Invertebrate Zoology, 2014, 11(2): 353–359

The first record of Monogenea (Plathelminthes) parasitic on char (Salmonidae: *Salvelinus*) from Kronotsky Lake (Kamchatka Peninsula), Russia

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ABSTRACT: Monogeneans are recorded as parasites of fishes in Kronotsky Lake for the first time. *Salmonchus* sp., *Gyrodactylus birmani* and *Gyrodactylus* sp. were found in char. *Salmonchus* sp. is similar to *Salmonchus alaskensis* (Price, 1937) and *Salmonchus grumosus* (Pugachev, 1984), but cannot be unambiguously identified as one of them. *Gyrodactylus* sp. is similar to *Gyrodactylus brachymystacis* Ergens, 1978 sensu You et al., 2006 in many features but different in details of the marginal hook sickle morphology.
How to cite this article: Sokolov S.G., Gordeev I.I. 2014. The first record of Monogenea (Plathelminthes) parasitic on char (Salmonidae: *Salvelinus*) from Kronotsky Lake (Kamchatka Peninsula), Russia // Invert. Zool. Vol.11. No.2. P.353–359.

KEY WORDS: *Salmonchus, Gyrodactylus birmani*, *Salvelinus albus*, *Salvelinus shmidti*, Kamchatka Peninsula, Kronotsky Lake.

Первые данные о моногенеях гольцов (Salmonidae: *Salvelinus*) оз. Кроноцкое (Камчатка)

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РЕЗЮМЕ: Моногенеи впервые отмечаются для фауны паразитов рыб оз. Кроноцкое. У гольцов отмечены *Salmonchus* sp., *Gyrodactylus birmani* и *Gyrodactylus* sp. *Salmonchus* sp. сходен с *Salmonchus alaskensis* (Price, 1937) и *Salmonchus grumosus* (Pugachev, 1984), но не может быть однозначно отнесен ни к одному из них. *Gyrodactylus* sp. по многим признакам сходен с *G. brachymystacis* Ergens, 1978 sensu You et al., 2006 от лососевых рыб Китая, но отличается деталями строения собственно крючка краевых крючьев.
Как цитировать эту статью: Sokolov S.G., Gordeev I.I. 2014. The first record of Monogenea (Plathelminthes) parasitic on char (Salmonidae: *Salvelinus*) from Kronotsky Lake (Kamchatka Peninsula), Russia // Invert. Zool. Vol.11. No.2. P.353–359.

КЛЮЧЕВЫЕ СЛОВА: *Salmonchus*, *Gyrodactylus birmani*, *Salvelinus albus*, *Salvelinus shmidti*, Камчатка, оз. Кроноцкое.

