Fish as a Cause of Diphyllobothriosis in the Population of Yakutia

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Abstract. High incidence of diphyllobothriosis in the middle reaches of the Lena river and all links of biocenotic relationships between potential intermediate, additional and definitive hosts prove the existence of a hotbed of *D. latum* in the study area. The circulation of the tapeworm follows the following pattern: human, carnivorous domestic animals – copepods – *Coregonus tugun* — human, carnivorous domestic animals. The main factor in the transmission of the invasive species is the traditional consumption of insufficiently disinfected salted fish by the population.

1. Introduction
The incidence of biogelminthiasis is of particular relevance to the Republic of Sakha (Yakutia), with the most common type being diphyllobothriosis that is a natural focal parasitosis. Human involvement in the economic activity of vast areas of Siberia with large reserves of valuable fish species, an increase in the share of fish and fish products in the diet of the region's population, and high rates of plerocercoid infestation of diphyllobothriids from the main fisheries reservoirs contribute to the spread of the disease among the population of the Republic. Foci of diphyllobothriosis are localized in the basins of the Lena, Kolyma, Indigirka and Vilyui rivers. [3; 6; 7] in the Republic of Sakha (Yakutia). Diphyllobothriosis is the second most common among fish-transmitted biohelminthiasis, accounting for 25% of the total incidence of biohelminthiasis in 2018 [2; 4; 8].

2. Materials and methods
The experimental part of the work was performed in the Department of "Parasitology and animal epizootology", in the ulus and veterinary research laboratories of Khangalassky, Namsky, Kobyaysky and in Yakutsk region in 2016–2019.

A retrospective analysis of the spread of diphyllobothriosis in the middle reaches of the Lena river was carried out on the basis of reports from the Republican center for state sanitary and epidemiological surveillance of the Republic of Saha (Yakutia) and regional health inspection services.

To identify the species composition of diphyllobothriid hosts, as well as their intermediate, additional, and definitive hosts, 26 zooplankton samples, 670 specimens of fish, 103 waterfowl fish-eating birds and 88 carnivorous animals were studied.

In order to study the environmental prerequisites for the creation of diphyllobothriosis foci, we studied the fauna of copepods in various types of reservoirs. To determine the species composition of copepods, determinants were used [1; 5].
To determine whether the fish were infected with plerocercoids of diphyllobothria, 714 specimens were researched belonging to 11 species: pike *Esox lucius* (Linne), perch *Perca fluviatilis* (Linne), ruff *Acerina cernua* (Linne), burbot *Lota lota* (Linne), tugun *Coregohus tugun lenesis* (Berg), Humpback whitefish *Coregohus lavaretus pidschian natio brachymystax* (Smitt), East Siberian grouse *Coregohus sardinella orientalis* (Kirillov), Arctic cisco *Coregohus autumnalis* (Pallas), muksun *Coregohus muksun* (Pallas), nelma *Stenodus leucichys nelma* (Pallas), grayling *Thymallus arcticus pallasii* (Valenciennes).

3. Results and discussion
In order to study the actual incidence of diphyllobothriosis in the Republic of Sakha (Yakutia), we conducted a retrospective analysis of the epidemiological situation based on statistical data from the accounting and reporting documentation of the Rospotrebnadzor Department for the Republic of Sakha (Yakutia) (according to form No. 1 "Information on infectious and parasitic diseases") for 2008–2018, "Maps of epidemiological examination of the focus of an infectious disease "(form No. 357/a), forms No. 2-18 "Information on the laboratories of sanitary-hygienic, microbiological and parasitological profile of federal budget health care institutions—centers of hygiene and epidemiology".

The most unfavorable in terms of morbidity are the uluses located in the middle reaches of the Lena rivers, where Yakutsk and its suburbs are located (989.8), Olekminsky (1075.9), Khangalassky (2909.1), Namsky (742.3), Kobyaysky (1473.1), Zhigansky (2363.6) uluses, and Kolyma–Srednekolymsky (602.2). In addition, in 11 uluses, the incidence rate is higher than the national average. Thus, in the ulus located in the middle reaches of the Lena river, the incidence of diphyllobothriosis exceeds the national average by 49.0–191.4 times, and the Kolyma river by 39.6 times.

