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SHORT COMMUNICATION

Parasites of *Hucho hucho* (L.), *Hucho taimen* (Pall.), and *Parahucho perryi* (Brevoort) (Salmonidae, Actinopterygii) – the state of knowledge

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Abstract. Representatives of the genera *Hucho* and *Parahucho* are examples of fish that have yet been subjects of comprehensive parasitological examination. This paper presents the most current list of parasites of the three best documented species of the genera *Hucho* (*Hucho hucho*, *Hucho taimen*) and *Parahucho* (*Parahucho perryi*) from the entire range of their occurrence. Notably, the decided majority of the parasitic worms, or helminths, identified in these hosts (trematodes, cestodes, nematodes) are represented by intestinal adult forms. This indicates that the fish of the genera *Hucho* and *Parahucho* are the definitive hosts of these parasites, as opposed to that of intermediate or paratenic host. This fact is significant in terms of potential parasitic pathogenesis and the consequent lowered host resistance to disadvantageous environmental impacts.

Keywords: *Hucho hucho*, *Hucho taimen*, *Parahucho perryi*, parasite species composition

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Salmonids of the genera *Hucho* and *Parahucho* are exceptionally valuable to recreational fisheries and local economies. Excessive exploitation, which is caused largely by poaching, requires that natural *Hucho* and *Parahucho* populations are protected and cultured under controlled conditions (Witkowski 1996, Grabowska et al. 2010). This alone is justification enough for the usefulness and necessity of learning about the parasites of these fish. Despite their economic importance and the interest of recreational fisheries, representatives of the genera *Hucho* and *Parahucho* still have not been the subject of any comprehensive parasitological studies.

Apart from a few European reports of parasites in *Hucho hucho* (L.), most of the available data presented in this paper comes from the regions of Siberia and the Far East, which is why the two other species are mentioned mainly in fauna catalogs or combined lists used in parasite identification keys. Consequently, detailed data regarding parasite species noted in the genera *Hucho* and *Parahucho*, their geographical distribution, and their infection indexes are fragmentary. The aim of this paper was to collect and compile all possible information available in the literature on the parasite species composition of the three best-known salmonid species from the genera *Hucho* and *Parahucho* – *Hucho Hucho* (L.), *Hucho*

taimen (Pall.), *Parahucho perryi* (Brevoort), throughout their areas of occurrence.

The information used to compile this paper was drawn from the available literature and, as far as was possible, it was verified in light of subsequent taxonomic revisions and changes in nomenclature (Bauer 1984, 1985, 1987, Pojmańska 1991, Niewiadomska 2003, Grabda-Kazubska and Okulewicz 2005, Moravec 1994, 2001, 2004, Dzika 2008). Names of taxa at both the genus and species levels that had been changed are included in the tables in parentheses beneath the current names. When it was possible, the occurrence of individual species was confirmed based on source literature. In instances when single records could not be confirmed in original publications, the source literature is cited as collective monographs (keys, catalogs, etc.).

The parasite list of species of the genera *Hucho* and *Parahucho* from the entire range of their occurrence in the present paper include a total of 91 taxa, of which 30 were noted in *Hucho hucho*, 59 in *Hucho taimen*, and 18 in *Parahucho perryi*. The most numerously represented parasites are parasitic Platyhelminthes, or flatworms, among which 20 taxa are digenean flukes (Digenea), 13 are tapeworms (Cestoda), and ten are parasitic monogenean flukes (Monogenea) found on the gills, skin, and fins. The remaining groups are include 18 taxa of parasitic roundworms (Nematoda), 11 taxa of spiny-headed worms (Acanthocephala), and seven species of parasitic crustaceans (Crustacea). To date, parasitic protozoans and leeches are the least numerous in these hosts with six taxa (Table 1).

