UDC 619:576.8:639.371.5.091(285:[477.52/.54+477.62]) DOI 10.36016/JVMBBS-2020-6-1-4

FEATURES OF THE PARASITIC SYSTEM FORMATION IN HERBIVOROUS FISH IN THE AQUACULTURE OF THE NORTH-EASTERN AND EASTERN REGIONS OF UKRAINE

Yevtushenko A. V.

National Scientific Center 'Institute of Experimental and Clinical Veterinary Medicine', Kharkiv, Ukraine, e-mail: aevt76@gmail.com

Summary. The research aimed to determine the peculiarities of the formation of the parasitic system in herbivorous fish in the aquaculture of the North-Eastern and Eastern regions of Ukraine. In fish farms of the North-Eastern and Eastern regions of Ukraine, 26 species of parasites were found in herbivorous fish: 19 species in the silver carp (11 — protozoa, 1 — monogeneans, 4 — trematodes, 3 — parasitic crustaceans); 18 species in the grass carp (6 — protozoa, 1 — monogeneans, 4 — trematodes, 4 — cestodes, 3 — parasitic crustaceans); and 20 species in the bighead carp (10 — protozoa, 1 — monogeneans, 4 — trematodes, 2 — cestodes, 3 — parasitic crustaceans). 11 species (42.3%) of registered parasites were invasive; 18 species (69.2%) of the detected herbivorous fish's parasites develop directly and 8 (30.8%) — with the participation of definitive and intermediate hosts; the fish is an additional (second intermediate) host in the life cycle of 6 species (23.1%) of parasites. Outbreaks of diseases caused by parasitic protozoa from the genera *Myxobolus, Cryptobia, Chilodonella,* and *Ichthyophthirius* have been reported in both fingerlings and two-year-olds. The protozoa from the genera *Ichthyobodo, Trichodina,* and *Trichodinella* were registered en masse only in fingerlings. Pathogens from the genus *Dactylogyrus* were more often registered among three-year-old silver and bighead carps. Metacercariae of *Ichthyocotylurus variegatus* were found en masse in fingerlings of the grass carp. *Posthodiplostomum cuticola* larvae in unfavorable farms were found with a high level of prevalence in fish of different age groups. Thong plerocercoids were more commonly recorded in two-year-old silver and bighead carps and fingerlings of the grass carp. The highest level of cestode infection with *Bothriocephalus acheilognathi* was recorded in fingerlings of the grass carp. Parasitic crustaceans *Sinergasilus lieni* with a high level of prevalence were registered in two-year-old and three-year-old fish. Crustaceans *Lernaea cyprinacea* massively affected two-year-old and three-year-old fish. Pathogens from the genera *Trichodina, Cryptobia,* and *Chilodonella*, and *Dactylogyrus hypophthalmichthys, Posthodiplostomum cuticola,* and *Sinergasilus lieni* were of the greatest epizootic significance for the silver carp; for the bighead carp — from the genus *Myxobolus,* (especially *M. pavlovskii*), *Chilodonella piscicola, Ichthyophthirius multifiliis, Dactylogyrus aristichthys, Posthodiplostomum cuticola, Diplostomum spathaceum, Digramma interrupta,* and *Sinergasilus lieni*; for the grass carp — *Bothriocephalus acheilognathi, Ichthyocotylurus variegatus, Ligula intestinalis, Sinergasilus major, Lernaea cyprinacea, Ichthyobodo necator,* and *Ichthyophthirius multifiliis*

Keywords: parasitic system, protozoa, helmints, parasitic crustaceans, herbivorous fish, aquaculture

Introduction. The main objects of aquaculture in Ukraine are herbivorous fish: the silver carp — *Hypophthalmichthys molitrix* (Valenciennes, 1844), the bighead carp — *Hypophthalmichthys nobilis* (Richardson, 1845), and the grass carp — *Ctenopharyngodon idella* (Valenciennes, 1844). This is a group of fish from the Far Eastern complex, which was acclimatized in the reservoirs of Ukraine in the second half of the 20th century. In addition to their industrial significance, these fish species are the improvers of water bodies, and their range of food (except for the bighead carp) is not competitive with other native species.

Herbivorous fish larvae are obtained only by the factory method — by incubating the eggs in special devices. This is due to the lower water temperature in the reservoirs of Ukraine than in the basins of the Amur, the Ussuri, and the Songhua River — the natural habitats of these species of fish.

Seeds from the broodstock begin to ripen at a temperature of 21–22°C. The broodstock is injected with pituitary hormones for the simultaneous maturation of eggs and milk. Eggs selected from females are fertilized with male milk in special containers and transferred to incubators. After hatching, the larvae are transferred into fry (growth) ponds. In autumn, fingerlings are transferred into the winter ponds, and after winter — in the spring, fingerlings are transferred into feeding ponds (Vovk, 1976).

Fish stocking material was first imported to Ukraine from the Far East in 1954 (Vovk, 1976). Prior to its introduction parasitic fauna of herbivorous fish counted 23 pathogen species (Davydov et al., 2011). A number of these parasites have spread significantly and disease outbreaks have begun to cause significant economic damage to fish farms.

