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MINI REVIEW

# Parasites of lake minnow, *Eupallasella percnurus* (Pall.): The state of knowledge and threats

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**Marcin Popiołek, Joanna Kubizna, Jacek Wolnicki, Jan Kusznierz**

**Abstract**. The lake minnow, *Eupallasella percnurus* (Pall.), has not been subject to any comprehensive ichthyoparasitological study; most information on its parasites comes from studies focused on other fish species. The knowledge of the geographical distribution of its parasites is especially incomplete. This paper presents the most up-to-date list of *E. percnurus* parasites throughout its distribution range. Most of the trematodes, tapeworms, and nematodes found in this host are larval forms. This means that the parasites use the *E. percnurus* mainly as an intermediate or paratenic host, and not the definitive host, which is important in light of potential parasite pathogenicity.

**Keywords**: *Eupallasella percnurus*, parasites, species composition, geographical distribution.

M. Popiołek [✉]
Department of Invertebrate Systematics and Ecology
Institute of Biology
Wrocław University of Environmental and Life Sciences
Kożuchowska 5b, 51-631 Wrocław, Poland
Tel. +48 71 320 58 83; e-mail: marcin.popiolek@up.wroc.pl

J. Kubizna
Department of Animal Nutrition and Feed Quality
Wrocław University of Environmental and Life Sciences
Wrocław, Poland

J. Wolnicki
Pond Fishery Department in Żabieniec
Inland Fisheries Institute in Olsztyn, Poland

J. Kusznierz
Department of Biology and Conservation of Vertebrates
Zoological Institute, University of Wrocław, Poland

Knowledge of parasites of fish species which are of no economic importance is usually scanty and fragmentary. The lake minnow, *Eupallasella percnurus* (Pall.), is one of such species. Its vast distribution range extends from the Oder River system to the Chukchi Peninsula and the Japanese island of Hokkaido. In the western part of its range, it is a relict species inhabiting small, shallow water bodies which are prone to disappearance as a result of shallowing and vegetation overgrowth (Kottelat and Freyhof 2007). The number of *E. percnurus* habitats which are subject to anthropogenic stress is increasing; nearly all known localities of the species have been disappearing since the middle of the twentieth century (Kusznierz 1995, Wolnicki and Sikorska 2009). Despite numerous new localities discovered recently, at present the fish is regarded as endangered in Poland where it is under strict legal protection and requires active protection measures (Wolnicki and Radtke 2009). The knowledge of the species' biology, and also potential threats, including ichthyoparasites, in its natural habitats is a prerequisite for successful protection (Popiołek et al. 2005, Popiołek and Kotusz 2007).

*E. percnurus* has never been the subject of any comprehensive ichthyoparasitological studies. Most information on its parasites comes from studies focused on other fish species, and knowledge of the geographical distribution of minnow parasites is especially incomplete. Nearly 90% of the data come from the Asian part of the former USSR where the species is mainly mentioned as a host in catalogs of

parasite fauna or in collective lists included in keys for parasite identification. As a result, detailed distributional data are practically nonexistent. Information on the species' parasites from the area of Poland is found in only two publications: Prost (1975) and Popiołek et al. (2005). The list presented here is based on literature (mainly in Russian). The information was verified, as far as possible, against later revisions and nomenclature changes (Bauer 1984, 1985, 1987, Pojmańska 1991, Niewiadomska 2003, Sudarikov et al. 2006, Dzika 2008). Wherever possible, data on the geographical distribution of the parasites and literature sources are given. The present work aims at establishing the species composition of parasites of *E. percnurus* from the entire area of its distribution and also at identifying potential threats caused by ichthyoparasites.

The list of *E. percnurus* parasites from its entire distribution range includes a total of 109 taxa (Table 1). Parasitic flatworms are the most numerous; of these 38 taxa represent digenetic trematodes (Digenea), 34 taxa – monogeneans (Monogenea), parasites of gills, skin, and fins, while 12 taxa represent tapeworms (Cestoda). The remaining groups are nematodes (Nematoda) and parasitic protists (Protista) with seven taxa each, crustaceans (Crustacea) with six taxa, and hookworms (Acanthocephala) with four taxa. Parasitic molluscs are represented by one species only.