The data presented in the tables show that the parasite fauna of *Hucho taimen*, a species with a vast range of occurrence that includes most of the northern Asian Arctic and Pacific ocean drainage basins and parts of the Pechora and Kama river drainage basins in Europe, is the most thoroughly investigated of the fish included in this report (Kottelat and Freyhof 2007). The list of *Hucho taimen* parasites includes 59 taxa, of which most are external flukes (12), tapeworms (10), roundworms (11), Monogenea (9), and Acanthocephala (8). The European species *Hucho hucho*, which occurs endemically in the mid and upper Danube River drainage basin, has the second highest number of known parasites. Rapidly deteriorating habitats in the Danube River basin prompted introducing this species to several rivers in the Vistula and Oder river basins in Poland, the Rhine and the Rhone rivers in France, and the Tagus River in Spain, where there are now stable populations (Kottelat and Freyhof 2007). Of the 30 parasites noted in this species, the most numerous are Digenea (9), Nematoda (6) Protista (5), and Cestoda (4). It is noteworthy that almost all of the known protozoan parasite species occurring among these fishes were confirmed in *Hucho hucho*. The least investigated fish species is *Parahucho perryi*, which occurs in the coastal waters of the Pacific Ocean, in the Sea of Japan, and the rivers of eastern Russia and the Hokkaido islands (Fukushima et al. 2011). Among the 18 parasite taxa confirmed in this species, only the roundworms (6 taxa) were investigated to a satisfactory degree (Table 2).

The numbers cited above only seem to be large. A substantial segment of the parasite fauna of these hosts was identified in the 1950s and 1960s, and many were identified only to the levels of genus, family, or order or even to those of the class or phylum. As a consequence of numerous changes and revisions since these periods, the parasite list of all the fish species of *Hucho* and *Parahucho* are somewhat out of date, which means that it is most probably incomplete and requires, at least, supplementation.

The analysis of the parasitic fauna composition of *Hucho hucho, Hucho taimen*, and *Parahucho perryi* indicates that only a small percentage of the flukes, tapeworms, and roundworms infecting these fishes are larval forms. In the case of *Siberian taimen*, these comprise 20.6% of all parasite taxa confirmed in this host, while in the Danube salmon and Sakhalin taimen they comprised 6.6% and 5.5%, respectively. This means that for the decided majority of parasites these fishes are the definitive hosts, and this, in turn, could stem from the fact that they are the top predators of the trophic chains in the environments they inhabit. This information could be significant in terms of their potential pathogenicity, because the presence of parasites in fish usually causes more pronounced

Table 1
List of parasite species recorded in fishes of the genera *Hucho* and *Parahucho*, indicating parasite stage and source reference (genera and species within higher taxa are arranged alphabetically)

	Parasite taxa	*Hucho hucho*	*Hucho taimen*	*Parahucho perryi*	Reference
	Protista				
1.	*Chilodonella cyprini*	+			Holčik et al. 1988
2.	*Ichthyobodo necatrix*	+			Žitňian 1976, Holčik et al. 1988, Bohl and Negele 1994
3.	*Ichthyophthirius multifilis*	+			Žitňian 1976, Holčik et al. 1988, Bohl and Negele 1994
4.	*Myxonema cerebralis*	+			Holčik et al.1988
5.	*Trichodina domergwuei* ?			+	Nagasawa et al. 1987
6.	*Trichodina* spp.	+			Bohl and Negele 1994
	Monogenea				
7.	*Discocotyle sagittata*		+		Pugachev 2002
8.	*Gyrodactylus* spp.	+	+		Bohl and Negele 1994, Pugachev 2002
9.	*Gyrodactylus taimeni*		+		Bauer 1985, Pugachev 2002
10.	*Microcotylidae* gen. sp.			+	Nagasawa et al. 1987
11.	*Tetraonchus gvosdevi* (*Salmonchus gvosdevi*)		+		Pugachev 2002
12.	*Tetraonchus huchonis* (*Salmonchus huchonis*)		+		Bychovskaja-Pavlovskaja et al. 1962, Bauer 1985, Holčik et al. 1988, Pugachev 2002
13.	*Tetraonchus pseudolenoki* (*Salmonchus pseudolenoki*)		+		Pugachev 2002
14.	*Tetraonchus roytmani* (*Salmonchus roytmani*)		+		Pugachev 2002
15.	*Tetraonchus skrjabini* (*Salmonchus skrjabini*)		+		Bychovskaja-Pavlovskaja et al. 1962, Bauer 1985, Holčik et al. 1988, Pugachev 2002
16.	*Tetraonchus spasskyi* (*Salmonchus spasskyi*)		+		Bychovskaja-Pavlovskaja et al. 1962, Bauer 1985, Holčik et al. 1988, Pugachev 2002
	Digenea				
17.	*Asymphylodora imitans* ?	+			Holčik et al. 1988, Moravec 2004
18.	*Asymphylodora markewitschi* ?	+			Holčik et al. 1988, Moravec 2004
19.	*Asymphylodora tincae* ?	+			Holčik et al. 1988, Moravec 2004
20.	*Azygia lucii*	+	+		Holčik et al. 1988, Moravec 2004, Pugachev 2003
21.	*Azygia mirabilis* ?	+			Moravec 2004
22.	*Azygia perryi*			+	Nagasawa et al. 1987
23.	*Azygia robusta*	+	+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Pugachev 2003, Moravec 2004
24.	*Bunodera luciopercae*		+	+	Nagasawa et al. 1987, Pugachev 2003
25.	*Crepidostomum farionis*		+		Pugachev 2003
26.	*Crepidostomum metoecus*	+			Moravec 2004
27.	*Diplostomum* spp. (l.)		+		Pugachev 2003
28.	*Diplostomum volvens* (l.)		+		Pugachev 2003
29.	*Ichthyocotylyrus erraticus* (l.)		+		Pugachev 2003
30.	*Nanophyteus salminicola* (*Nanophyteus schikhobalovi*)		+		Holčik et al. 1988
31.	*Nicolla proaviatum* ?	+			Moravec 2004
32.	*Orientoceradium pseudobargi*		+		Holčik et al. 1988
33.	*Phyllodistomum simile*	+			Moravec 2004