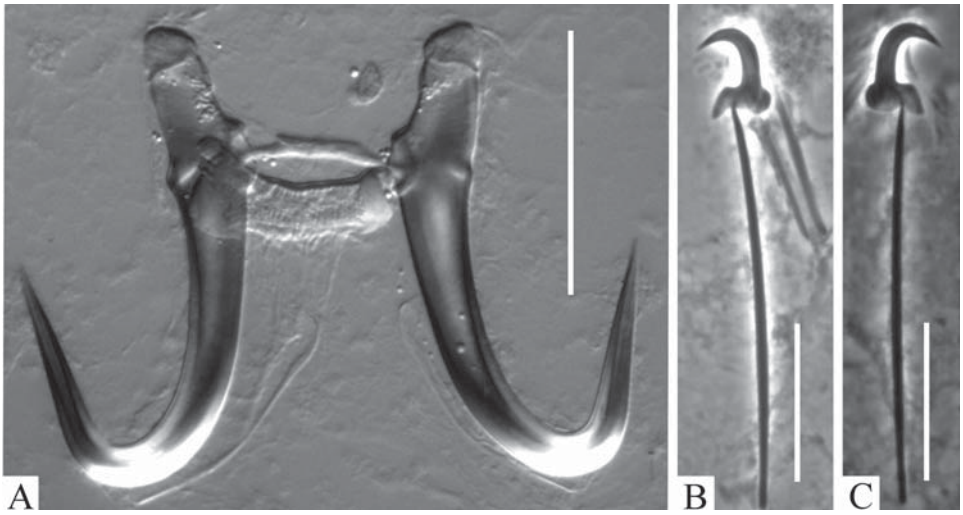

Fig. 1. *Gyrodactylus birmani*.
A — hamuli; B, C — marginal hooks. Scale bars: A — 45 μm; B, C — 15 μm.
Рис. 1. *Gyrodactylus birmani*.
A — срединные крючья; B, C — краевые крючья. Масштаб: A — 45 мкм; B, C — 15 мкм.

Introduction

Kronotsky Lake is the largest area of freshwater in the Kamchatka Peninsula, Russia. The ichthyofauna of this lake comprises resident sockeye salmon (kokanee salmon) O*ncorhynchus nerka kennerlyi* Suckley, 1861 and three species of char with ambiguous taxonomical position: *Salvelinus albus* Glubokovsky, 1977, *S. cronocius* Viktorovsky, 1978 and *S. shmidti* Viktorovsky, 1978. There are many sources where different authors have diametrically opposed opinions about the systematic position of these species (Victorovsky, 1978; Savvaitova, 1989; Chereshnev et al., 2002; Ostberg et al., 2009 etc). *Salvelinus cronocius* and *S. shmidti* are endemic in this lake. The Kronotskaya River is the only river that takes its source from the lake and connects the lake with the Kronotsky Gulf of the Pacific Ocean. Fast and turbulent rapids are a natural obstacle for fishes travelling upstream to the lake. According to Victorovsky (1978), Parensky et al. (2004) and other authors, source and the upper part of the Kronotskaya River are inhabited by resident *S. malma* (Walbaum, 1792) and a peculiar dwarf form of *S. malma* (Pavlov et al, 2012).

Repeated investigations of the parasitofauna of the Kronotsky fishes reliably recorded 21 species of parasites of different taxa (Zschokke & Heitz, 1914; Kurenkov, 1977; Butorina et al., 1980, 2008; Butorina, 2003; Atrashkevich et al., 2005), but no monogeneans were found. At the same time representatives of this group of ectoparasitic flatworms are regularly found on salmonid fish from other water bodies of the Kamchatka Peninsula (Konovalov, 1971; Pugachev, 1983; Butorina et al., 2011; Busarova, 2012; etc). The present work records data on monogeneans of the Kronotsky Lake.

Materials and methods

Seven individuals of *S. albus* (Fork length, FL=435–666 mm), 22 individuals of *S. shmidti* (FL =206–446 mm) and 1 individual of *S. cronocius* (FL =580 mm) from the south-east part of the Kronotsky Lake (54°43′0.6″N; 160°21′45.5″ E) were examined from June 20 to August 15, 2011. Monogeneans were found only in *S. albus* and *S. shmidti*. All monogenean specimens were mounted in glycerin-gelatin, following Gussev

Fig. 2. *Gyrodactylus* sp.
A — hamuli; B — ventral bar; C, D — marginal hook sickles. Scale bars: A — 40 μm; B — 17 μm; C, D — 6 μm.
Рис. 2. *Gyrodactylus* sp.
A — срединные крючья; B — брюшная соединительная пластинка; C, D – собственно крючки краевых крючьев. Масштаб: A — 40 мкм; B — 17 мкм; C, D — 6 мкм.

(1983), and were studied using a research microscope with phase-contrast and DIC.

Dimensions of the hard parts of the haptors of monogeneans of the genus *Gyrodactylus* Nordmann, 1832 were obtained in accordance with Ergens (1985), with the following proposed by Shinn et al. (2004): marginal hook sickle distal width and marginal hook sickle aperture distance. The measurements and terminology of sclerotized structures of *Salmonchus* sp. are given according to Pugachev (1984).