Among the seven parasitic protists recorded from *E. percnurus*, five have been recorded from Ukraine and two from Western Siberia (Bykhovskaya-Pavlovskaya 1962, Movchan and Smirnov 1981). All the listed species are potentially pathogenic to *E. percnurus*. Species of the genera *Myxobolus* and *Sphaerospora* are noteworthy. They cause dangerous myxosporoses of internal organs, skin, gills, and fins (Prost 1994). The genera included in the list are characterized by low species-specificity and also have representatives in the fauna of Poland. It seems likely that the absence of their records from the nativei *E. percnurus* is only a matter of insufficient study (Popiołek and Kotusz 2007).

Monogeneans (Monogenea) are represented by 34 monoxenic species of five genera. Most of them belong to the genera *Dactylogyrus* and *Gyrodactylus*. Though they are usually highly host-specific, a fair number have been recorded from *E. percnurus*: eight and 20 species, respectively. According to Harris et al. (2004), *E. percnurus* is a typical host of only three species of the genus *Gyrodactylus* (*G. mantschuricus*, *G. percnuri*, *G. phoxini*), while the remaining ones have a wider range of hosts. It should be emphasized that as many as five of the monogenean species listed for the Eurasian minnow have been recorded from Poland (Prost 1975). The pathogenicity of Monogenea varies and depends mainly on invasion intensity and the age of the fish. Strong or mass invasions in the case of small fishes such as the minnow can cause deformation, hyperemia, and gill lesion, while the fin-covering skin can undergo necrosis (Prost 1994). Infected individuals grow slowly while gill, skin, and fin lesions can constitute gates for secondary, bacterial, or fungal infections.

Digenetic trematodes (Digenea) form the largest group of *E. percnurus* parasites. Among the 38 taxa recorded from this host, as many as 27 are larval forms – metacercariae, located in internal organs, muscles, body cavities as well as in the eyes, fins, and on the skin. The minnow is the second intermediate host for these allogenic helminths, the development cycle of which ends in bodies of piscivorous birds and mammals that consume fish infected with larvae. Members of the genera *Diplostomum*, *Tylodelphys*, and *Posthodiplostomum* form an important group of metacercariae from the point of view of pathogenesis. Species of the first two taxa, located in the lens or vitreous body of the fish eye, impair host vision. Species of the third genus, also recorded in Poland (Kubizna 2008), encyst on the skin and fins, causing dark-stained spots. As a result, fish that are attacked or "marked" by the parasites die from blindness or are easy prey for predators. The development of the larvae of the above-mentioned trematodes also depends on water temperature (Prost 1994). In small, shallow, isolated reservoirs, water heats more quickly thus shortening the life cycle and accelerating the accumulation of parasites in the host. On the other hand, relatively small field water reservoirs are not especially attractive for the piscivorous birds that are necessary to complete the life cycle. This might

**Table 1**
List of parasite species recorded from the lake minnow, *Eupallasella percnurus*, with parasite development stage, geographical distribution, and references (genera and species within higher taxa are arranged alphabetically)