In addition, herbivorous fish have been found to be highly susceptible to some species of local parasites, pathogens of such diseases as diplostomosis, digramosis, postodiplostomosis, ligulosis, etc. (Davydov et al., 2005, 2011; Musselius, 1969). A similar picture was registered during the acclimatization of herbivorous fish in other countries (Beretar', 2009; Lysenko, 2003, 2004).

The monograph 'Ecology of Fish Parasites in Water-Bodies of Ukraine' (Davydov et al., 2011) contains more than 200 scientific papers devoted to the study of species diversity of herbivorous fish's parasites in aquatic ecosystems of Ukraine. Along with this, data on the current epizootic status of water bodies in the aquaculture of the North-Eastern and Eastern regions of Ukraine are missing.

The aim of the research was to determine the peculiarities of the formation of the parasitic system in herbivorous fish in the aquaculture of the North-Eastern and Eastern regions of Ukraine. In this regard, the following tasks were set: to study the species composition of parasites, to determine the level of infection of fish, to study the age dynamics of infection, to identify epizootically significant species of parasites that can cause disease outbreaks and fish death.

Materials and methods. Fifteen specimens of each fish species and age groups were studied in a specialized laboratory of the National Scientific Center 'Institute of Experimental and Clinical Veterinary Medicine' (Kharkiv, Ukraine). Ichthyological material was taken in different seasons of the year from spawning, growing, feeding, and wintering ponds in specialized fish farms, as well as agricultural ponds of Kharkiv, Sumy, Poltava, and Donetsk regions.

Ichthyological analysis was performed by the method of incomplete helminthological autopsy according to Bykhovskaya-Pavlovskaya (1985) and Markevich (1951). Species affiliation of parasites was determined by the 'Keys to Parasites of Freshwater Fish of the Fauna of the USSR' (Bauer, 1984, 1985, 1987).

Prevalence of infection (PI, %) was determined by the formula:

$$PI = \frac{x}{y} \times 100\%$$

where: x — the number of fish in which parasites were found; y — the total number of studied fish.

Statistical processing of the obtained results was carried out following the recommendations on biometrics using the parametric Student's *t*-test (Van Emden, 2019).

Results and discussion. According to the results of the research (Table 1), 19 species of parasites were found in the silver carp: 11 species (59.7%) of protozoa, 1 (5.3%) — monogeneans, 4 (21.0%) — trematodes, 3 (15.8%) — parasitic crustaceans; 20 species of parasites were registered in the bighead carp: 10 species (50.0%) of protozoa, 1 (5.0%) — monogeneans, 4 (20.0%) — trematodes, 2 (10.0%) — cestodes, 3 (15.0%) — parasitic crustaceans; and 18 species of parasites were recorded in the grass carp: 6 species (33.3%) of protozoa, 1 (5.6%) — monogeneans, 4 (22.0%) — trematodes, 4 (22.0%) — cestodes, 3 (16.7%) — parasitic crustaceans.

In total, 26 species of parasites were found in herbivorous fish, of which 11 species (42.3%) are invasive.

It should be noted that 18 species (69.2%) of the detected herbivorous fish's parasites develop directly and 8 (30.8%) — with the participation of definitive and intermediate hosts. The fish is an additional (second intermediate) host in the life cycle of 6 species (23.1%) of parasites.

Representatives of the genus *Dactylogyrus* are specific parasites to their hosts: in the case of the silver carp only *D. hypophthalmichthys* was registered, in the grass carp — *D. ctenopharyngodonis*, and in the bighead carp — *D. aristichthys*. Representatives of parasitic crustaceans from the genus *Sinergasilus* showed species specificity too: *S. lieni* was registered in the silver carp and the bighead carp, and *S. major* in the grass carp.

It is important to note that in the silver carp coupled with the bighead carp, 15 species (68.2%) of the detected pathogens are parasites on the surface of the body, skin and gills; one species is a parasite of the intestinal mucosa, one species — a parasite of the eyes, one species — the subcutaneous tissue, three species — the abdominal cavity.

In the grass carp, 11 species (61.1%) were found to be parasites on the surface of the body, skin and gills; one species were parasites of the eyes, three species — the abdominal cavity, and two species — the intestine. *M. ellipsoides* was localized in all organs and tissues of the three species.

According to the results of studying the age dynamics of infection of herbivorous fish with pathogens of protozooses, the data shown in Fig. 1 were obtained.

Thus, the data in Fig. 1 show that outbreaks of diseases caused by parasitic protozoa were recorded mainly in this fingerlings and two-year-old fish. It should be noted that the highest level of PI by microsporidia was recorded in fingerlings and two-year-old fish. At the same time, PI *M. pavlovskii* in fingerlings reached 89%, in two-year-olds — 78%, the level of infection of three-year-olds and four-year-olds was much lower — 14% and 11%, respectively.

The prevalence of *M. drjagini* and *M. ellipsoides* in two-year-olds was 14% and 20%, three-year-olds — 9% and 12%, fingerlings — 3% and 8%, respectively. A similar pattern was registered in the *E. sinensis* infection: PI in two-year-olds was 12%, three-year-olds — 8%, fingerlings — 3%. Another picture was observed when infecting fish with pathogens of ciliaphorosis — *T. acuta, T. nigra, T. epizootica*: the highest level of infestation was recorded in fingerlings — 81%, 58%, 19%, and the infection in two-year-olds was much lower — 22%, 14 %, 4%, respectively.