Cont. Table 1

	Parasite taxa	*Hucho hucho*	*Hucho taimen*	*Parahucho perryi*	Reference
34.	*Plagioporus* sp.		+		Pugachev 2003
35.	*Sanguinicola* sp.		+		Holčik et al. 1988
36.	*Tylodelphys clavata* (l.)		+		Pugachev 2003
	Cestoda				
37.	*Bothriocephalus* spp.			+	Nagasawa et al. 1987
38.	*Cyathocephalus truncatus*	+			Holčik et al. 1988, Moravec 2001, 2004
39.	*Diphyllobothrium dendriticum* (*Diphyllobothrium strictum*) (l.)		+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Pugachev 2002
40.	*Diphyllobothrium nihonkaiense* (l.)			+	Scholz et al. 2009
41.	*Diphyllobothrium* spp. (l.)		+		Pugachev 2002
42.	*Eubothrium crassum*	+	+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Pugachev 2002, Moravec 2004
43.	*Eubothrium rugosum*		+		Pugachev 2002
44.	*Eubothrium salvelini*	+	+		Holčik et al. 1988, Pugachev 2002, Moravec 2004
45.	*Eubothrium* spp.		+		Pugachev 2002
46.	*Proteocephalus exiguus*		+		Pugachev 2002
47.	*Proteocephalus* spp. (l.)		+		Pugachev 2002
48.	*Triaenophorus crassus* (l.)		+		Pugachev 2002
49.	*Triaenophorus nodulossus*	+	+		Pugachev 2002, Moravec 2001, 2004
	Triaenophorus nodulossus (l.)	+	+		Žitnian 1976, Holčik et al. 1988, Pugachev 2002, Moravec 2001, 2004
	Nematoda				
50.	*Anisakis simplex* (l.)			+	Moravec and Nagasawa 1989a
51.	*Camalanidae* gen. sp.			+	Nagasawa et al. 1987
52.	*Camallanus lacustris*		+		Holčik et al. 1988, Pugachev 2004
53.	*Contracaecum* sp. (l.)		+		Pugachev 2004
54.	*Cucullanus truttae*	+	+	+	Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Moravec and Nagasawa 1989a, Moravec 1994, 2004, Pugachev 2004,
55.	*Cystidicola farionis*	+	+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Moravec 1994, 2001, 2004
56.	*Cystidicoloides ephemeridarum*	+	+		Holčik et al. 1988, Moravec 1994, 2001, 2004, Pugachev 2004
57.	*Hystrerothylacium aduncum* (*Contracaecum adduncum*)		+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988
58.	*Philometridae* gen. sp.			+	Nagasawa et al. 1987
59.	*Philometroides masu*			+	Moravec and Nagasawa 1989b
60.	*Pseudocapillaria salvelini* (*Capillaria brevispicula*)		+		Holčik et al. 1988, Pugachev 2004
61.	*Pseudocapillaria tomentosa*		+		Pugachev 2004
62.	*Raphidascaris acus*	+	+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Moravec 1994, 2001, 2004

