Abstracts
Diseases, parasites & behaviour

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Reproductive strategies evolve to increase individual fitness, but maximizing individual fitness does not automatically enhance population fitness. Moreover, the effects of a strategy can change with changing selection pressures. In the case of coregonids, this means that the evolutionary consequences of different reproductive strategies need to be studied in the context of exploitation and supplementary breeding. And vice versa, the long-term consequences of different management options can only be fully understood in the light of reproductive strategies. These strategies affect, for example, the timing of maturation and of reproduction, investment into gonads and gametes and the corresponding trade-offs, sexual signaling, individual behavior at the spawning location, and mate choice. We study these strategies in coregonids and other salmonids of Switzerland, combining laboratory work with large-scale field experiments. For example, when sampling wild populations and studying their offspring under experimental conditions in the laboratory, we typically find significant additive genetic variance for growth, survival, and stress tolerance. Sexual signals often reveal such aspects of heritable fitness, but sometimes they seem to instead be influenced by alternative life-history strategies. I will present some of our studies and use their results to discuss the evolutionary consequences of non-random fishing and of supplementary breeding.
Microbial community structure in host-parasite system: case of Coregonus lavaretus and its cestodes parasitizing their digestive tract and muscles

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The study of host–helminth–microbiota interactions is essential to clarify the mechanism of their relationship and understand possible potential to alter host homeostasis. The aim of the study was to identify composition and structure of microbial community of the digestive tract and muscles of sympatric pair of whitefish from Teletskoye Lake (West Siberia, Russia) and their parasites Triaenophorus crassus and Proteocephalus sp.

Microbial communities associated with the cestodes Coregonus lavaretus pidschian and C. l. pravdinellus were studied using next-generation high-throughput sequencing of the 16S ribosomal RNA genes.

The dominant phyla in associated microbiota of the cestodes extracted from intestine of C. l. pidschian and from intestine and muscles of C. l. pravdinellus were represented by Proteobacteria and Tenericutes, respectively. At the genus level the microbiota of cestodes parasitizing the intestine of C. l. pidschian were dominated by Rickettsiella, Mycoplasma, and unclassified bacteria from Aeromonadaceae and Enterobacteriaceae families. The microbiota of cestodes parasitizing the intestine and muscles of C. l. pravdinellus were dominated by Mycoplasma and Acinetobacter, respectively. The reported study was funded by RFBR, project number 19-34-60028.
Myxozoan, oomycetal and bacterial infections in farmed whitefish in Finland

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Finland is one of the few countries with a commercial farming of whitefish (Coregonus sp.). The production has been rather stable around 800 – 1200 tons/year, and the calculated increase in production has not been realized. This might be partly due to the sensitivity of whitefish to different diseases. The present study thus intend to give an overview of selected transferrable diseases affecting farmed whitefish.

Infections in farmed whitefish with the myxozoan parasite Hennequya zschokkei is a rather recent problem. Our studies showed that the pathogen is transferred to farms in coastal regions together with the fry and that infection prevalence is increased with an increased size of the transferred fry.

Whitefish seems also to be vulnerable to the oomycete Saprolegnia both in fresh and brackish water. Our recent results showed that S. parasitica is the species responsible for these disease outbreaks.

Different bacterial infections in whitefish has been studied for the last 15 years. Farmed whitefish in brackish water is considered to be especially vulnerable to Pseudomonas anguilliseptica. Additionally, infections with Edwardsiella piscicida has been reported from whitefish farms in fresh water.

In conclusion, farmed whitefish seems to be more sensitive to different transferrable diseases compared to rainbow trout.
PARASITIC COMMUNITIES OF COREGONID FISH OF LAKE BAIKAL

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Coregonus migratorius and C. lavaretus are characterized by depleted, unbalanced component communities of parasites, as they have the following values of biological diversity indices: D>0.5; E <0.5; Sch<1.

According to our proposed classification of parasitic communities of Lake Baikal fish (Rusinek, 2005, 2007), C. migratorius and C. lavaretus have the following structure of parasitic communities: a2b2c2 (a2 – always more generalist species, the proportion of generalist individuals is also greater (b2) and the generalist dominates (c2).

Living in sublitoral (5-100 m) along with other fish, Coregonidae have the same structure of component communities – a2b2c2.

The structure of parasitic fish communities according to their food specialization is represented by different variants: in the case of mature component communities corresponds to the variant – a1b1c1 (a1 – more species of specialists, b1 – more species of specialists, c1 – dominates specialist (for benthic fish parasites, including whitefish), a2b2c1 (a2 – more generalist species, b2 more species of generalists, c1 – dominates specialist (benthic family Abyssocottidae), a1b2c1 (a1 – more species specialists, b2 – more the share of individuals species generalists, c1 – dominates specialist (marked by have predators, for immature component communities (plankton eating fishes) – a2b2c2.
Parental sexual ornamentation, parasites and offspring performance in whitefish (Coregonus lavaretus)