When determining the composition of definitive hosts of diphyllobothriids in Central Yakutia, we studied 103 specimens of birds by incomplete helminthological dissection, including gulls (32 common gulls, 28 black-headed gulls and 2 Iceland gulls), terns (21 common terns and 3 black terns), 12 black-throated loons and 5 red-breasted mergansers, as well as 15 specimens of silver foxes kept in cages at the Pokrovskoe animal farm. 25 silver foxes, 21 cats, and 25 dogs were examined by coproovoscopic method. The analysis of the reporting data of the Yakut Republican veterinary testing laboratory was carried out. The highest incidence of diphyllobothriosis in dogs is observed in the lower reaches of large rivers. So, in Nizhnekolymsky ulus, the prevalence is 17.68%, in the Allakhovskoy it is 10.71%, in the Bulunsky — 7.62%, and in the Zhigansky — 3.57. In the middle reaches of the Lena river, it varies from 1.31 to 2.9%. In cats, there is no difference in the prevalence depending on the section of the Lena river and ranges from 5.88 to 6.12%. The incidence of fur-bearing animals in private farms averaged 3.03%, and the disease was not registered in state farms. The high infestation of dogs with diphyllobothriids in the lower reaches of large rivers is explained by the use of non – decontaminated wild species of fish for their food: pike, perch, burbot and ruff, as well as the entrails of whitefish.

Of the six bird species studied, *D. dendriticum* was found only in the common gull in the Kobyai ulus, with the prevalence of 46.1% and the intensity of infection (hereinafter referred to as *I*) of 3.33±0.7601. *D. ditremum* was found in the black-throated loon, the prevalence and the *I* were equal to 16.6% and 3.000±1.000 specimens respectively. *D. latum* is widely distributed among carnivorous domestic animals of the villages of Zhatay and Sangar. In the first village, the prevalence in dogs was 46.6% with the *I* of 3.142±0.404 specimens, and in the second – 30.0% and 3.500±0.500, respectively. The prevalence in cats in the village of Zhatay is 23.0%, the *I* – 2.0±0.577 copies, in the village of Sangar 12.5% and 2 copies, respectively. Thus, in the middle reaches of the Lena river, the diphyllobothriid species composition is represented by three species: *D. latum, D. dendriticum, and D. ditremum* in domestic carnivores and fish-eating birds. The first type was detected only in dogs and cats, the second only in the common gull, and the third in the black-throated loon.
To clarify the role of waterfowl in the distribution of diphyllobothriids, we studied the contents of their stomachs in the area of the village of Sangar in September during the mass fishing of Arctic cisco by the population. During this period, up to 10 tons of fish are caught per day, which is processed on the same day. All 39 gulls that were opened had only the entrails of fish in their stomachs. Fish-eating birds consuming the throw-away waste—remains of internal organs of fish—contributes to their intensive infection and preserves natural hotbeds of diphyllobothriosis.

To find out the fish of the main additional hosts of diphyllobothriids, we examined 670 specimens belonging to 11 species in the middle reaches of the Lena river in the area of Yakutsk, Khangalassky, Namsky and Kobyai uluses by a complete helminthological autopsy, including 84 pikes, 15 burbots, 113 perch, 48 ruffs, 15 graylings, 69 Arctic cisco, 12 muksuns, 27 grouses, 258 tuguns, 8 nelmas and 21 whitefish. Examination for diphyllobothriid larvae carried out for each fish species separately indicates a wide distribution of plerocercoids D. latum, D. dendriticum and D. ditremum on the Lena river:

**Pike.** The study of 84 specimens of pike caught in the middle reaches of the Lena river (Yakutsk district, Khangalassky, Namsky and Kobyai ulus) were found to be infected with D. latum plerocercoids in an average of 38.0% with the II of 3.76 specimens. The localization of plerocercoids in most cases is the same: the larvae were in a free state in the abdominal cavity, gonads, liver, and musculature.

**Perch.** The study of 113 specimens of perch found that the average rate of infection with D. latum plerocercoids is 13.2% with the II of 1-3 specimens. Data from Table 5 show that of the three uluses, the most infected are the perch of the Namsky ulus (34.1%).

**Tugun.** Out of the dissected 258 specimens, 21 tuguns were found to have diphyllobothriid plerocercoids, which accounted for 8.1% of the prevalence. Of these, 17 fish were found to have D. latum larvae with the II of 1-2 specimens, localized freely without capsules in the muscle tissue, and 4 fish – D. ditremum with the II of 1.5 specimens, located on the surface of the digestive tract in capsules.

**Humpback whitefish.** The study of 21 specimens showed that 14.2% of whitefish were found to be infected with D. ditremum larvae with the II of 1 specimen located in a capsule on the surface of the esophagus.

**Ruff.** The average infection rate of ruff with plerocercoids of Diphyllobothrium was 20.8%, and in Namsky ulus – 61.5% with the II of 1-2 specimens that had larvae located in the muscles and internal organs freely.

