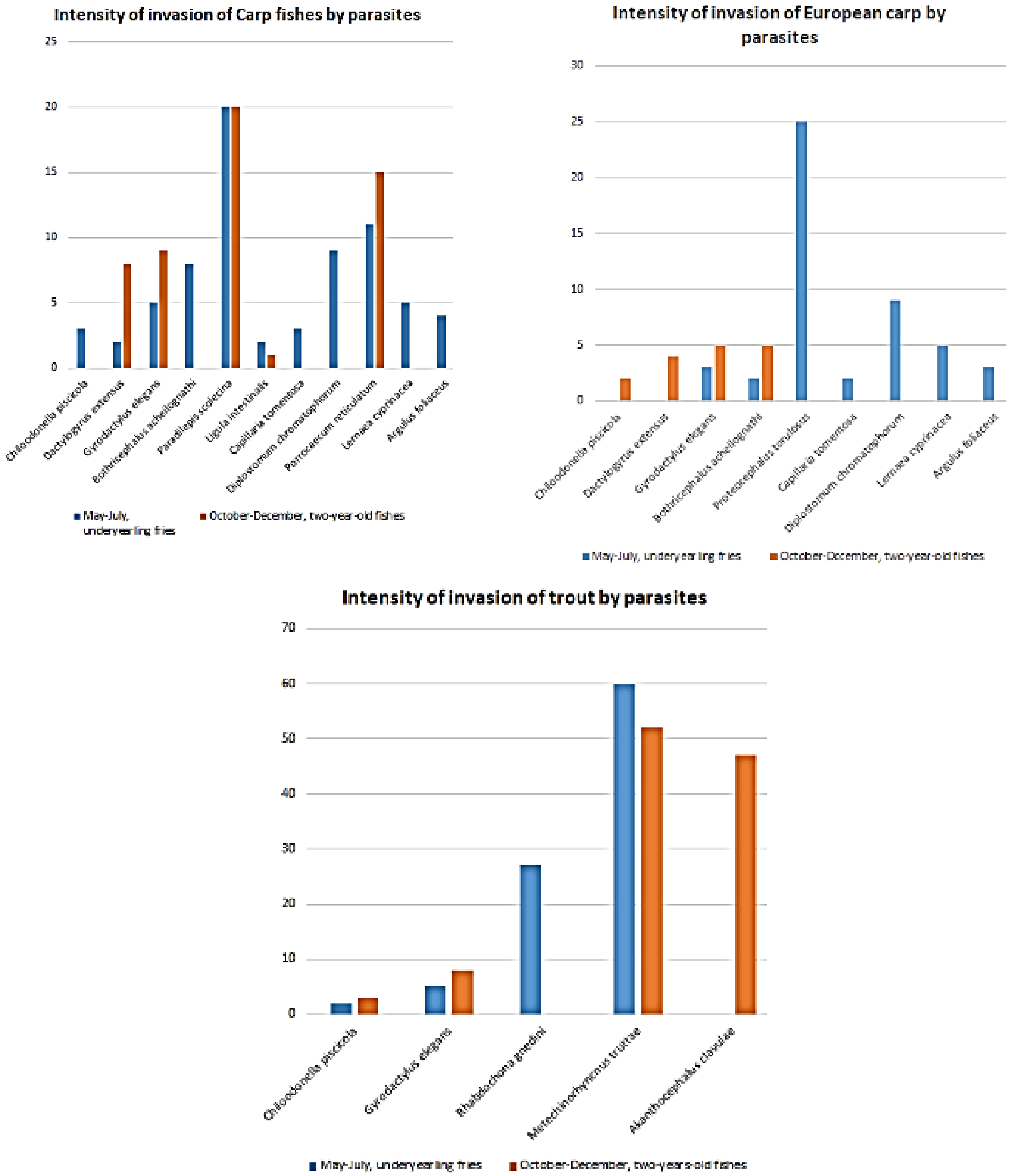

Figure 2. **Intensity of invasion of various fishes by parasites depending on season and age**

Under yearling fry of carp in spring-summer months had extensiveness and intensity of invasion by *Gyrodactylus elegans* equal to 13% and 1–5 parasites per fish, and 8% and 3–9 fishes in autumn, accordingly. Unger yearling fry and three-years-old fishes of European carp had extensiveness and intensity of invasion equal to 8% and 1–5 fishes, accordingly.

The fries of trout in spring demonstrated extensiveness and intensity of invasion by

Gyrodactylus truttae equal to 12% and 1–5 parasites per fish, accordingly. In autumn the extensiveness and intensity of invasion were equal to 8% and 3–8, accordingly.

In warm seasons the causative agent of bothricephalosis, tapeworm species *Bothricephalus acheilognathi* had extensiveness and intensity of invasion equal to 17% and 1–8, accordingly. Two-years-old fishes were free of parasites. Under yearling carp fishes in autumn and winter seasons had extensiveness and intensity of invasion equal to 16%, 1–5 fishes per basin and 18%, 1–2, 1–5 fishes per basin. The same trout fries were free of tapeworms.

The extensiveness and intensity of invasion of under yearling carp fries by *Paradilepis scolecina* in spring season were equal to 69.2% and 6–20 fish per basin, accordingly; two-years-old carp fishes had above-mentioned parameters of invasion equal to 17,9% and 10–20 parasites per fish. We could not observe this parasite in adult carp and trout fishes.

The extensiveness and intensity of invasion of carps by tapeworm species *Proteocephalus torulosus*in spring season were equal to 47,8% and 6–25 parasites per fish. The two-years fishes were free of parasites. Also, we could not find this parasite in carp and trout fishes.