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We studied association between sexual ornamentation, offspring performance and parasites of the whitefish, Coregonus lavaretus. Predation avoidance (freezing and swimming close to the side of tank in the presence of predator, 0-y brown trout) and survival (in the absence of predator) was measured for newly hatched whitefish larvae, originated from crossing 10 females and 10 males in all possible combinations. The parental fish were examined for parasites and for breeding tubercle ornamentation height of lateral breeding tubercles, roughness class of lateral breeding tubercles, number of lateral breeding tubercles and number of front head breeding tubercles. In males, elaborate ornamentation was connected to low survival of larvae, to high abundance of Diplostomum parasites in the eye lens, and to high total abundance of Diplostomatidae flukes in the eye. In females, elaborate ornamentation was not connected to offspring performance but was connected to high number of parasite taxa and to high total abundance of all parasites. Among the larval families, a significant male-female interaction was evident in predation avoidance behavior of larvae, but the survival of larvae was affected by male (sire), only. Thus, sexual ornaments of whitefish did not necessarily signal good individual quality of the bearer in this study.
Successful applications of synthetic miRNAs to resolve problems pertinent to fish biology and immunology prompted us to use RNA interference methods to investigate patterns of microcystin-LR–induced liver injury (MILI) in a teleost fish, whitefish (Coregonus lavaretus). In that fish, repeated exposure to microcystin-LR (MC-LR) results in severe liver damage, followed by an unexpected resilience to further exposures to the toxin and regeneration of the damaged liver structure. In these aberrant processes, we found expression of one microRNA, MiR92b-3p, to be substantially reduced in the challenged group. To study the potential biological function of MiR92b-3p in fish, 30 gram whitefish individuals were intraperitoneally injected with synthetic miRNA analogs containing either sense (mimic) or anti-sense (inhibitor) sequence of MiR92b-3p. To further understand the role of MiR92b-3p in MILI, two additional groups of whitefish fry were exposed to MC-LR together with the synthetic miRNA analogs to inhibit MiR92b-3p expression before MILI or to induce MiR92b-3p after MILI. Our preliminary results indicate that the MiR92b-3p synthetic analogs were effectively delivered via intraperitoneal injection to the systemic circulation and the liver of whitefish, and that they achieve functionality without causing any apparent toxic effects in the challenged animals. National Science Centre of Poland grant No.2016/21/B/NZ9/03566.
Helminth community structure in sympatric pair of whitefish Coregonus lavaretus from Teletskoye Lake

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Teletskoye Lake is the largest water body in the Altai Mountains (West Siberia, Russia). This lake inhabited by sympatric pair of whitefish formed by Coregonus lavaretus pidschian (zoobentivorous) and C. l. pravdinellus (zooplanktivorous). The main aim of the present study was to estimate the taxonomical composition and rates of infection of helminths infected these whitefish.

Both whitefish were infected with three species of helminths: Triaenophorus crassus (Cestoda), Proteocephalus sp., (Cestoda) and Discocotyle sagittata (Monogenea). For C. l. pravdinellus the prevalence was 100, 96.7, and 76.6% for T. crassus, Proteocephalus sp. and D. sagittata respectively. For C. l. pidschian, in addition to the mentioned species, another four species were registered – Neoechinorhynshus crassus (Acanthocephala), Cystidicola farionis (Nematoda), Tylodelphys clavata (Trematoda) and an undefined species of nematode located in the intestine. For C. l. pidschian the prevalence was 53.3, 46.7, 43.3, and 23.3% for Proteocephalus sp., T. crassus, D. sagittata, and C. farionis respectively. The prevalence of the rest helminths was less than 10%. We think that the difference in feeding habits of both whitefish caused the differences in species composition and rates of infection of their helminths. This work was supported by the Russian Science Foundation, project no. 19-74-00104.
Incubation media modify silver nanoparticle toxicity for whitefish (Coregonus lavaretus) and roach (Rutilus rutilus) embryos

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Toxicological studies were performed to assign AgNP transformation within several test media to effects on embryos of whitefish (Coregonus lavaretus) and roach (Rutilus rutilus). Total silver was determined with inductively coupled plasma mass spectrometry (ICP-MS), while AgNP were characterized by transmission electron microscopy, and single particle ICP-MS. Thermodynamic speciation calculations were performed to estimate silver species distributions for each medium. Several studies reported an increased AgNP dissolution with decreasing ionic strength of the test medium, however, no such pattern was observed for the type of AgNP used in this study. Our results suggest that physicochemical factors of the surrounding test medium in addition to Ag⁺ dissolution may alter toxicity. Whitefish was more sensitive to AgNP exposure in comparison to roach. Until now, no study assessed the sensitivity of roach to AgNP exposure and only one study was performed with whitefish. Our results revealed the need for testing non-standard fish species, since whitefish was more sensitive compared to the standard test organism (zebrafish) at comparable test conditions. Toxicity was lower in the two standard test media compared to lake water, therefore, further research is needed on different incubation media and NP coatings to allow for a comprehensive risk assessment of AgNP.
The occurrence of the death of whitefish in one of the fish farms in Karelia

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In summer-autumn 2012 a high rate of mortality of two-year-old whitefish (Coregonus muksun) was registered in the cage farm in Lake Ladoga. It was stated that the fish investigated in September did not have clinical and pathological signs of any infection disease, however, the dissection revealed infiltration of bile from gall bladder into body cavity and intestines of almost all individuals. According to toxicological characteristics, the given feed showed its unsuitability in fish farming. In December 2012 the clinical examination of whitefish revealed spotted hemorrhages at fin bases and intestine walls which back and middle parts were especially inflamed. It was shown that during the parasitological analysis 15% of whitefish had atypical localization (heart cavity) of plerocercoids Diphyllobothrium dendriticum. The feed studied in December did not demonstrate toxic effect. It was supposed that changing of fish habitat conditions in cage farming can disturb historically developed parasite-host interactions, which leads to spreading the parasite location in the host.