ISSN 2075-1117, Russian Journal of Biological Invasions, 2016, Vol. 7, No. 2, pp. 200–204. © Pleiades Publishing, Ltd., 2016.
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The First Finding of *Apophallus müehlingi* (Jägerskiöld, 1899) Lühe, 1909 (Trematoda, Heterophyidae) in Karelia

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Received August 2, 2014

Abstract—Data on the finding of *Apophallus müehlingi* (Jägerskiöld, 1899) Lühe, 1909 in gulls of Lake Ladoga and its morphological characteristics are provided for the first time. In common gull (*Larus canus*), this parasite occurred more often. In little gull (*L. minutus*), trematodes were single specimens. Mature *A. müehlingi* are registered only in these gull species during the spring period, immediately after their return from the wintering areas. Detection of the parasite indicates a potential environmental threat. To date, *A. müehlingi* is found only in the definitive host. However, the penetration of gastropods *Lithoglyphus naticoides* Pfeiffer, 1828, the parasite's first intermediate host, into Lake Ladoga will form favorable conditions for the life cycle of the parasite. This may lead to the epizooty of fish by *A. müehlingi*.

Keywords: Apophallus müehlingi, gulls, biological invasions, invaders, South Karelia
DOI: 10.1134/S2075111716020144

INTRODUCTION

Biological invasions of alien species is an important problem of fundamental and applied research, which has been closely monitored by various researchers, including parasitologists, because the number of parasitic invaders penetrating into aquatic ecosystems has increased in recent years (Zhokhov and Pugacheva, 2001; Yakovleva and Yakovlev, 2010; Ieshko et al., 2012; Evlanov et al., 2013; Sokolov et al., 2013). Spreading of fish parasites outside their natural range may lead to the epizooty and death of native fish species lacking adaptation to such new parasites (Lutta, 1941; Johnsen and Jensen; 1986; Ieshko et al., 2008). Parasites may spread with their hosts during habitat expansion (Sokolov et al., 2013; Ieshko et al., 2013). Thus, European bullhead (*Cottus gobio* L.) has become widespread within the lake-river system of the Teno River (North Finland) after 20 years. The invasion of *C. gobio* resulted in structural changes in the fish community and trophic relations of fish in the water body. *Apatemon gracilis* (Rudolphi, 1819) Szidat, 1928, which occurred in the river with the host, turned out to be the dominant parasite of fish inhabiting this river (Ieshko et al., 2012).

Trematodes of waterfowl birds play a special role in the understanding of range dynamics among parasites and formation of new helminthiasis foci. The range of these parasites depends not only on the territory where their definitive hosts live but also on the obligatory presence of some snails as the first intermediate hosts. In particular cases, mature trematodes are carried by birds, but their life cycle is not realized, because the intermediate hosts are not present in a new water body.

As shown in a number of works (Biserova, 1990, 2005; Zhokhov and Pugacheva, 2001; Tyutin and Slyn'ko, 2008), there are several trematode species which penetrated into the Middle and Lower Volga through the Volga–Don Canal. Special attention should be paid for two species, *Rossicotrema donicus* Skrjabin & Lindtrop, 1919 and *Apophallus müehlingi*, being pathogenic to fish. These new helminthiasis foci developed owing to the migrations of the first intermediate hosts of helminths in the 1960s. They were mollusks *Lithoglyphus naticoides* and *L. pyramidatus* Möllendorff, 1873 (Gastropoda: Lithoglyphidae) from the Black Sea region. As shown by research (Semenova and Ivanov, 1989), it took trematodes 30 years from the invasion of the mollusks to dominate in the helminth fauna and to have high infestation rates of fish. During mass infestation, *A. müehlingi* can cause a black spot disease of young fish—apophallesis (Biserova, 1990, 2005).

Therefore, the presented data are very important for development of the classical views in parasitology on possible causes, rates, and consequences of the distribution of parasites, such as *A. müehlingi* (Zhokhov and Pugacheva, 2001; Tyutin and Slyn'ko, 2008; Tyutin and Izvekova, 2013). Anthropological transformation of the drainage system, construction of channels, and change in the historically developed water routes can have serious ecological consequences. The accumulated knowledge reveals the key factors in forma-

tion of the natural helminthiasis foci. As mentioned in (Zhokhov and Pugacheva, 2001), waterfowl birds and migratory fish could have much earlier brought *A. müehlingi* to the Volga River, but a stable focus developed only after the penetration of *Lithoglyphus naticoides*, the first intermediate host, which is the key element in the life cycle of the parasite.