Table 1 — Species composition of herbivorous fish's parasites and places of their localization in the conditions of aquaculture of the North-Eastern and Eastern regions of Ukraine

No.	Parasite species	Localization	Fish species		
			Silver carp	Bighead carp	Grass carp
1	* *Cryptobia branchialis* (Nie in Chen, 1956)	gills	+	+	–
2	*Ichthyobodo necator* (= *Costia necatrix*) (Henneguy, 1883)	gills, skin	+	+	+
3	* *Eimeria sinensis* Chen, 1956	intestine	+	+	–
4	* *Myxobolus pavlovskii* (Achmerov, 1954)	gills	+	+	–
5	* *Myxobolus drjagini* (Achmerov, 1954)	subcutaneous tissue	+	+	–
6	*Myxobolus ellipsoides* Thélohan, 1892	all organs and tissues	+	–	+
7	*Chilodonella piscicola* (Zacharias, 1894) Jankowski, 1980	gills, body surface	+	+	+
8	*Ichthyophthirius multifiliis* Fouquet, 1876	gills, body surface	+	+	+
9	*Trichodina acuta* Lom, 1961	gills, body surface	+	+	+
10	*Trichodina nigra* Lom, 1961	gills, body surface	+	+	–
11	*Trichodinella epizootica* (Raabe, 1950) Sramek-Husek, 1953	gills, body surface	+	+	+
12	* *Dactylogyrus hypophthalmichthys* Achmerov, 1952	gills	+	–	–
13	* *Dactylogyrus aristichthys* Long et Yu, 1958	gills	–	+	–
14	* *Dactylogyrus ctenopharyngodonis* Achmerov, 1952	gills	–	–	+
15	*Diplostomum spathaceum* (Rudolphi, 1819) mtc	eyes	+	+	+
16	*Posthodiplostomum cuticola* (Nordmann, 1832) mtc	skin	+	+	+
17	*Ichthyocotylurus variegatus* (= *Tetracotyle variegate*) (Creplin, 1825) Odening, 1969 mtc	abdomen	+	+	+
18	*Apophallus donicus* (Skrjabin et Lindtrop, 1919) mtc	body surface, fins, gills	+	+	+
19	* *Khawia sinensis* Hsü, 1935	intestine	–	–	+
20	* *Bothriocephalus acheilognathi* Yamaguti, 1934	intestine	–	–	+
21	*Ligula intestinalis* (Linnaeus, 1758) l	abdomen	–	+	+
22	*Digramma interrupta* (Rudolphi, 1810) l	abdomen	–	+	+
23	* *Sinergasilus lieni* Yin, 1949	gills	+	+	–
24	* *Sinergasilus major* (Markevich, 1940)	gills	–	–	+
25	*Lernaea cyprinacea* Linnaeus, 1758	skin	+	+	+
26	*Argulus foliaceus* (Linnaeus, 1758)	skin	+	+	+

Remarks: * — invasive species, mtc — metacercariae, l — larvae.