**Burbot.** 15 specimens of the burbot were examined, of which all turned out to be infected with larvae of the Diphyllobothrium, and the prevalence was 100%, the II was from 27.4 to 48.8 plerocercoids.

**Grayling.** Upon dissecting 15 specimens, all of them were found to be free of diphyllobothriid larvae.

**Semianadromous fish: Arctic cisco, muksun, European cisco, nelma** were studied in the area of the village of Sangar and downstream of the Lena river. 69 specimens of Arctic cisco, 12 muksun, 27 European cisco, 15 grayling and 8 nelma were dissected. D. latum plerocercoids were not found in any of the studies. Omul and muksun are infected with larvae of D. dendriticum (in the first the prevalence is 10.1%, the II is 1–3 specimens, and in the second one the prevalence is 33.3% and the II is 1–3 copies) and D. ditremum (in the first the prevalence is 55.0%, the II is 1–6 copies, in the second one the prevalence is 41.6% and the II is 1-2 copies). Only D. ditremum was found in the European cisco (the prevalence — 66.6%, the II 5–17 copies). According to the study, the white salmon and the grayling were not infected by difillobotrioz larvae.

4. **Conclusions**

According to a retrospective analysis of the incidence of diphyllobothriosis in the population of Yakutia, the highest rate of infestation is observed along the main channel of the middle course of the Lena river, which is 49.0–191.4 times higher than the average incidence in Russia.
Diphyllobothriasis carnivores are widespread in the territory of the Republic of Sakha (Yakutia). The highest incidence among dogs is observed in the lower reaches of the Lena, Kolyma and Indigirka rivers (the prevalence from 7.62 to 17.68%), in comparison with the average river flow (the prevalence from 1.31 to 2.9%). In cats, there are no differences in the prevalence depending on the section of the Lena river, and it ranges from 5.88 to 6.12%, while in fur-bearing animals, the disease is detected only in private farms with 3.03%.

On the territory of the middle reaches of the Lena river, the species composition of diphyllobothriids is represented by three species: *Diphyllobothrium latum*, *D. dendriticum* and *D. ditremum*. The extent of *D. dendriticum* infestation in the common gull is 46.1% with the II of 3.33±0.76 specimens, the extent of *D. ditremum* infestation in the black-throated loon is 16.6%, and the II is 3.00±1.00 specimens. The morphological characteristics of diphyllobothriids differ somewhat from those described by other authors in the distance of the scolex transition to the body, i.e. in the length of the neck.

In the middle reaches of the Lena river, the extent of fish invasion by diphyllobothriid plerocercoids ranges from 17.8 to 56.0%. The plerocercid fauna of the diphyllobothriids of the middle Lena river is represented by four types: type A — *D. latum*, type C — *D. dendriticum*, and types E and B — *D. ditremum*.

Additional hosts of *D. latum* are: pike with the prevalence of is 38.0% with the II of 3.76 copies. larvae; burbot with the prevalence of 100% and the II of 27.4 – 48.8 specimens; perch with the prevalence of 13.2% and the II of 1-3 specimens; ruff with the prevalence of 61.5% and the II of 1-2 specimens. and tugun with the prevalence of 8.1% and the II of 1-2 copies; for *D. dendriticum*: the Arctic cisco with the prevalence of 10.1% and the II of 1-3 copies; muksun with the prevalence of 33.3% and the II of 1-3 copies; for *D. detremum*: the Arctic cisco with the prevalence of 55.0% and the II of 2-6 copies; muksun with the prevalence of 41.6% and the II of 1-3 larvae; the European cisco with the prevalence of 66.6% and the II of 5-17 copies; humpback whitefish with the prevalence of 14.2% and the II of 1 specimen, and tugun with the prevalence of 1.5% and the II of 1 specimen of plerocercoid.

The leading epizootological role is played by 7 species of copepods: *Eudiaptomus gracilis*, *E. graciloides*, *Arctodiaptomus acutilodatus*, *A. dudichi*, *Cyclops strenuus*, *C. kolensis*, *C. insignis*. These species are widespread and common in the copepod fauna of the studied section of the Lena river.

The presence of a high incidence of diphyllobothriasis in the middle reaches of the Lena river and the presence of all links of biocenotic relationships proves the existence of a focus of *D. latum* in the study area. The circulation of the tapeworm follows the following pattern: human, carnivorous domestic animals – copepods – *Coregonus tugun* — human, carnivorous domestic animals. The main factor in the transmission of the invasive origin is the traditional consumption of salty tugun by the population processed using the local method. The main factor of infection of people with plerocercoids *D. dendriticum* is eating the internal fat of the Arctic cisco, the muksun and the broad whitefish when cutting fish.

5. References
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