This paper provides the first data on the occurrence of *Apophallus müehlingi* in gulls of Lake Ladoga, reveals the main role of particular host species in potential distribution of the parasites, and presents the morhological description of trematodes. This research is an important stage in the monitoring of the dynamics of the parasite expansion in Northwest Russia. We consider the fact that the prospects for spreading of *Lithoglyphus* through smaller rivers of the Upper Volga region and for penetration into the basin of Lake Ladoga are real (Tyutin and Slyn'ko, 2008).

MATERIALS AND METHODS

The following seven bird species of the family Laridae were studied: little gull *Larus minutus* Pallas, 1776 (14 specimens (sp.)), common gull *L. canus* Linnaeus, 1758 (13 sp.), common tern *Sterna hirundo* Linnaeus, 1758 (8 sp.), Arctic tern *S. paradisaea* Pontoppidan, 1763 (4 sp.), black-headed gull *L. ridibundus* Linnaeus, 1758 (2 sp.), European herring gull *L. argentatus* Pontoppidan, 1763 (1 sp.), and lesser black-backed gull *L. fuscus* Linnaeus, 1758 (1 sp.). All birds were captured in May 2012–2014 during the spring hunting season on the southeastern shore of Lake Ladoga (South Karelia). Some birds were collected by fishermen from fishing gear, i.e., birds that were entangled in cages or stationary nets and died.

Sampling, fixation, and laboratory inspection of the parasitological material were performed by the standard methods (Dubinina, 1971). Helminths were identified using the following keys: *Opredelitel' trematod...* (Guide to Trematodes) (1986), Movsesyan et al. (2004). The morphological description of the species is based on measurements of 16 fixed stained helminths, which were represented by only mature specimens.

Microscopic examination and measurements of the parasites were performed using a microscope Olympus CX–41 and the software Levenhuk ToupView v. 3.5 (V. Levenhuk in Scientific Center of the collective usage platform (Institute of Biology, Karelian Research Centre of the Russian Academy of Sciences).

RESULTS AND DISCUSSION

Having studied the parasitic fauna of birds during the spring period on the southeastern shore of Lake Ladoga for three years, we registered *Apophallus müehlingi* trematodes. All parasites were mature maritae. This fact may indicate that the gulls were infected with

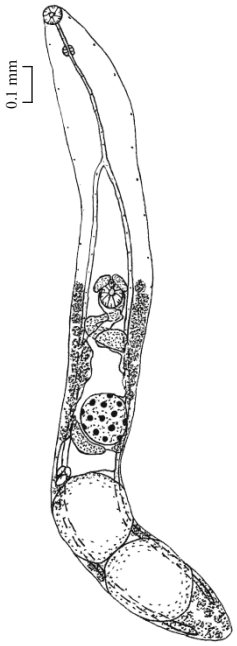

Fig. 1. *Apophallus müehlingi* (orig.), common gull (*Larus canus*), Lake Ladoga, Karelia.

A. müehlingi trematodes in their wintering areas or during migrations.

Among all bird specimens under study, *A. müehlingi* was found in *L. canus* and *L. minutus* (Figs. 1 and 2). In the case of *L. canus*, 3 of 13 specimens (2–85 worms) were invaded. As for *L. minutus*, 1 of 14 specimens (13 worms) was infected. This pattern of invasion is associated with the feeding habits of birds. The diet of *L. canus* is based on fish, whereas *L. minutus* prefers aquatic invertebrates and small fish (Il'ichev and Zubakin, 1988; Zimin et al., 1993; Sazonov, 2011). The second intermediate hosts of *A. müehlingi* are cyprinid and percid fish (Biserova, 1989, 1990, 2005). On the basis of these factors, it can be suggested that *L. canus* is the main disseminator of *A. müehlingi* in Karelia.

The morphological characteristics of helminths from different hosts were similar, but their sizes were different (see table). Larger worms were registered in *L. canus*. This may be associated with the size of the host, i.e., the larger the bird, the larger the helminths found in it.

We cannot say with certainty that this parasite develops in Lake Ladoga, because there are no data in the literature on any findings of its first intermediate host (mollusks of the genus *Lithoglyphus*) in the fauna of the water body (Aleksandrov, 1965; Sokolova, 1965; *Ladozhskoe ozero...*, 2000; *Raznoobrazie bioty Karelii...*, 2003). Metacercariae of the parasite have not been found as yet in fish from Lake Ladoga (Lebedeva, 2005; Rumyantsev, 2007; Rumyantsev and Mamontova, 2008; Lebedeva and Ieshko, 2009). At

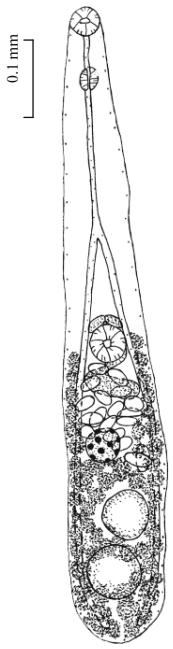

Fig. 2. *Apophallus müehlingi* (orig.), little gull (*Larus minutus*), Lake Ladoga, Karelia.

the same time, the parasite occurs in many cyprinid species from water bodies of the Volga region and smaller rivers of the Baltic coast (Sudarikov et al., 2002; Biserova, 2005; Sitko et al., 2006). Thus, this helminth species is currently considered as an alien one for the water area of Lake Ladoga.