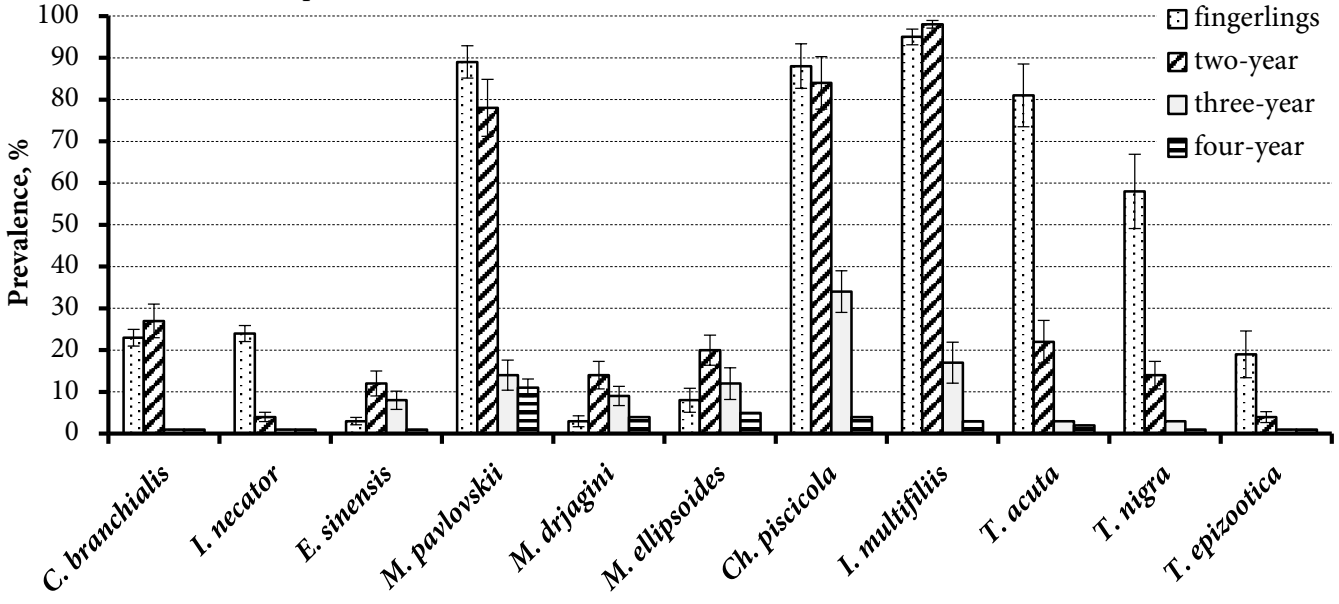

Figure 1. Age dynamics of infection of herbivorous fish with pathogens of protozooses during outbreaks of diseases in fish farms of the North-Eastern and Eastern regions of Ukraine

Outbreaks of protozoozes caused by other parasitic ciliates — *Ch. piscicola* and *I. multifiliis* were accompanied by high levels of infection in both fingerlings — 88%, 95% and two-year-olds — 84%, 98%, respectively. As for the pathogens of mastigophorosis, a high level of prevalence of *I. necator* was registered in fingerlings — 24%, and the pathogen *C. branchialis* was detected with a fairly high level of infection in fish both fingerlings (23%) and two-year-olds (27%). Infection of four-year-olds with the protozoa was significantly reduced and turned into a form of parasite carriage.

When studying the seasonal dynamics of infection of fish with protozoa, it was found that the peak level of infection of the silver carp with parasites from the genera *Trichodina* and *Trichodinella* was registered in August, the protozoa of the genus *Cryptobia* — in August–September. Outbreaks of ichthyoftiriosis infection (*I. multifiliis*) were most often recorded in the conditions of significant fish density that occurred in early summer when fry were in spawning ponds (when growing young) or in autumn among fish of different ages after transferring into winter ponds (under the conditions of autumn temperature rise). The highest level of infection of fish with chylodonels (*Ch. piscicola*) was recorded in winter ponds from October to April.

Outbreaks of disease depended on water temperature, the optimal value for the development of these parasites ranged from 5°C to 18°C. Infection of young silver carp with myxosporidia (*M. pavlovskii, M. ellipsoides, M. drjagini*) was registered from the first days of their placing in growing ponds and an increase in intensity was observed throughout the warm period of the year. The highest level of infection of both fingerlings and two-year-old silver carp was registered at the beginning of the winter period. The death of the bighead carp from myxobolic parasitemia was sometimes observed.

Thus, according to the results of the conducted researches it was established that the pathogens from the genera *Trichodina* and *Cryptobia*, to a lesser extent — *Chilodonella*, had the greatest epizootic significance for the silver carp. Representatives of the genus *Myxobolus*, especially *M. pavlovskii*, which caused outbreaks among fingerlings and two-year-olds, proved to be epizootically important species for the bighead carp. *Ch. piscicola* and *I. multifiliis* were also of epizootic significance. In the grass carp, protozoa were found mainly in the form of parasite carriage with a slight level of prevalence, but outbreaks caused by *I. necator* and *I. multifiliis* have been reported.

The level of infection of the silver carp coupled with the bighead carp with pathogens of helminthiasis and crustaceosis in outbreaks of the diseases in fish farms in the North-Eastern and Eastern regions of Ukraine is shown in Fig. 2. Pathogens from the genus *Dactylogyrus* were more frequently registered among three-year-olds with a maximum level of *D. hypophthalmichthys* infection in the silver carp — 74% and *D. aristichthys* in the bighead carp — 54%.

Metacercariae of *Diplostomum spathaceum* were more often registered in two-year-old fish — 34%, less often in fingerlings (22%) and three-year-olds (15%). *P. cuticola* larvae in unfavorable farms were found with a high level of prevalence in fish of different age groups: PI of two-year-olds — 81%, three-year-olds — 54%, fingerlings — 38%.

