Nematodes in fish of genus *Cottocomephorus* (Cottidae)

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Abstract. The data on the morphology and relative abundance of nematodes in bottom-pelagic cottids *Cottocomephorus grewingki* and *C. inermis* met in Lake Baikal are presented. Three species of nematodes (*Comephoronema werestschagini, Ichtiobronema hamulatum, Contracaecum osculatum baicalensis*) were found. The differences in cottids invasion with nematodes are shown.

1. Introduction
Yellowfin Baikal sculpin *Cottocomephorus grewingki* (Dybowski, 1874) and longfin Baikal sculpin *C. inermis* (Jakowlew, 1890) are endemic for Lake Baikal, they are met throughout the entire open area of the lake. They inhabit the zone with the depths ranging from 20-25 to 300 m [1]. The both species belong to Baikal bottom-pelagic fish, i.e., they are associated both with the lake pelagic zone and its bottom biocenoses. These cottids are an important element of the pelagic trophic system of Lake Baikal: juveniles are prey for omul *Coregonus migratorius*, and adults are eaten by whitefish *Coregonus baicalensis*, sturgeon *Acipenser baerii*, and Baikal seal *Phoca sibirica* [2].

The aim of this work was to determine the species composition, prevalence and morphology of the nematodes in cottocomephorids in Lake Baikal.

2. Materials and methods
The longfin and yellowfin Baikal sculpins were captured with gill nets at the depth of 50-100 m in Barguzinsky Bay (53°27’ N, 108°45’ E) in April 2018. The frozen fish was delivered to the laboratory, and examined using common parasitological techniques [3]. The standard length (SL) was measured, and the age was determined by otoliths [4]. The parasite species were identified using identification guides [5]. Total, 61 specimens were examined.

The prevalence (*P*, %), infection intensity represented by the limits (*I*, specimens (spec.)), and abundance (*A*, spec.) were used for the quantitative assessment of the infection [6]; the data are presented as mean and standard errors (M ± s.e.). The data were analysed using the Statistica 6.0 software package. The parasite distribution deviated from the normal one; therefore, the Nonparametric Statistics module was used. The comparison of the sculpin infection with certain helminth species by its abundance was carried out using the nonparametric Mann-Whitney criterion. For analysing the differences in the prevalence, the Fisher’s exact test was used.

3. Results and Discussion
Three species of Nematoda were found. In terms of the abundance index and the prevalence, the dominant species was *Contracaecum osculatum baicalensis*, the subdominant one was *Comephoronema werestschagini*, and the common one was *Ichtyobronema hamulatum* (table 1).
Table 1. The invasion of yellowfin (Y) and longfin (L) Baikal sculpins with nematodes.

| Species                                      | $P$, %     | $I$, sp. | $A$, sp. |
|----------------------------------------------|------------|----------|----------|
| Comephoronema werestschagini Layman, 1933    | 45.45 ± 13.53 | 1-58     | 5.45 ± 10.87 |
| Ichtiobronema hamulatum (Moulton, 1931)      | 27.27 ± 0.21 | 1-3      | 0.41 ± 9.72 |
| Contracaecum osculatum baicalensis Mozgovoi et Ryjkov, 1950 | 86.36 ± 5.97 | 1-22     | 6.27 ± 7.49  |

$P$ – prevalence, $I$ – intensity of invasion, min-max, $A$ – abundance, $n$ - the number of fishes examined.

The analysis of the invasion of the two species of cottocomephorids showed that yellowfin Baikal sculpin as a whole was more severely infested with nematodes (table 1): the extent of its invasion with C. o. baicalensis is higher than in longfin sculpin with a high level of confidence ($p < 0.001$), and the infestation of I. hamulatum – with the confidence level of $p < 0.01$.

C. o. baicalensis (figure 1) is an endemic subspecies that parasitizes teleost fish at the 3rd larval stage [7]. Its larvae are found in the connective tissue capsule in the serous membrane of the pyloric appendages and stomach, as well as freely in the body cavity. With the increase in the fish size and age, the infection with C. o. baicalensis increases [8]. Previously, it was shown that the life cycle can be completed with the participation of an optional paratenic host – an invertebrate and only one intermediate fish host [9]. The definitive host C. o. baicalensis is Baikal seal Phoca sibirica (Gmelin, 1788) [10-12]. The life cycle of the nematode in Lake Baikal has not been identified; it is assumed that the paratenic host is Macrohectopus branickii [10]. The intermediate hosts for C. o. baicalensis are 16 fish species [13]. Probably the infestation of sculpins also occurs directly upon contacting 3rd stage larvae.

![Figure 1. Contracaecum osculatum baicalensis](image)

The life cycle of the endemic nematode C. werestschagini (figure 2) has not been studied [13]. Its geographical range is limited to Lake Baikal. It is most often reported for endemic cottids [7, 14]. The intermediate hosts of the related species C. oschmarini are gammarus Pallasea quadrispinosa and Echinogammarus baicalensis [13]. Probably amphipods, possibly pelagic species M. branickii, are also intermediate hosts in Lake Baikal, since this pelagic amphipod is most often found among the food of long-winged sculpin adults [14-16]. The nematode C. werestschagini is usually localized in the sculpin stomachs.
Figure 2. Comephoronema werestschagini: a – anterior end, b – posterior end.