According to Tyutin and Slyn'ko (2008), *Apophallus müehlingi* trematodes are the most representative biological "mark" of mollusks in a new water body, because "the direct result of host specifics of partheni-tae in many trematode species is almost complete overlapping of their ranges with the ranges of hosting mollusks."

From this point of view, an additional factor indicating possible development of *Apophallus müehlingi* in the system of Lake Ladoga is the finding of *Parasymphylodora markewitschi* Kulakowskaja, 1947 in the following three fish species inhabiting this water body: roach (*Rutilus rutilus* L., 1758), ide (*Leuciscus idus* L., 1758), and chub (*Squalius cephalus* L., 1758) (Lebedeva, 2006). Both parasitic species use the same hosts and were found in *Lithoglyphus naticoides* from the system of the Volga River when the foci of apophallesis were investigated (Tyutin and Slyn'ko, 2008).

Sizes of the maritae of *A. müehlingi* from different hosts (mm)

Characteristics*	Host	
	L. canus	*L. minutus*
Body length	1.406–2.016 (1.719)	0.741–1.254 (0.946)
Body width	0.201–0.270 (0.232)	0.114–0.160 (0.138)
Length of oral sucker	0.028–0.046 (0.038)	0.023–0.034 (0.028)
Width of oral sucker	0.035–0.056 (0.044)	0.030–0.043 (0.038)
Pharynx length	0.027–0.045 (0.034)	0.019–0.030 (0.024)
Pharynx width	0.019–0.034 (0.026)	0.016–0.024 (0.021)
Length of ventral sucker	0.040–0.071 (0.059)	0.028–0.049 (0.039)
Width of ventral sucker	0.038–0.070 (0.055)	0.028–0.044 (0.038)
Length of genital papilla	0.022–0.042 (0.032)	0.013–0.026 (0.020)
Width of genital papilla	0.011–0.025 (0.017)	0.009–0.017 (0.013)
Length of anterior testis	0.135–0.205 (0.173)	0.054–0.107 (0.083)
Width of anterior testis	0.120–0.168 (0.143)	0.050–0.110 (0.081)
Length of posterior testis	0.140–0.229 (0.182)	0.066–0.127 (0.095)
Width of posterior testis	0.120–0.170 (0.148)	0.054–0.123 (0.091)
Ovary length	0.069–0.121 (0.100)	0.032–0.085 (0.065)
Ovary width	0.072–0.124 (0.097)	0.031–0.084 (0.065)
Egg length	0.028–0.038 (0.033)	0.035–0.040 (0.037)
Egg width	0.015–0.021 (0.018)	0.013–0.020 (0.017)
Number of worm specimens	10	6

* Average values of the characteristics are given in brackets.

Considering the fact that mollusks of the genus *Lithoglyphus* have rapidly colonized the system of the Volga River in the 20th century, one can expect that they will move further northwards, into the basin of Lakes Ladoga and Onega. Thus, favorable conditions will develop for realization of the life cycle of *Apophallus müehlingi*, an invasive species of trematodes.

Successful ranges expansion of *A. müehlingi* is also promoted by birds and mammals carrying mature maritae, which were registered by us. Possibly, as birds in the water area of Lake Ladoga are studied further, new species of the definitive hosts for *A. müehlingi* will be found, because the set of hosts for this parasite is larger in other regions. In Vologda oblast, *A. müehlingi* was registered in *L. argentatus*, in addition to *L. canus* (Shabunov and Radchenko, 2003). In the Czech Republic and Slovakia, the parasite was carried by *L. argentatus*, *L. canus*, *L. ridibundus*, and *Phalacrocorax* (Sitko et al., 2006).

Data obtained on the occurrence of the new alien invader, one of the most invasive species among trematodes, in Karelia show that there is an urgent need for further detailed research on the distribution of new hydrobionts in Lake Ladoga.

ACKNOWLEDGMENTS

This study was financially supported from funds of the Russian federal budget for state assignment (theme no. 0221-2014-0004), as well as by grants of the President of the Russian Federation (project no. MK-5350.2015.4) and the Russian Foundation for Basic Research (project no. 14-34-50729).

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Translated by N. Shulaev