Results and discussion

The monogeneans *Gyrodactylus birmani* Konovalov, 1967, *Gyrodactylus* sp. and *Salmonchus* sp. (Table 1; Figs. 1–4) were found in char from Kronotsky Lake. Haptor hard parts of

Table 1. Occurrence of monogeneans in char in Kronotsky Lake.
Таблица 1. Встречаемость моногеней у гольцов озера Кроноцкое.

Monogeneans/ Виды моногеней	Site of infection/ Локализация	Hosts and indexes of infection: prevalence (P), infection intensity (I)/ Хозяин и показатели зараженности: экстенсивность (P), интенсивность (I)	
		Salvelinus albus n=7	*Salvelinus shmidti* n=22
Salmonchus sp.	gills/ жабры	–	(P) in 2 from 22 (9.1%) (I)1–2
Gyrodactylus birmani	fins, nasal fossae/ плавники, носовые ямки	(P) in 5 from 7 (I) 6–109	(P) in 3 from 22 (13.6%) (I) 3–16
Gyrodactylus sp.	fins/ плавники	–	(P) in 1 from 22 (4.5%) (I)1

Gyrodactylus sp. are as follows: total length of hamuli 86 and 89 μm, root — 34 μm, shaft — 66 and 67 μm, point — 44 μm; ventral bar — 37 × 46 μm, ventral bar membrane length — 23 μm, marginal hook total length — 46–47 μm, marginal hook sickle length — 10 μm, length of base of marginal hook sickle — 3 μm, width of base of marginal hook sickle — 6–7 μm, marginal hook sickle distal width — 8 μm and marginal hook sickle aperture distance — 9 μm. Edge of marginal hook sickle with two bends (in middle part of sickle shaft and on the boundary of sickle point and sickle shaft) (Fig. 2, 3).

Only one of the three found specimens of *Salmonchus* sp. was adult. Unfortunately, its dorsal and ventral anchors were not located strictly lateral on the slide. Dorsal anchors: inner length — 87 and 94 μm, outer length — 109 and 112 μm, length of main part — 72 and 78 μm, blade — 36 and 33 μm. Ventral anchors: inner length — 68 and 70 μm, outer length — 95 and no data (broken), length of main part — 61 and 74 μm, blade — 40 and 39 μm. Marginal hooks: total length — 16–17 μm, length of handle — 8–9 μm. Size of connecting bar — 26 × 44 μm. Tube of copulatory organ 104 μm long, supporting apparatus 84 μm long.

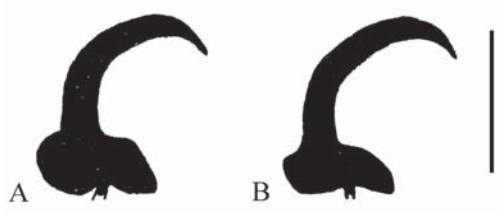

Fig. 3. Marginal hook sickles.
A — *Gyrodactylus* sp.; B — *G. brachymystacis* Ergens, 1978 sensu You et al., 2006 (after You et al., 2006). Scale bar 8 μm.
Рис. 3. Собственно крючки краевых крючьев.
A — *Gyrodactylus* sp.; B — *G. brachymystacis* Ergens, 1978 sensu You et al., 2006 (из: You et al., 2006). Масштаб 8 мкм.

Gyrodactylus birmani in the water bodies of the Kamchatka Peninsula was recorded mainly as a parasite of Dolly Varden (Konovalov, 1971; Butorina et al., 1980 etc). Butorina (2003) recorded this parasite from *S. albus* from the Azabache Lake and Karmanova (1998) found this parasite on Pacific salmon parr in the Paratunka River basin.