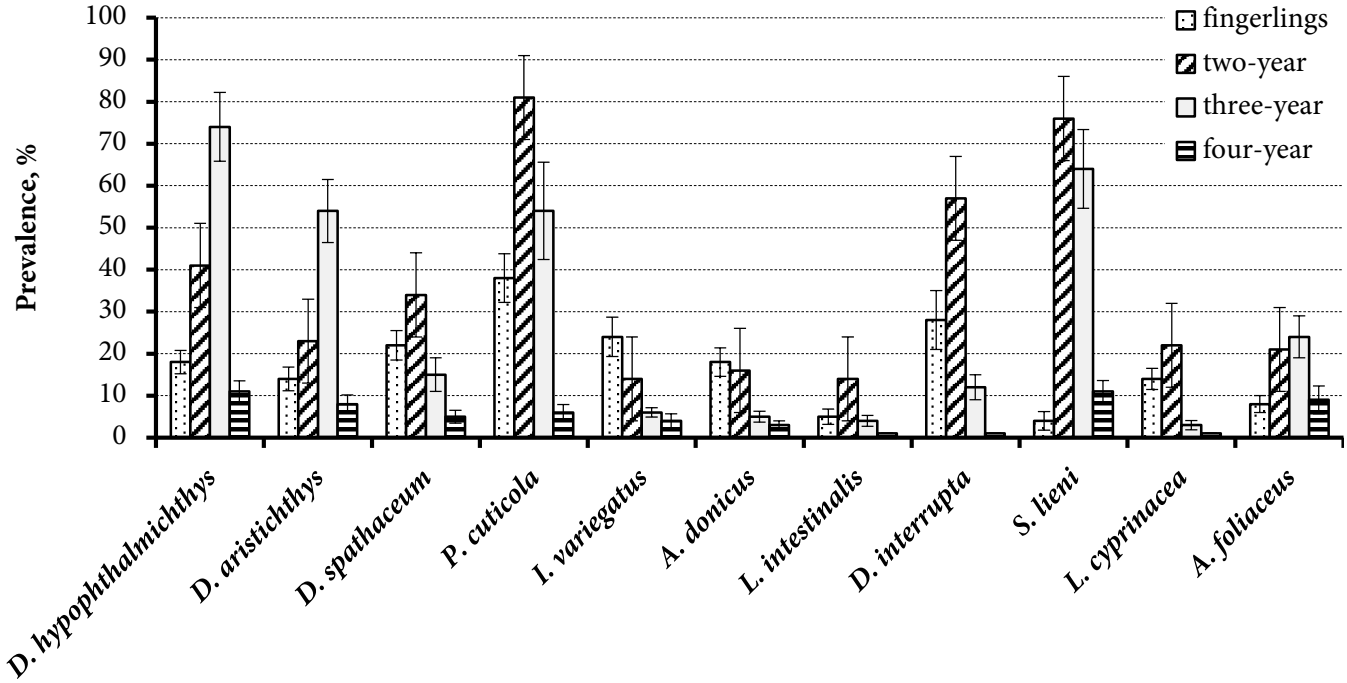

Figure 2. Age dynamics of infection of the silver carp and the bighead carp with helminthic and crustacean pathogens in disease outbreaks in fish farms in the North-Eastern and Eastern regions of Ukraine

Similar dynamics of infection was observed when infected with metacercariae of *I. variegatus* and *A. donicus* — 24% and 18% in fingerlings, 14% and 16% in two-year-olds, and it significantly reduced in older fish. Thong plerocercoids in outbreaks of ligulidosis were also more common registered among two-year-olds: PI with *L. intestinalis* — 14%, PI with *D. interrupta* — 57%.

Parasitic crustaceans *S. lieni* with a high level of prevalence were registered in two-year-old and three-year-old fish — 76% and 64%, respectively. *L. cyprinacea* was more often found among two-year-olds (PI — 22%) and fingerlings (PI — 14%). *A. foliaceus* were registered among fish of different age groups: PI in fingerlings — 8%, two-year-olds — 21%, three-year-olds — 24%, four-year-olds — 9%.

The age dynamics of infection of the grass carp with pathogens of helminthiasis and crustaceasis is shown in Fig. 3.

