The parasitofauna of the Siberian sterlet *Acipenser ruthenus marsiglii* of the Lower Irtysk

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In the Ob-Irtysh basin, studies on the parasitofauna of the Siberian sterlet are very limited and confined to the middle of the twentieth century. The decrease in the numbers of sterlet over the past half century may have led to a change in the qualitative and quantitative composition of the parasitofauna. The aim of this work is to study the parasitofauna of the Siberian sterlet in the rivers Irtysk and Tobol. 85 specimens of Siberian sterlet (L = 27.8–51.5 cm, 2+ – 6+) from the Tobol and Irtysk rivers were examined by the method of complete parasitological dissection during the periods from 5 to 21 June and from 14 to 22 July 2017. A comparison of the biodiversity of parasites was performed using the indices: Berger-Parker. 11 species of parasites were found, including four species specific to sturgeons: Cryptobia acipenseris (Joff; Lewashow; Boschenko, 1926), Haemogregarina acipenseris (Nuvortarya, 1914), Crepidostomum auriculatum (Wedl, 1858), Capillospirura ovotrichura (Skjabin, 1924). Seven broadly specific species: Trichodina sp., Proteocephalus sp. (plerocephals), Diplostomum chromatophorum mtc. (Vrówn, 1931), Echinorhynchus cinctulus (Porta, 1905), Piscicola geometra (Linnaeus., 1761), Ergasilus sieboldi (Nordmann, 1832), Unionidae gen. sp. Cryptobia acipenseris and H. acipenseris were recorded for the first time in the Ob-Irtysh basin. *C. acipenseris* was found only in three fish from the total number of examined sterlet (3.5%). In the River Tobol the extent of infestation *H. acipenseris* was higher (22.7%) than in the River Irtysk 11.1%. The carriers of *C. acipenseris* and *H. acipenseris* in the Lower Irtysk are allegedly leeches of *Piscicola geometra* (10.6%). The most common parasites found were *C. auriculatum* (32.9%) and *C. ovotrichura* (15.3%). In the River Irtysk, metacecariae of *Diplostomum chromatophorum* (Vrówn, 1931) (metacecariae) were discovered in the lens of the eye in the studied fish. The maximum EI of this parasite was noted in the fish sample near the city of Tobolsk – 12.5% with AI – 1 and IO – 0.12. In the Gornoslinkino area in June and July, the infection level was low (EI 4.3% and 8.3%, respectively). In the June sample of fish from the River Tobol no metacecariae of this species were detected. Single cases of infection of *Proteocephalus* sp. (plerocephals), *E. cinctulus*, *E. sieboldi*, Unionidae gen. sp. were found. In the River Irtysk the parasitofauna was dominated by *C. ovotrichura*, in the River Tobol – *C. auriculatum*. The number of parasite species noted in the Siberian sterlet in the Ob-Irtysh basin according to our own and literary data is greater than that found in sterlet from the River Yenisei: 18 and 11 respectively. Common to the sterlet of the two basins are 8 species of parasites: *Cryptobia acipenseris, Dicylothrium armatum, Crepidostomum auriculatum, Capillospirura ovotrichura, Truttaedacnitis citellarius, Echinorhynchus cinctulus, Piscicola geometra, Unionidae gen. sp.* The fauna of the Ob-Irtysh basin was enriched by the "southern" narrowly specific parasite of sturgeon – *H. acipenseris*. For many years the infection of *C. auriculatum* has practically not changed.

Keywords: parasites; *Haemogregarina acipenseris*; *Cryptobia acipenseris*; *Capillospirura ovotrichura*; Siberian sterlet; Tobol; Irtysk.