In the Holarctic region more than 15 species of the genus *Gyrodactylus* show a specifity for salmonid fish (Ergens, 1985; Beverley-Burton, 1984; Ogawa, 1986; Moravec, 2004; Malmberg et al., 2007; Kuusela et al., 2008 etc). Moreover, non-specific species of *Gyrodactylus* are also found in these fishes, and their obligatory hosts are fishes from other families. But in Kronotsky Lake, its feeders and in the upper reaches of the Kronotskaya River there are only char and kokanee salmon (Victorovsky, 1978 etñ). Thus, the *Gyrodactylus* sp. recorded by us could have only salmonid fish as the obligatory hosts. Among species from the genus *Gyrodactylus* that are host-specific for salmonid fish only *G. lenoki* Gussev, 1953, *G. asiaticus* Ergens, 1978 and *G.*

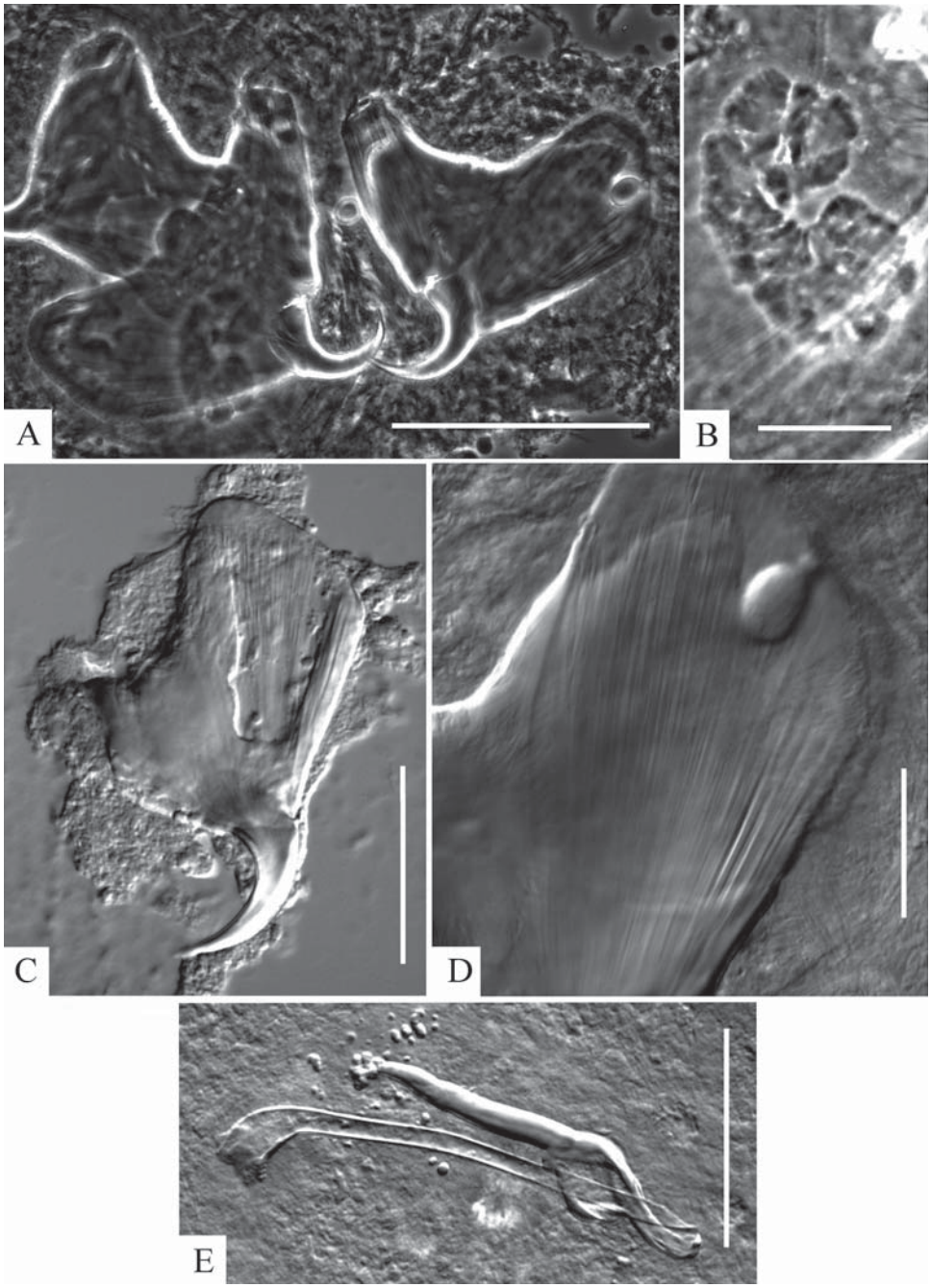

Fig. 4. *Salmonchus* sp.