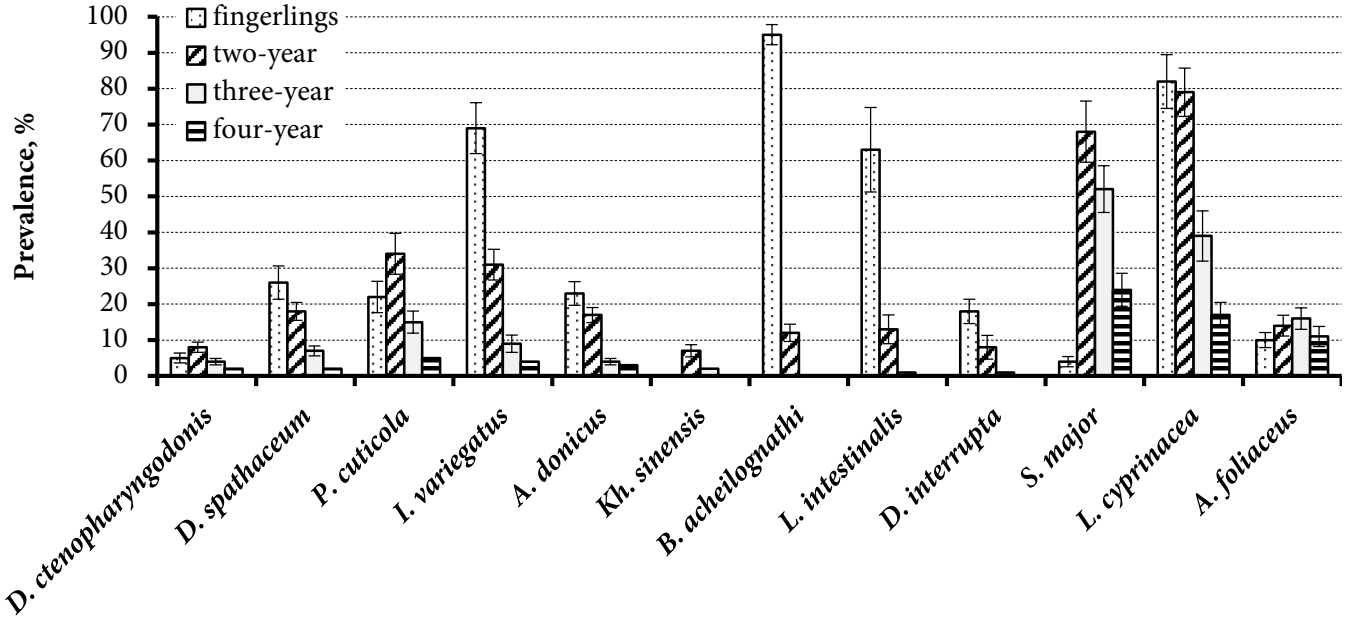

Figure 3. Age dynamics of infection of the grass carp with helminthic and crustacean pathogens in disease outbreaks in fish farms in the North-Eastern and Eastern regions of Ukraine

Parasitic fauna and the level of infection of the grass carp differed slightly from other herbivorous fish species. Thus, monogeneans *D. ctenopharyngodonis* were registered with a low level of infection in fish of all age groups (PI in fingerlings — 5%, two-year-olds — 8%, three-year-olds — 4%). Metacercariae of *I. variegatus* were found en masse in fingerlings of the grass carp with PI 69%, the lowest level of prevalence was registered in two-year-olds and three-year-olds — 31% and 9%, respectively.

A similar pattern of dynamics of infection was observed when infected with metacercariae of trematodes *D. spathaceum* and *A. donicus* — 26% and 23% in fingerlings, and 18% and 17% in two-year-olds, respectively.

Metacercariae of *P. cuticola* were more often registered in two-year-olds (PI — 34%), less often in fingerlings (PI — 22%) and three-year-olds (PI — 15%). Pleguercoids ligulide were registered mainly in fingerlings (PI with *L. intestinalis* — 63%, *D. interrupta* — 18%) and two-year-olds (PI with *L. intestinalis* — 13%, *D. interrupta* — 8%).

Infection with *B. acheilognathi* in fingerlings reached 95%, while prevalence of two-year-olds did not exceed 12%, and in older fish helminths were not detected. It should be noted that *Kh. sinensis* with PI of 7% and 2%, respectively, were found in two-year-old and three-year-old grass carp.

Compared with other herbivorous fish species, the grass carp was more often affected by crustaceans *L. cyprinacea*. The PI in fingerlings and two-year-olds reached 82 5 and 79%, and the level of infection of three-year-olds and four-year-olds was 39% and 17%, respectively. A high level of infection with crustaceans *S. major* was registered. Thus, the PI in fingerlings was insignificant (4%), but in older fish it reached 68% in two-year-olds, 52% in three-year-olds, 24% in four-year-olds. The level of *A. foliaceus* infection in fish of different age groups almost did not differ and ranged from 10% in fingerlings to 16% in three-year-olds.

According to the analysis of seasonal dynamics of infection of fish with helminthiasis and crustacean pathogens, it was found that monogeneans in fingerlings of the silver carp began to be registered in July, the maximum level of infection of fish regardless of age was observed in late July–August, with decreasing the water temperature prevalence decreased.

Pathogens of postodiplostomosis were registered in fish throughout the year, but the highest level of infection was observed in the autumn. During the winter,

prevalence decreased slightly, but began to increase again during the summer. When infected with metacercariae of *D. spathaceum, I. variegatus,* and *A. donicus*, the peak level of infection was also observed in autumn, but during the winter period prevalence did not decrease significantly. Infection with plerocercoids ligulide (*L. intestinalis, D. interrupta*) occurred throughout the summer and in late autumn prevalence was the highest. Due to the death of fish weakened by pathogens during the winter, the level of prevalence decreased significantly in the spring.

A similar pattern was observed in the infection of the grass carp with pathogens of botryocephallosis, but the peak of the infection was observed in late summer–early autumn. The highest level of infection with parasitic crustaceans from the genera *Sinergasilus* and *Lernaea* was recorded throughout the summer period with the maximum level of prevalence in September. Crustaceans *A. foliaceus* were recorded on fish throughout the year.

Therefore, based on the results of research, it was found that monogeneans *D. hypophthalmichthys*, metacercariae of *P. cuticola*, *S. lieni* have a veterinary-sanitary (epizootic) significance in aquaculture for the silver carp, for the bighead carp — *D. aristichthys, P. cuticola, D. spathaceum, D. interrupta, S. lieni*, for the grass carp — *B. acheilognathi, I. variegatus, L. intestinalis, S. major, L. cyprinacea.*

According to Davydov et al. (2012) modern fauna of herbivorous fish's parasites in reservoirs of Ukraine is represented by 83 species. At the same time, about 20 species of invasive species of parasites have survived, including 11 species of protozoa (*C. branchialis, Eimeria mylopharyngodoni, Myxidium ctenopharyngodonis, Sphaerospora amurensis, Sphaerospora cyprini, Myxobolus dispar, Myxobolus latus, M. drjagini, M. ellipsoides, Balantidium ctenopharyngodoni, Thrichodina nobilis*), four species of monogeneans (*D. ctenopharyngodonis, Dactylogyrus lamellatus, D. hypophthalmichthys, Gyrodactylus ctenopharyngodontis*), three species of cestodes (*Biacetabulum appendiculatus, Kh. sinensis, B. acheilognathi*), two species of trematodes (*Amurotrema dombrovskajae, Sanguinicola skrjabini*), one species of crustaceans (*S. lieni*). Other parasites are native species that have been transmitted to herbivorous fish from native ichthyofauna.