Introduction

Sterges are one of the oldest groups of fish, the biology and cultivation of which is a subject of interest all around the world (Guinot et al., 1992; Israel & May, 2010; Wuerzt et al., 2011; Akhulat et al., 2013; Vasilev et al., 2014). The smallest representative of sturgeon is the sterlet (*Acipenser ruthenus* (Linnaeus, 1758)). It is a nonmigratory species, inhabits the rivers of the following basins: Azov, Caspi-an, Black, Adriatic and Baltic seas, and also the Northern Dvina River and its tributaries – Shuona and Vychegda. It is common in the basins of the Siberian rivers: Ob and Yenisei, where it forms a subspecies – *Acipenser ruthenus marsiglii* (Brandt, 1833) (Zhuravlev, 2000). Sterlet quite like warm water, winter in river pockets, and are typical benthophages – the basis of their food is chironomid larvae, Simuliidae, may-flies, dragonflies, molluscs, and other representatives of macrozoobenthos (Strel’nikova, 2012). Because of the high industrial value of sterlet, and therefore their intensive fishing, and also change in hydrological and hydrochemical regimes of water bodies (places of spawning and fattening), by the end of the 1970s, the reserves of sterlet in the Ob-Irtysh basin had become critical (Liberman, 2017). Currently, there is no industrial fishing of sterlet in this basin, catching takes place only for scientific purposes.

Studies on the morphology and biology of parasites of sturgeons in natural and artificial water bodies have been conducted by a number of scientists (Appy & Anderson, 1982; George & McCabe, 1993; Choudhury & Dick, 2001; Sepúlveda et al., 2010; Lysenko, 2013). The species composition of the parasitofauna of the sterlet has been best studied in the Volga basin, where the species is represented by the nominate subspecies (Dubinin, 1952; Ivanov, 1968; Izyumova, 1977; Lyubarskaya & Lavrent'eva, 1985; Fedotkina & Shinkarenko, 2015). In the rivers of the basins of the Azov and the Black seas, parasites of sterlet were studied by Kazarnikova & Shestakovskaya (2006), Cakic et al. (2008),
Parasites of sterlet have been well studied in the Yenisei and Ob-Irtysh basins (Zahvatkin, 1938; Volkova, 1941; Bauer, 1948; Petrushevskij et al., 1948; Shul'man, 1954; Dobrohotova, 1960; Titova, 1965; Skryabina, 1974). However, the last publication with original data on sterlet parasites in the Ob-Irtysh basin was published more than 50 years ago (Titova, 1965).

The decrease in the number of sterlet over the last half-century could have led to change in qualitative and quantitative composition of their parasitofauna. Therefore, due to absence of the corresponding studies over many years, the presentation of new data on the species composition of parasites of sterlet is relevant.

The objective of this research was to study the current condition of the parasitofauna of the Siberian sterlet in the Irtysh and Tobol rivers.

Materials and methods

The material was collected during the periods from 5th to 21st June and from 14th to 22nd July of 2017 from the Tobol and Irtysh rivers, located within the Tobol and Uvatsky districts of the Tyumen oblast.

Using the method of full parasitological autopsy, we examined 85 specimens of sterlet: 22 specimens with absolute body length (L) 30.8–51.5 cm from the Tobol River (Karachino village, 58°02′50″ N, 88°06′35″ E; June), 23 specimens with L = 29.2–37.6 cm from the Irtysh near Gornoslinkino village (58°43′54″ N, 68°41′54″ E; June), 24 specimens with L = 27.8–36.2 cm from the Irtysh near Gornoslinkino (July) and 16 specimens with L = 31.5–46.0 cm from the Irtysh in the area of the city of Tobolsk (58°11′04″ N, 68°12′59″ E; July).

We studied individuals of different sex and age range 2+ – 6+.

Full parasitological analysis, standard methods of fixation and staining of parasites were conducted according to the methods of L. E. Bykovskaya-Pavlovskaya (1985). Blood was drawn from the tail vein, a smear was prepared, dried in the air, and then fixated in a mixture of 95% ethyl spirit and diethyl ether (1 : 1) during 30 minutes, the fixed smears were then dried in the air at room temperature, stained using azure-eosine in a 1 : 10 solution during 40 minutes. For identifying the nematodes, we used the work of Moravec (2013), for the remaining groups of parasites – identification guides to parasites of fresh water fish of the fauna of the USSR (Opredelitel’, ..., 1984, 1987).