Cont. Table 1

	Parasite taxa	*Hucho hucho*	*Hucho taimen*	*Parahucho perryi*	Reference
63.	*Raphidascaris* sp. (l.)		+		Pugachev 2004
64.	*Rhabdochona denudata* ?	+			Holčik et al. 1988
65.	*Rhabdochona gnedini*	+			Moravec 2004
66.	*Rhabdochona* sp.			+	Nagasawa et al. 1987
67.	*Salvelinema salmonicola* (*Metabronema salvelini*)		+		Bychovskaja-Pavlovskaja et al. 1962
	Acanthocephala				
68.	*Acanthocephala* gen. sp.			+	Nagasawa et al. 1987
69.	*Acanthocephalus* sp.			+	Ohtaka et al. 2002
	Raphidascaris acus (l.)	+	+		Moravec 1994, 2001, 2004, Pugachev 2004
70.	*Echinorhynchus cinctulus* (*Echinorhynchus borealis*)		+		Pugachev 2004
71.	*Echinorhynchus cryophilus* (*Metechinorhynchus cryophilus*)		+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988
72.	*Echinorhynchus gadi*		+		Pugachev 2004
73.	*Echinorhynchus salmonis* (*Metechinorhynchus salmonis*)		+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Pugachev 2004
74.	*Echinorhynchus truttae*		+		Pugachev 2004
75.	*Neoechinorhynchus crassus*		+		Pugachev 2004
76.	*Neoechinorhynchus rutili*	+	+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Moravec 2001, 2004, Pugachev 2004
77.	*Paracanthocephalus tenuirostris* (*Acanhocephalus tenuirostris*)		+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Pugachev 2004
78.	*Pomphorhynchus laevis*	+			Holčik et al. 1988, Moravec 2004
	Hirudinea				
79.	*Acantobdella peledina*		+		Pugachev 2004
80.	*Acantobdellida* gen. sp.		+		Kaygorodova et al. 2012
81.	*Limnotrachelobdella taimeni* (*Trachelobdella taimeni*)		+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988
82.	*Limnotracheobdella okae*			+	Furiness et al. 2007
83.	*Piscicola respirans* (*Cystobranchus respirans*)	+			Holčik et al. 1988, Moravec 2001, 2004
84.	*Taimenobdella amurensis*		+		Holčik et al. 1988
	Crustacea				
85.	*Argulus coregoni*	+	+		Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Moravec 2001, 2004
86.	*Basanistes briani*		+		Pugachev 2004
87.	*Basanistes enodis*		+		Holčik et al. 1988
88.	*Basanistes huchonis*	+			Ivaska 1951, Bychovskaja-Pavlovskaja et al. 1962, Witkowski and Błachuta 1980, Holčik et al. 1988, Moravec 2001, 2004
89.	*Basanistes woskoboinikovi*		+	+	Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Pugachev 2004
90.	*Caligus orientalis*			+	Urawa and Kato 1991
91.	*Salmincola stellatus* (*Salminicola stellata*)		+	+	Bychovskaja-Pavlovskaja et al. 1962, Holčik et al. 1988, Nagasawa et al. 1987, 1984, Nagasawa and Urawa 1991, Shed'ko and Shed'ko 2003

Explanation: (l.) – larval stage, ? – parasites of accidental or uncertain findings

Table 2
Numbers of parasite taxa recorded in fishes of the genera *Hucho* and *Parahucho*

Group of parasites	*Hucho hucho*	*Hucho taimen*	*Parahucho perryi*
Protista	5	0	1
Monogenea	1	9	1
Digenea	9	12	2
Cestoda	4	10	2
Nematoda	6	11	6
Acanthocephala	2	8	2
Hirudinea	1	4	1
Crustacea	2	5	3
Total	30	59	18

symptoms of disease more rapidly and lowered resistance to detrimental environmental impacts. Therefore, in the cases of the hosts considered in this report, it seems that the pathogenic impact of parasites is not among the most dangerous threats that could lead to the extinction of these valuable species.

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