| Species of parasite | Stage | Distribution /Reference |
|---|---|---|
| Protista | | |
| *Apiosoma piscicolum* (Blanchard) | Adl. | former USSR (11) |
| *Goussia carpelli* Léger et Stankovich | Adl. | Ukraine (10), former USSR (11) |
| **Myxobolus suturalis* Schulman | Adl. | Ukraine (10), former USSR (11) |
| *Myxobolus musculi* Keysselitz | Adl. | Ukraine (10), former USSR (11) |
| *Myxobolus permagnus* Wegener | Adl. | Ukraine (10), former USSR (11) |
| *Sphaerospora elegans* Thélohan | Adl. | Ukraine (10) |
| *Trichodina reticulate* Hirschmann et Partsch | Adl. | former USSR (11) |
| Monogenea | | |
| **Cleidodiscus branchus* Müeller | Adl. | Northern Asia (2), Ukraine (10), former USSR (12) |
| *Dactylogyrus amurensis* Achmerov | Adl. | Ukraine (10), former USSR (11) |
| *Dactylogyrus borealis* Nybelin | Adl. | Ukraine (10) |
| *Dactylogyrus ersinensis* Spasskij et Rojtmann | Adl. | N Asia (2), Poland (5) |
| *Dactylogyrus gvosdevi* Gusev | Adl. | Ukraine (10), former USSR (11) |
| *Dactylogyrus malevitzkajae* Gusev | Adl. | N Asia (2), Ukraine (10), former USSR (11) |
| *Dactylogyrus oreoluecisci* Ergens et Dulmaa | Adl. | N Asia (2) |
| *Dactylogyrus phoxini* Malewitzkaja | Adl. | N Asia (2), Ukraine (10), Poland (5), former USSR (11,12), |
| *Dactylogyrus vaststor* Nybelin | Adl. | N Asia (2) |
| *Diplozoon paradoxum* Nordmann | Adl. | Ukraine (10), former USSR (11) |
| *Gyrodactylus aphyae* Malmberg | Adl. | Ukraine (10) |
| *Gyrodactylus cotti* Roman | Adl. | Ukraine (10) |
| *Gyrodactylus dulmaae* Ergens | Adl. | Ukraine (10) |
| *Gyrodactylus hrabei* Ergens, 1957 | Adl. | Ukraine (10) |
| *Gyrodactylus jiroveci* Ergens et Bychowsky | Adl. | Ukraine (10) |
| *Gyrodactylus laevis* Malmberg | Adl. | N Asia (2), Ukraine (10) |
| *Gyrodactylus lagowskii* Ergens | Adl. | Ukraine (10) |
| *Gyrodactylus limneus* Malmberg | Adl. | N Asia (2), Ukraine (10) |
| *Gyrodactylus llewellyni* Ergens et Dulmaa | Adl. | Ukraine (10) |
| *Gyrodactylus longoacuminatus* Žitnan | Adl. | Ukraine (10) |
| *Gyrodactylus lucii* Kulakowskaja | Adl. | Ukraine (10) |
| *Gyrodactylus macronychus* Malmberg | Adl. | N Asia (2), Ukraine (10) |
| *Gyrodactylus magnificus* Malmberg | Adl. | N Asia (2), Poland (5) |
| *Gyrodactylus malmbergensis* Prost | Adl. | N Asia (2), Ukraine (10) |
| *Gyrodactylus menschikowi* Gvosdev | Adl. | Ukraine (10) |
| *Gyrodactylus minimus* Malmberg | Adl. | N Asia (2), Ukraine (10) |
| *Gyrodactylus pannonicus* Molnar | Adl. | Ukraine (10) |
| *Gyrodactylus percnuri* Prost | Adl. | Poland (5) |
| *Gyrodactylus phoxini* Malmberg | Adl. | Ukraine (10), Poland (5) |
| *Gyrodactylus prostate* Ergens | Adl. | Ukraine (10) |
| *Paradiplozoon* spp. | Adl. | Ukraine (10) |
| *Pellucidhaptor fidus* Pugachev | Adl. | N Asia (2, 4) |
| *Pellucidhaptor merus* (Zaika) | Adl. | Ukraine (10) |
| *Pellucidhaptor rogersi* Gusev et Lukjanceva | Adl. | Ukraine (10) |
| Digenea | | |
| *Allocreadium isosporum* (Looss) | Adl. | N Asia (1) |
| *Allocreadium transversale* (Rudolphi) | Adl. | N Asia (1) |
| *Allocreadium* spp. | Adl. | N Asia (1), former USSR (11) |
| *Apatemon* sp. | Larv. | N Asia (6) |
| *Asymphylodora* spp. | Adl. | N Asia (1) |
| **Diplostomum baeri* Dubois | Larv. | N Asia (1) |
| **Diplostomum commutatum* (Diesing) | Larv. | N Asia (1) |
| **Diplostomum pungiti* Shigin | Larv. | N Asia (1) |
| **[1]Diplostomum helveticum* (Dubois) | Larv. | N Asia (1) |
| *Diplostomum huronense* (La Rue) | Larv. | N Asia (1) |