We calculated the extensity of the invasion (EI, %), intensity of the invasion (II, minimum – maximum, specimens), abundance index (AI, specimens per fish), for intra-erythrocytic parasites – parasitemia index (X) (Bush et al., 1997; Woo et al., 2006).

\[ E = \frac{n}{N} \times 100\% \]

where \( E \) – invasion extensity, \( n \) – number of host individuals infested with parasites, \( N \) – number of studied host individuals.

\[ M = \frac{m}{N} \]

where \( M \) – abundance index, \( m \) – number of parasites found in the studied selection of hosts, \( N \) – number of examined host individuals.

\[ X = \frac{A + c \times 100\%}{B + c} \]

where \( A \) – number of affected erythrocytes, \( B \) – number of erythrocytes in one microscope field, \( C \) – number of examined microscope fields.

No less than 50 microscopic fields were examined for each preparation.

For identifying the dominant species in the communities, we used the Berger-Parker dominance index (d) (Mehgarran, 1992):

\[ d = \frac{N_{\text{max}}}{N} \]

where \( N_{\text{max}} \) – number of the most abundant species, \( N \) – total number of parasites in the community.

Results

In the basin of the Lower Irtysh, the Siberian sterlet was found to have 11 species of parasites (Table 1), represented by different systematic groups: Ciliophora – 1, Kinetoplastida – 1, Apicomplexa – 1, Cesto- da – 1, Trematoda – 2, Chromadorea – 1, Palaeancahocephala – 1, Hirudinea – 1, Copeoda – 1, Bivalvia – 1. Among them, 4 species are specific to sturgeon – Cryptobia acipenseris (Joff, Lewashow, Boschenko, 1926), Haemogregarina acipenseris (Nawrotzky, 1914), Crepidostomum auriculatum (Wedl, 1858), Capilliospira ovotrichura (Skrjabin, 1924) (Table 1). Cryptobia acipenseris and the intra-erythrocytic parasite Haemogregarina acipenseris were found as a result of microscopic analysis of the smears. C. acipenseris (Fig. 1) was recorded in June, one specimen from the Tobol and in July, two specimens from the Irtysh (in one of each of the researched stretches). We assessed 2–4 parasites in each blood smear.

C. acipenseris has an oval body shape, is 6.5–8.2 * 2.2–3.0 μm in size, with two rounded ends or one rounded and one sharpened end (Fig. 2). The nucleus is composed of a few chromatin granules. It is positioned both in the middle of the body and in one of its ends. Most often, one parasite is found in an erythrocyte, more rarely two, and we also found parasites outside erythrocytes due to their decomposition. The highest EI of this parasite was recorded in a selection of fish caught in July in the Irtysh River in the area of Tobolsk – 31.2% at average value of parasitemia of 0.06 ± 0.02%. The lowest EI was in fish caught in the same month in the Irtysh in the area of Goroslinkino village (8.3%) at average value of parasitemia equaling 0.12 ± 0.11%. The highest average values of parasitemia were observed in sterlet from the Tobol River – 0.19 ± 0.13%. It is interesting that these parasites were not found at all in the selection of fish from the Irtysh, collected in the same month as the fish from the Tobol (June).

Table 1

| Species of parasite | Localization | El, % | II, specimens | Al, specimens |
|---------------------|--------------|-------|---------------|---------------|
| Cryptobia acipenseris | blood        | 4.5   | –             | 3.2           |
| Haemogregarina acipenseris | erythrocytes | 22.7  | –             | 11.1          |
| Trichodina sp. | body surface, fins, gills | 100.0 | –             | 9.5           |
| Diplostomum chromo-
| matophorum, mtc² | intestine | 4.09  | 1–23          | 3.1           |
| Capilliospira ovotrichura | intestine | 9.1   | 2–28          | 1.4           |
| Echinorhynchus cinctulus | intestine | –     | –             | 1.6           |
| Phyllodina geometra | gills, fins | 4.5   | 1            | 0.04          |
| Ergasilus sieboldi | gills       | –     | –             | 1.6           |
| Unionidae sp.² | gills, fins | –     | –             | 1.6           |

Note: EI – extensity of invasion, II – intensity of invasion min-max, AI – abundance index, mtc – metacercariae, pl – plerocercoid,² – larval stage.