The life cycle of *I. hamulatum* has not been studied [13]. *I. hamulatum* spreads throughout the Holactic and occurs in lotid fish, it is reported in freshwater scorpeniform fishes, in particular, in Lake Baikal [11, 18]. It is assumed that benthic invertebrates play the role of their first intermediate hosts (Diptera, Ephemeroptera) [13]. The low infestation of longfin sculpin with *I. hamulatum* is explained by the fact that this species inhabiting the water column of the pelagic zone of Lake Baikal visits the shallow water for spawning only. *Ichthiobronema hamulatum* is found in the intestines of the hosts.

Among the nematode fauna, *C. werestschagini* is an endemic species, *C. osculatum baicalensis* is an endemic subspecies, and *I. hamulatum* is a widespread (Holarctic) species.

The differences in the level of the infection with different nematode species reflect the differences in the host diet. The main food component of yellowfin is mesozooplankton, predominantly *Epischura baicalensis*. The food spectrum of long-winged sculpins primarily consists of macrohectopus and juvenile pelagic cottids. The importance of bottom amphipods and insects in the food is not high [16].

The highest is the number of nematodes with the complex cycle, for which planktonic organisms are the intermediate hosts. The number of helminths associated in their development with benthic organisms is much lower.

4. Conclusions
In conclusion, in Lake Baikal bottom-pelagic cottids *Cottocompeorus grewingki* and *C. inermis* are infested with three species of nematodes: *Comephoronema werestschagini*, *Ichthiobronema hamulatum*, *Contracaecum osculatum baicalensis*.

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References
[1] Taliev D N 1955 *European Bullheads from the Baikal Lake [Bychki-podkamenshchiki Baikala] (Moscow: AS USSR) p 602
[2] Sideleva V G and Kozlova T A 1989 Adaptation of Cottoidei fishes to pelagic conditions of Lake Baikal *Dokl. Akad. Nauk SSSR* 309(6) 1499–501
[3] Bykhovskaya-Pavlovskaya I E 1985 *Fish Parasites: a Study Guide [Parazity ryb. Rukovodstvo po izucheniyu] (Leningrad: Nauka) p 123
[4] Pravdin I F 1966 *Fish Study Guide [Rukovodstvo po izucheniyu ryb] (Moscow: Pishchevaya Promyshlennost) p 376
[5] Keys to Parasites of Freshwater Fish of the Fauna of the USSR [Opredelitel' Parazitov Presnovodnykh Ryb Fauny SSSR] 1987 Parasitic Multicellulars (Leningrad: Nauka) 2 p 428
[6] Bush A O, Lafferty R D, Lotz J M and Shostak A W 1997 Parasitology meets ecology on its own terms: Margolis et al. revisited J. Parasitol. 83(4) 575–83
[7] Zaika V 1965 The Parasite Fauna of Fishes of Lake Baikal (Moscow: Nauka) p 107
[8] Baldanova D R, Khamnueva T R, Tsyrendylykova M Ts, Konovalova V V and Dugarov Zh N 2020 Age dynamics of helminth fauna in longfin Baikal sculpin Cottocomephorus inermis (Cottidae) Journal of Ichthyology 60(2) 339–43
[9] Koie M and Fagerholm H P 1995 The life cycle of Contracaecum osculatum (Rudolphi, 1802) sensu stricto (Nematoda, Ascaridoidea, Anisakidae) in view of experimental infections Parasitol. Res. 81(6) 481–9
[10] Dynamics of Animal Helminth Infestation [Dinamika zarazhennosti zhivotnykh gel'mintami] 1991 (Ulan-Ude: BSC SB RAS) p 202
[11] An Annotated List of the Fauna of Lake Baikal and its Catchment Area 2001 ed O A Timoshkin et al. 1 (Novosibirsk: Nauka) p 832
[12] Pronin N M et al. 2007 Fishes of Lake Baikal and its Basin 2007 (Ulan-Ude: BSC SB RAS) p 284
[13] Pugachev O N 2004 Catalogue of Freshwater Fish Parasites of Northern Asia: Nematodes, Acanthocephalans, Leeches, Mollusks, Crustaceans, and Ticks (St. Petersburg: Zoological Institute RAS) p 250
[14] Sokolov S G, Voropaeva E L and Malysheva S V 2019 Redescription and molecular characterisation of Comephoronema werestschagini Layman, 1933 (Nematoda: Cystidicolidae) from the endemic Baikal fish Cottocomephorus grewingkii (Dybowski, 1874) (Scorpaeniformes: Cottocomephoridae) with some comments on cystidicolid phylogeny Russian Journal of Nematology 27(1) 57–66
[15] Sideleva V G and Mekhanikova I V 1990 Food specialization and evolution of the Cottoidei fishes from Lake Baikal Proc. of Zoological Institute, AS USSR 222 144–61
[16] Zubin A A 1992 Feeding of Baikal benthopelagic scorpaeniformes fishes (Cottoidei) Voprosy Ikhtiologii 32(1) 147–51
[17] Sideleva V G and Kozlova T A 2010 The comparative study of endemic cottoid fishes (Cottoidei, Comephoridae) and their adaptation to pelagic habitat in Lake Baikal Proc. of Zoological Institute, AS USSR 314(4) 433–47
[18] Sokolov S G and Malysheva S V 2017 Molecular characterization of Ichtyobronema hamulatum (Moulton, 1931) (Nematoda: Quimperiidae), a common parasite of burbot Lota lota (Linnaeus) (Actinopterygii: Lotidae) Helminthologia 54(3) 183–8