**cont. Table 1**

| Species of parasite | Stage | Distribution /Reference |
|---|---|---|
| *Diplostomum mergi* Dubois | Larv. | N Asia (1) |
| *Diplostomum phoxini* (Faust) | Larv. | N Asia (1) |
| **Diplostomum pseudospathaceum* Niewiadomska | Larv. | N Asia (1) |
| **Diplostomum spathaceum* (Rudolphi) | Larv. | N Asia (1,6) |
| *Diplostomum* spp. | Larv. | N Asia (1) |
| *Ichtyocotylurus pileatus* (Rudolphi) | Larv. | N Asia (1) |
| *Ichtyocotylurus platycephalus* (Creplin) | Larv. | N Asia (1) |
| *Ichtyocotylurus variegates* (Creplin) | Larv. | N Asia (1) |
| *Isoparorchis hypselobagri* Billet | Adl. | Ukraine (10), former USSR (11) |
| *Metagonimus yokogawai* (Katsurada) | Larv. | Ukraine (10), former USSR (11) |
| *Metorchis bilis* (Braun) | Larv. | N Asia (1) |
| *Metorchis xanthostomus* (Creplin) | Larv. | N Asia (1) |
| *Opisthorchis felineus* Rivolta | Larv. | N Asia (1) |
| *Opisthorchis longissimus* (Linstow) | Larv. | N Asia (1) |
| *Paracoenogonimus ovatus* Katsurada | Larv. | N Asia (6) |
| **Parasymphylodora markewitschi* (Kulakowskaja) | Adl. | N Asia (1) |
| *Petasiger neocomense* Fuhrmann | Larv. | N Asia (1) |
| *Phyllodistomum elongatum* Nybelin | Adl. | N Asia (1) |
| *Phyllodistomum folium* (Olfers) | Adl. | N Asia (1) |
| *Phyllodistomum macrocotyle* (Luhe) | Adl. | N Asia (1) |
| *Plagioporus* spp. | Adl. | N Asia (1) |
| *Posthodiplostomum brevicaudatum* (Nordmann) | Larv. | N Asia (1,6) |
| *Posthodiplostomum cuticola* (Nordmann) | Larv. | N Asia (1,6), Poland (9) |
| *Prohemistomum* spp. | Larv. | N Asia (1) |
| *Prohemistomum* spp. II | Larv. | N Asia (1) |
| *Rhipidocotyle campanula* (Dujardin) | Larv. | N Asia (1) |
| *Sphaerostomum globiporum* Rudolphi | Adl. | N Asia (1) |
| **Tylodelphys clavata* (Nordmann) | Larv. | N Asia (1) |
| Cestoda | | |
| *Caryophyllaeus laticeps* (Pallas) | Adl. | N Asia (2) |
| *Eubothrium crassum* (Bloch) | Adl. | N Asia (6) |
| *Eubothrium* sp. | Adl. | N Asia (6) |
| *Digramma interrupta* (Rudolphi) | Larv. | N Asia (2) |
| *Diphyllobothrium* spp. | Larv. | N Asia (2) |
| *Ligula colymbi* Zeder | Larv. | N Asia (2, 6) |
| *Ligula intestinalis* (Linnaeus) | Larv. | N Asia (2, 6) |
| *Paradilepis scolecina* (Rudolphi) | Larv. | N Asia (2) |
| *Proteocephalus torolosus* (Batsch) | Adl. | N Asia (2,6) |
| *Proteocephalus* spp. | Adl. | N Asia (2,6) |
| *Schistocephalus solidus* (Müller) | Larv. | N Asia (2,6) |
| *Triaenophorus nodulosus* (Pallas) | Larv. | N Asia (2), Ukraine (10), former USSR (11) |
| Nematoda | | |
| *Eustrongyloides* sp. | Larv. | N Asia (3) |
| *Pseudocapillaria salvelini* (Polyansky) | Adl. | N Asia (3) |
| *Pseudocapillaria tomentosa* (Dujardin) | Adl. | N Asia (3) |
| *Philometra rischta* Skrjabin | Adl. | N Asia (3) |
| *Raphidascaris acus* (Bloch) | Larv. | N Asia (3,4, 6,7), Poland (8) |
| *Spiroxys contortus* (Rudolphi) | Larv. | Poland (8) |
| *Streptocara crassicauda* (Creplin) | Larv. | N Asia (3) |
| Acanthocephala | | |
| **Acanthocephalus tenuirostris* (Achmerov et Dombrowskaja-Achmerova) | Adl. | N Asia (3), former USSR (11) |
| *Acanthocephalus* spp. | Larv. | Poland (9) |
| *Neoechinorhynchus rutili* (Muller) | Adl | N Asia (3) |
| *Polymorphus magnus* Skrjabin | Larv. | N Asia (6) |