According to our data, 26 species of parasites were found in herbivorous fish, of which 11 species are invasive.

It should be noted that the fauna of herbivorous fish's parasites differs in different regions of Ukraine. According to Katiukha and Vozniuk (2016), only pathogens of diplostomosis and sinergasillosis in the silver carp and only pathogens of lerneosis in the grass carp were found in the aquaculture of Rivne Region.

The obtained results on the age and seasonal dynamics of infection allow the introduction of a set of treatment and prevention measures in the control of pathogens (Dunn and Hatcher, 2015). Thus, to control monogeneans and parasitic crustaceans, it is recommended to take preventive measures at the beginning of the growing season in June among fish of all ages.

Double treatment of fish with larval cestodes and trematodes is recommended — in July and September among fingerlings and two-year-olds. In intestinal cestodes, the most effective treatment period is August–September. Preventive treatment of fish of all ages with parasitic protozoa should be carried out after transferring fish into winter ponds.

Conclusions. 1. In fish farms of the North-Eastern and Eastern regions of Ukraine, 26 species of parasites were found in herbivorous fish: 19 species in the silver carp (11 — protozoa, 1 — monogeneans, 4 — trematodes, 3 — parasitic crustaceans); 18 species in the grass carp (6 — protozoa, 1 — monogeneans, 4 — trematodes, 4 — cestodes, 3 — parasitic crustaceans); and 20 species in the bighead carp (10 — protozoa, 1 — monogeneans, 4 — trematodes, 2 — cestodes, 3 — parasitic crustaceans). 11 species (42.3%) of registered parasites were invasive; 18 species (69.2%) of the detected herbivorous fish's parasites develop directly and 8 (30.8%) — with the participation of definitive and intermediate hosts; the fish is an additional (second intermediate) host in the life cycle of 6 species (23.1%) of parasites.

2. Outbreaks of diseases caused by parasitic protozoa from the genera *Myxobolus, Cryptobia, Chilodonella,* and *Ichthyophthirius* have been reported in both fingerlings and two-year-olds. The protozoa from the genera *Ichthyobodo, Trichodina,* and *Trichodinella* were registered en masse only in fingerlings. Pathogens from the genus *Dactylogyrus* were more often registered among three-year-old silver and bighead carps. Metacercariae of *Ichthyocotylurus variegatus* were found en masse in fingerlings of the grass carp. *Posthodiplostomum cuticola* larvae in unfavorable farms were found with a high level of prevalence in fish of different age groups. Thong plerocercoids were more commonly recorded in two-year-old silver and bighead carps and fingerlings of the grass carp. The highest level of cestode infection with *Bothriocephalus acheilognathi* was recorded in fingerlings of the grass carp. Parasitic crustaceans *Sinergasilus lieni* with a high level of prevalence were registered in two-year-old and three-year-old fish. Crustaceans *Lernaea cyprinacea* massively affected two-year-old and three-year-old fish.

3. Pathogens from the genera *Trichodina, Cryptobia,* and *Chilodonella*, and *Dactylogyrus hypophthalmichthys, Posthodiplostomum cuticola,* and *Sinergasilus lieni* were of the greatest epizootic significance for the silver carp; for the bighead carp — from the genus *Myxobolus,* (especially *M. pavlovskii*), *Chilodonella piscicola, Ichthyophthirius multifiliis, Dactylogyrus aristichthys, Posthodiplostomum cuticola, Diplostomum spathaceum, Digramma interrupta,* and *Sinergasilus lieni*; for the grass carp — *Bothriocephalus*

acheilognathi, Ichthyocotylurus variegatus, Ligula intestinalis, Sinergasilus major, Lernaea cyprinacea, Ichthyobodo necator, and *Ichthyophthirius multifiliis.*

Prospects for further research. The obtained results will help to increase the effectiveness of control of the epizootic situation, will allow more rapid and effective implementation of anti-epizootic measures, will justify the development of more effective treatment and prevention measures, which will improve the quality and safety of fishery products.

References

Bauer, O. N. (ed.) (1984) *Keys to Parasites of Freshwater Fish of the Fauna of the USSR. Volume 1. Parasitic Protozoa [Opredelitel' parazitov presnovodnykh ryb fauny SSSR. Tom 1. Parazitic heskie prosteyshie]* (3 vols). Leningrad: Nauka. [in Russian].

Bauer, O. N. (ed.) (1985) *Keys to Parasites of Freshwater Fish of the Fauna of the USSR. Volume 2. Parasitic Metazoa (Chapter 1) [Opredelitel' parazitov presnovodnykh ryb fauny SSSR. Tom 2. Parazitic heskie mnogokletochnye (Pervaya chast')]* (3 vols). Leningrad: Nauka. [in Russian].