A — dorsal anchors; B — connecting bar; C — ventral anchor; D — surface of basal part of dorsal anchor; E — copulatory organ. Scale bars: A — 80 μm; B, D — 20 μm; C — 45 μm; E — 50 μm.

Рис. 4. *Salmonchus* sp.

A — спинные срединные крючья; B — соединительная пластинка; C — брюшной срединный крючок; D — поверхность базальной части спинного срединного крючка; E — копулятивный орган. Масштаб: A — 80 мкм; B, D — 20 мкм; C — 45 мкм; E — 50 мкм.

brachymystacis Ergens, 1978 sensu You et al., 2006 have edge of marginal hook sickles with two bends. With regard to the length and configuration of the marginal hook sickle, the length of the hamuli and its other dimensions, and the shape and size of the ventral bar, *Gyrodactylus* sp. is similar to *G. branchymystacis* Ergens, 1978 sensu You et al., 2006, that is recorded as a parasite of *Parasalmo mykiss* (Walbaum, 1792) and *Brachymystax lenok* (Pallas, 1773) in China (You et al., 2006, 2008; Sun et al., 2008). However, the marginal hook sickles of *Gyrodactylus* sp. have a larger base and, accordingly, a narrower aperture in comparison with *G. brachymystacis* Ergens, 1978 sensu You et al., 2006 (Fig. 3). There are differences between these parasites in the shape of the hamulus root, but they are not significant. *Gyrodactylus* sp. may be a new species, but this could not be confirmed because the sample of specimens of *Gyrodactylus* sp. was too small. In turn, taxonomic identity of *G. brachymystacis* sensu You et al., 2006 and *G. brachymystacis* Ergens, 1978 s. str. is very doubtful due to differences between these parasites in the shape of the marginal hook sickle. The drawings of Ergens (1978, 1985) and the holotype photograph in You et al. (2006) show that the edge of marginal hook sickles of *G brachymystacis* s. str. smoothly rounded.

Salmonchus sp. is similar to *Salmonchus alaskensis* (Price, 1937) and *S. grumosus* (Pugachev, 1984) on morphology of the copulatory organ, connecting bar, shape of anchors and striation of their basal parts, but could not be unambiguously identified as one of them. Shape of the proximal part copulatory organ's tube and little length marginal hook handle make *Salmonchus* sp. similar to *S. alaskensis*. At the same time short internal processes of ventral anchors make this parasite similar to *S. grumosus*. Unfortunately, we could not found fan-shaped plates which are of great taxonomical importance (Gussev, Pugachev, 1985). Only one species from genus *Salmonchus* Spassky et Roytman, 1958 — *S. alaskensis* was earlier found in fishes of the Peninsula (Konovalov, 1971; Butorina et al., 1980; Sokolov, 2009; etc).

To date, including results of this paper, 15 species and non-identified monogeneans from families Tetraonchidae and Gyrodactylidae, have been recorded in salmon (mikizha, char and Pacific salmon), grayling, cyprinids, sticklebacks and flounders (juvenile starry flounder) from the inner waters of the Kamchatka Peninsula (Akhmerov, 1954; Konovalov, 1971; Sokolov, 2010a, b etc). Moreover, migratory mikizha and Pacific salmon from the lower reaches of Kamchatka west coast rivers are noted as hosts of an oceanic species of gyrodactylid, *Laminiscus strelkowi* Bychowsky et Poljansky, 1953 (Konovalov, 1971; Sokolov, 2005).

Acknowledgments

The study was carried out thanks to a cooperative agreement between the Kronotskii State Biosphere Reserve, IPEE RAS and FSUE "VNIRO".

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Responsible editors N.M. Biserova, E.N. Temereva, K.G. Mikhailov