Crepidostomum auriculatum trematode (Fig. 3) and Capilliospira ovotrichura nematode (Fig. 4) were found in all examined selections of fish. All specimens found of C. auriculatum and C. ovotrichura were mature. The nematode parasitized mostly in the stomach, more rarely in the intestine, trematodes were found throughout the length of intestine. The highest infestation with C. auriculatum was recorded in fish from the Tobol River in June (Table 1). In the Irtysh, maximum EI equalled 37.5%, with infestation intensity of 1–36 specimens per fish and Al – 3.9 (area of Tobolsk, July). Maximum extensivity of infestation with Capilliospira ovotrichura was observed in fish from the Irtysh River near Goroslinkino (July) – 29% at II of 1–21 specimens per fish and Al – 1.7, whereas maximum intensity of invasion – 93 specimens per fish at 5.9 abundance index was recorded near Tobolsk (EI – 12.5%). On the whole, Capilliospira ovotrichura is the most abundant parasite of sterlet in the Irtysh (d = 0.680), whereas in the Tobol River, the dominant was Crepidostomum auriculatum trematode (d = 0.690).

In the Irtysh river, in the lenses of the studied fish, we found Diplostomum chromatophorum (Brown, 1931) metacercariae. Maximum EI with this parasite was recorded in the fish selection from the area of
Regul. Mech. Biosyst., 9(3)

Tobolsk – 12.5% and II – 1 and AI – 0.12. In the area of Gornoslinkino in June and July, the infestation was low (EI – 4.3% and 8.3% respectively). In the June selection of fish from the Tobol River, no metacercariae of this species were found.

Fig. 1. Cryptobia acipenseris (Joff, Lewashow, Boschenko, 1926) in blood of Siberian sterlet

Among the rest of the recorded species, parasites of sterlet which belong to Trichodina sp. were frequently found, parasitizing the body surface, gills and fins. The identification to species level was impossible due to the poor condition of the material. All fish species were infested with this parasite only in the June selection from the Tobol (Table 1). In each preparation of slime scrape, we found 1–3 trichodinids. At the same time, fish from the Irtysh (June) was found to be freer from this parasite. In July, in the Irtysh River, the extensity of invasion, depending on the area of the study, ranged from 8.3% (Gornoslinkino) to 25.0% (Tobolsk). Rare parasite species were Proteocephalus sp. cestode (plerocercoid), Diplostomum chromatophorum (Brown, 1931) trematode (metacercaria), Echinorhynchus cinctulus (Porta, 1905) acanthocephala (immature female), Ergasilus sieboldi (Nordmann, 1832) copepod crustacean, Piscicola geometra (Linnaeus, 1761) leech and Unionidae gen. sp. mollusc (glochidium).

Discussion

Most of the parasite species found (6) are reliably known to have a complex life cycle: Haemogregarina acipenseris, Proteocephalus sp., Diplostomum chromatophorum, Crepidostomum auriculatum, Capillospira ovotrichura, Echinorhynchus cinctulus. Four species have a direct life cycle – widely distributed and insignificantly specific to any hosts: Trichodina sp., Piscicola geometra, Ergasilus sieboldi, Unionidae gen. sp.

Cryptobia acipenseris were recorded in different sturgeon in the basins of Don, Volga, Donau and Yenisei (Dubinin, 1952; Baska, 1990; Bauer et al., 2002). According to Shuľman (1954), the range of C. acipenseris should coincide with the range of sterlet. However, the absence of data on the records of this parasite in the Ob-Irtysh basin could not prove this supposition. Our data verify the hypothesis of this author. The studies by Pazooki and Masoumian (2004), conducted on mature Acipenser gueldenstaedti and A. persicus from the Caspian Sea, demonstrated a significantly different occurrence of Cryptobia acipenseris during examination of humid and stained blood smears (EI – 45% and 55% compared to 15% and 25%). These authors recommend assessing the infestation of fish with kinetoplastids and flagellates by humid blood smears. The evidence presented by Pazooki and Masoumian (2004) should be checked by referring to additional material. The life cycle of C. acipenseris has not been studied completely. According to the literature data, transmission of Cryptobia to fish is possible by direct transmission from leeches (Woo, 2003).