The one- and two-years-old carps were free of tapeworm species *Ligula intestinalis*. The intermediate host of this helminth inhabits in water fleas. Larvae of this parasite infects the fry. The plerocercoid stage of *L. intestinalis* develops in abdominal cavity of fish during 10–14 months. This stage can persist in abdominal cavity about 3 years. Due to these details in life cycle of *Ligula intestinalis* we found mature and immature helminths in abdominal cavity of infected fishes. So, the extensiveness and intensity of invasion of carps by *L. intestinalis* in spring were equal to 30.4% and 1–2 parasites per fish, accordingly. Two-years-old fishes had extensiveness and intensity of invasion equal to 17% and 1–1 per basin. We could not find this parasite in other species of farm fishes.

We found the nematode pathogen species, *Capillaria tomentosa* in spring season only in under yearling fries of carp and European carp. The extensiveness and intensity of invasion were equal to 3.6%, 7% and 2–3, 2–2 parasites per fish, accordingly. The two-years-old fishes were free of parasites.

During spring and summer seasons the trematode species *Diplostomum chromatophorum* was found in under yearling and three-years-old fry of carp and European carp. The extensiveness and intensity of invasion of carps by this parasite were equal to 6.8%, 6.9% and 3–9, 6–9 parasites per fish, accordingly. We could not find parasites in three-years-old fishes of carp in cold seasons [10].

The extensiveness of invasion of fry and two-years-old trout by fish trematode *Bunocotyle cingulata* were equal to 29% and 25%.

The extensiveness and intensity of invasion of trout fry by nematode species *Rhabdochona gnedini* in spring season were equal to 47.3% and 1–27 parasites per fish, accordingly. Two-years-old fishes were free of parasites.

The extensiveness and intensity of invasion of under yearling carps by trematode parasite *Porrocaceum reticulatum* in warm season were equal to 23% and 9–11 parasites per fish, accordingly and in winter were equal to 26% and 5–15 fishes per basin.

Trout fry in spring had extensiveness and intensity of invasion by acanthocephalan parasite species *Metechinorhynchus truttae* equal to 78.9% and 21–60 parasites per fish. In addition, underyearling fry in autumn had extensiveness and intensity of invasion equal to 60.9% and 15–52 parasites per fish. Two-years-old trouts in autumn demonstrated the extensiveness and intensity of invasion by *Acanthocephalus clavulae* equal to 58% and 10-47 parasites per fish.

The intermediate host for causative agent of acanthocephalosis is amphipods. These crustaceans swallow the eggs of parasite in water environment. The acanthocephalan larva, acanthor reaches abdominal cavity of fish. Then larvae develop to pre-acanthor and invasive acanthella stage of life cycle.

When fish swallow the amphipod host causative agent of acathocephallosis can infect it. The under yearling fry of carp species *Lernaea cyprinacea* demonstrated the low level of invasion by acanthocephalans in spring-summer season. The extensiveness and intensity of invasion of infected fishes were equal to 9% and 1–5 parasites per fish, accordingly. Two-years-old fishes were free of parasites. We could not find this acanthocephalan species in trout fishes.

The under yearling fry of carp and European carp in warm season had extensiveness and intensity of invasion by *Argulus foliaceus* equal to 20%, 18% and 1–4, 1–4 parasites per fish.

During comparative investigation of parasite fauna in trout farms we noted the prevalence of two parasitic species, *Ichthyophthirius multifiliis* (33.3%) and *C. necatrix* (33.5%). The highest level of extensiveness of invasion (80%) were registered in Zagatala trout farm.

There was no heavy mortality in fish fry. The highest level of extensiveness and intensity of invasion of fishes by parasites were found in warm seasons. The invasion of fishes by protozoan parasite *C. necatrix* had reached to maximum level since March to May in warm season and in September in autumn.

We had observed infection by various parasites in salmonids since birth of fries. During 6 month the level of extensiveness and intensity of invasion by several species of parasites was increasing and had reached maximum in two-years-old fishes. For example, extensiveness of invasion of fishes by acanthocephalans was equal to 60.9–58.8% in two-years-old fishes.

Conclusions

A seasonal study of fish parasite invasion found that the main high extensiveness and intensity of infestation occurs in the warmer months of the year. According to our investigation, the infection of trout fry occurs in the first days of their life; during the 6 months the intensity and intensity of infection with different species of parasites gradually increases and reaches a maximum in two-years-old fishes.

The parasitic ciliate *Ichthyophthirius multifiliis* (extensiveness of invasion 33.3%) and polymastigine flagellate *C. necatrix* (extensiveness of invasion 33.5%) are the most common parasitic species in trout farms in Azerbaijan. In addition, the most pathogenic species of fishes in above-mentioned farms were recorded (*Metechinorhyncnus truttae*, *Acanthocephalus clavulae*, *Paradilepis scolecina*, *Proteocephalus torulosus*, *Rhabdochona gnedini*).

The ecological factors influencing the prevalence of parasitoses in fish farms were revealed. Visual monitoring of the water samples was demonstrated that the water in these pools was clear, odorless and colorless. The content of the main ions (Ca^{2+}, Mg^{2+}, Cl^{-}, SO_4^{2-}) and biogenic substances (NO_2^{-}, NO_3, NH_4) in the water samples was record within the normal range. Thereby, we evaluated the water samples as pure.

As a result of the work carried out, we have given an epizootic assessment of the investigated fish farms. Preventive measures have been taken to control fish diseases.

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