Bauer, O. N. (ed.) (1987) *Keys to Parasites of Freshwater Fish of the Fauna of the USSR. Volume 3. Parasitic Metazoa (Chapter 2) [Opredelitel' parazitov presnovodnykh ryb fauny SSSR. Tom 3. Parazitic heskie mnogokletochnye (Vtoraya chast')]* (3 vols). Leningrad: Nauka. [in Russian].

Beretar', I. M. (2009) 'Parasite fauna of the silver carp in pond farms of Krasnodar Territory' [Parazitofauna belogo tolstolobika v prudovykh khozyaystvakh Krasnodarskogo kraya], *Veterinariya Kubani*, 5, pp. 14–16. Available at: https://www.elibrary.ru/item.asp?id=21279012. [in Russian].

Bykhovskaya-Pavlovskaya, I. Ye. (1985) *Fish Parasites [Parazity ryb]*. Leningrad: Nauka. [in Russian].

Davydov, O. N., Bazeev, R. E., Kurovskaya, L. Ya. and Temnikhanov, Yu. D. (2005) 'Changes in helminth number during introduction of herbivorous fish into Kiev water basin' [Izmeneniya chislennosti gel'mintov pri introduktsii rastitel'noyadnykh ryb v Kievskom vodokhranilishche], *Vestnik zoologii. Supplement*, 19(1), pp. 96–97. Available at: http://mail.izan.kiev.ua/vz-pdf/suppl/Supplement%202005-19-1.pdf. [in Russian].

Davydov, O. N., Neborachek, S. I., Kurovskaya, L. Ya. and Lysenko, V. N. (2011) *Ecology of Fish Parasites in Water-Bodies of Ukraine [Ekologiya parazitov ryb vodoemov Ukrainy]*. Kiev. ISBN 9789660262348. [in Russian].

Davydov, O. N., Kurovskaya, L. Ya., Neborachek, S. I. and Lysenko, V. N. (2012) 'Parasitofauna of phytophagous fishes in some cultivation regions' [Parazitofauna rastitel'noyadnykh ryb v nekotorykh regionakh kul'tivirovaniya], *Fisheries Science of Ukraine [Rybohospodarska nauka Ukrainy]*, 3–4, pp. 136–148. Available at: http://nbuv.gov.ua/UJRN/rnu_2012_3-4_30. [in Russian].

Dunn, A. M. and Hatcher, M. J. (2015) 'Parasites and biological invasions: Parallels, interactions, and control', *Trends in Parasitology*, 31(5), pp. 189–199. doi: 10.1016/j.pt.2014.12.003.

Katiukha, S. M. and Vozniuk, I. O. (2016) 'Spreading of parasitic diseases of fishes in the ponds of the Rivne Oblast' [Poshyrennia invaziinykh khvorob ryb u vodoimakh Rivnenskoi oblasti], *Veterinary Biotechnology [Veterynarna biotekhnolohiia]*, 28, pp. 94–101. Available at: http://nbuv.gov.ua/UJRN/vbtb_2016_28_12. [in Ukrainian].

Lysenko, A. A. (2003) 'Associated diseases of pond fishes in intensive fish-farming' [Assotsiativnye zabolevaniya prudovykh ryb pri intensivnom ryborazvedenii], *Veterinary [Veterinariya]*, 12, pp. 32–34. Available at: https://www.elibrary.ru/item.asp?id=16895268. [in Russian].

Lysenko, A. A. (2004) 'Associated diseases of fish during breeding in pond farms of the Krasnodar Territory' [Assotsiativnye zabolevaniya ryby pri razvedenii v prudovykh khozyaystvakh Krasnodarskogo kraya], *Proceedings of the Kuban State Agrarian University [Trudy Kubanskogo gosudarstvennogo agrarnogo universiteta]*, 406(434), pp. 57–61. [in Russian].

Markevich, A. P. (1951) *Parasite Fauna of Freshwater Fish of the Ukrainian SSR [Parazitofauna presnovodnykh ryb Ukrainskoy SSR]*. Kiev: Publishing House of the Academy of Sciences of Ukrainian. [in Russian].

Musselius, V. A. (1969) 'Parasites of phytophagous fish from the Far East cultivated in ponds of the European part of the USSR' [Parazity rastitel'noyadnykh ryb dal'nevostochnogo kompleksa pri vyrashchivanii v prudovykh khozyaystvakh Evropeyskoy chasti SSSR], *Parazitologiya*, 3(3), pp. 236–243. Available at: https://www.zin.ru/journals/parazitologiya/content/1969/prz_1969_3_8_Musselius.pdf. [in Russian].

Van Emden, H. F. (2019) *Statistics for Terrified Biologists*. 2nd ed. Hoboken, NJ: John Wiley & Sons. ISBN 9781119563679.

Vovk, P. S. (1976) *Biology of Far Eastern Herbivorous Fish and Their Economic Use in Water Bodies of Ukraine [Biologiya dal'nevostochnykh rastitel'noyadnykh ryb i ikh khozyaystvennoe ispol'zovanie v vodoemakh Ukrainy]*. Kiev: Naukova dumka. [in Russian].