Fig. 2. Blood smears of Siberian sterlet with intra-erythrocytic Haemogregarina acipenseris (Nawrotzky, 1914)

Haemogregarina acipenseris was previously recorded only in sturgeon in the basin of the Caspian and the Black Seas. It was recorded in sterlet in the Volga and Danube (Perekropov, 1930; Baska, 1990), and also in Russian sturgeon and Persian sturgeon, and beluga from the
Lower Volga, Northern and Southern Caspian Sea (Ivanov, 1968; Pazooki & Masoumian, 2004). The sizes of *H. acipenseris* merozoites from Siberian sterlet coincide with equivalent parameters from Volga sterlet (Perekröpov 1930), but significantly differ from merozoites from sturgeon (Pazooki & Masoumian, 2004): 6.5–8.2 * 2.2–3.0 µm compared to 4.0–5.0 * 1.5–3.0 µm. The identification of haemogregarine species found by Pazooki & Masoumian (2004) needs to be proved.

Crepidostomum (Braun, 1900) genus (Atopkin & Shedko, 2014; Soldatova, 1938; Dobrohotova, 1960). The distribution of these parasites coincides with the range of sturgeon (Skryabina, 1974; Appy & Anderson, 1982). The species composition of non-specific parasites which occur in sturgeon species, including the nominative subspecies of sterlet (Zahvatkin, 1938; Volkova, 1941; Petrushevskij et al., 1948; Bauer, 1948, 1959; Shul'man, 1954; Skryabina, 1974). Shul’man (1954) suggests the presence of several mechanisms, either physiological or biochemical, which render the sterlet immune to the “host – parasite” system than at increase in the number of the latter. And, if a higher number of parasite individuals concentrate in a small number of host individuals, then it is enough for survival of the parasites’ population due to the larva forms which live in intermediate hosts (Anderson & May, 1978; May & Anderson, 1978).

Metacercariae of *Diplostomum chromatophorum* trematodes were recorded in Siberian sterlet for the first time. Infestation with this common and low-specific parasite was insignificant and causes no great damage to fish (Marcogliese et al., 2001; Voutilainen et al., 2008).

According to the literature data, sterlet in the Ob-Irtysh basin were found to host 11 species of parasites (Table 2), of which, 7 species were not observed by us: *Hexamita truttae* (Schmidt, 1920), *Trichodina domerguei* (Wallengren, 1897), *Trichodina carassii* (Dogiel, 1940), *Dichobothrium armatum* (Leuckart, 1835), *Diplostomum spathaceum* (Rudolphi, 1819), *Truttaedacnitis citellarius* (Ward & Magath, 1917), *Cystidicoloïdes ephemeridarum* (von Linstow, 1872) (Moravec, 1981).

Perekröpov (1930) thought that the entire life cycle of *H. acipenseris* takes place in the blood of sterlet. Shul’man (1954) doubted the reliability of this study, for he assumed that transmission of haemogregarines from one fish to another is not possible without participation of blood-sucking invertebrates. It seems that as a result of experimental studies, it was determined that haemogregarines of fish are transmitted by leeches of the Piscicolidae family (Khan, 1980; Woo, 2006). Carriers of *H. acipenseris* in the Lower Irtysh are *Piscicola geometra* leeches, which were found on sterlets’ pharyngeal arches and fins.

The most abundant helminths of Siberian sterlet in the Lower Irtysh basin were *C. auriculatum* trematode and *C. ovotrichura* nematode, both specific to sturgeon. It should be mentioned that *C. ovotrichura* in the Irtysh basin were recorded earlier only in the Zaysan Lake (Zahvatkin, 1938; Dobrohotova, 1960). The distribution of these parasites coincides with the range of sturgeon (Skryabina, 1974; Appy & Anderson, 1982).

We would like to emphasise the rarity of *Dichobothrium armatum* monogenes in the Siberian sterlet, the parasite being common in other sturgeon species, including the nominative subspecies of sterlet (Zahvatkin, 1938; Volkova, 1941; Petrushesvskij et al., 1948; Bauer, 1948, 1959; Shul’man, 1954; Skryabina, 1974). Shul’man (1954) suggests the presence of several mechanisms, either physiological or biochemical, and an ecological peculiarity of the Siberian sterlet subspecies, which prevent infestation with *D. armatum*. This aspect should be studied further.

The species composition of non-specific parasites which occur in sturgeon depends on the local ecological conditions and differs in each particular water body. In water bodies of Siberia (Ob, Yenisei, Lena), sturgeon become infested with species typical for northern fish: Salmoideae, Coregonus and burbot (Shul’man, 1954). This was proved by our...
discovery of the acanthocephalan *E. cinctulus*. This parasite was recorded for the first time in sterlet of the Ob-Irtysh basin.

### Table 2

| Parasitofauna | Yenisei Basin (Bauer, 1948; Skryabin, 1974) | Lake Zaysan and the Black-Irtysh (Petrovsky et al., 1948) | Lower Ob (R. Irtysh, 1965; Dobrohotova, 1960) |
|---------------|------------------------------------------|--------------------------------------------------------|------------------------------------------|
| Number of researched specimens of sterlet | 96 and 2¹ | 40 | 4 | 148 and 5² |
| Hexamita truttae | – | 200 | – | – |
| Cryptobia acipenseris | – | – | – | 3.5 |
| Haemogregarina acipenseris | – | – | – | 14.1 |
| Trichodina domoreyi | – | 6.6 | – | – |
| Trichodina carassii | – | 13.2 | – | – |
| Trichodina sp. | – | – | – | 32.9 |
| Dicyobothrium armatum | – | – | – | – |
| Amylithia foliacea | – | 20.0–92.4 | – | – |
| Proteocephalus sp. | – | – | – | – |
| Cystocephalus truncatus | – | 7.7–33.3 | – | – |
| Diplodistomum chomatophorum | – | – | – | 5.9 |
| Diplodistomum spathulatum | – | – | – | – |
| Cepedostomum auriculatum | 30.8–100.0 | 33.0 | * | 10.0–27.0 |
| Capillipirura truncata | 20.0–53.0 | – | * | – |
| Truttaedacnitis citellarius | 15.4 | – | – | 40.0 |
| Cystidicolidae ephemeridarum | – | – | – | 15.0 |
| Echinorhynchus citellarius | 6.6–23.1 | – | – | – |
| Echinorhynchus salmonis | – | – | – | – |
| Piscicola geometra | 6.6–26.6 | – | – | 10.6 |
| Ergasilus sieboldi | – | – | – | * |
| Unioinidae gen. sp. | 7.0 | – | – | – |
| Total number of species | 11 | 4 | 3 | 4 |

Note: * – single specimens of the parasite found.

The total number of species recorded for the Siberian sterlet in the Ob-Irtysh basin was higher than that for sterlet from the Yenisei: 18 and 11 respectively (Table 2). The species found in fish of two basins were the following: *Cryptobia acipenseris, Dicyobothrium armatum, Cepedostomum auriculatum, Capillospirura ovotrichura, Truttaedacnitis citellarii*, *Echinorhynchus citellarius, Echinorhynchus salmonis*, *Piscicola geometra*, *Ergasilus sieboldi*, and *Unioinidae gen. sp.* To a large extent, the interbasin parasitological differences are related to the lower extent of study of parasitofauna of sterlet in the Yenisei. However, the absence of *Amylithia foliacea*, which is parasite specific to sturgeon, in the Ob-Irtysh basin, and the high infestation with this species in the Yenisei, as well as its presence in Siberian sturgeon in the Ob-Irtysh basin indicates that there are other factors.

In the water bodies of Siberia, the species composition of parasites of the Siberian sterlet is significantly poor compared to that of sterlet in the Volga-Caspian basin, where the species is recorded as hosting 44 species of parasites, 20 of which are specific to sturgeon (Kazarnikova & Shhestakovskaya, 2006).

### Conclusion

During the summer of 2017, *A. ruthenus mariscalii* in the Lower Irtysh basin was found to host 11 species of parasites, the most abundant of which are specific parasites of sturgeon: the trematode *Cryptobia acipenseris* and the nematode *Capillospirura ovotrichura*. Compared to the data obtained for this region over 70 years ago (Petrushevskij et al., 1948), infestation of sterlet with *Cepedostomum auriculatum* almost has not changed, and blood parasites *Cryptobia acipenseris* and Haemogregarina acipenseris were recorded in the Ob-Irtysh basin for the first time.

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