**cont. Table 1**

| Species of parasite | Stage | Distribution /Reference |
|---|---|---|
| Crustacea | | |
| *Argulus foliaceus* (Linnaeus) | Adl. | N Asia (3) |
| *Ergasilus tumidis* Markevitsch | Adl. | former USSR (11) |
| *Ergasilus briani* Markevitsch | Adl. | N Asia (3) |
| *Lernaea cyprinacea* Linnaeus | Adl. | N Asia (3) |
| *Tracheliastes polycolpus* Nordmann | Adl. | N Asia (3) |
| *Tracheliastes sachalinensis* Markevitsch | Adl. | former USSR (11) |
| Molusca | | |
| *Anodonta cygnea* (Linnaeus) | Larv. | N Asia (3) |

Explanation: Adl. – adult stage; Larv. – larval stage; * – name based on the most contemporary taxonomic revision; [1] – species of unclear taxonomic position, according to Niewiadomska (2003) *D. helveticum* is a synonym of *D. spathaceum*, whereas in the monograph by Sudarikov et al. (2006) it is considered a distinct species; (1) Pugachev 2003; (2) Pugachev 2002; (3) Pugachev 2004; (4) Pugachev 1989; (5) Prost 1975; (6) Malyshev (1982); (7) Sous and Malyshev (1983); (8) Popiołek et al. (2005); (9) Kubizna (2008); (10) Movchan and Smirnov (1981); (11) Bykhovskaya-Pavlovskaya; (12) Bauer (1985)

partly account for the absence of records of these parasites from the lake minnow on the western fringes of its range in comparison to Asia where the fish also inhabits much larger water bodies. The remaining 11 of the recorded digeneans, which are most often located in the gut, parasitize the minnow as adults. They are not specific to this host, and their pathogenicity is usually low or has not been studied.

The tapeworm fauna of the lake minnow includes 12 taxa. Among them only five are adult forms located in the gut. The remaining species are represented by plerocercoid larvae which are located in the body cavity and muscles or in cysts in the liver parenchyma. Their development, like that of most of the trematodes above, ends in the bodies of piscivorous birds. Plerocercoids of *Triaenophorus nodulosus* as well as *Ligula intestinalis* and *L. colymbi* are the most pathogenic. Larvae of the first species damage fish livers, decrease body increments, and can even cause death. The presence of plerocercoids of *Ligula* inhibits fish growth, causes disturbances in the function of internal organs and reproduction, and in cases of strong invasion can result in the perforation of body covers and death (Pojmańska 1991).

Nematodes, hookworms, and parasitic crustaceans have fewer representatives among the lake minnow parasites. The list of recorded nematodes includes seven species, and only three of them parasitize the minnow as adults. The remaining ones, which occur as larvae and are most often located in cysts in the gut wall or in the organs of the body cavity, use the fish as a paratenic host. Two of them (*Raphidascaris acus* and *Spiroxys contortus*) have also been recorded from the lake minnow in Poland (Popiołek et al. 2004). Hookworms are also rather poorly represented among minnow parasites. Only four taxa have been recorded in the literature, and one of them has been identified to the genus level. The remaining ones are typical intestinal fish parasites: *Acanthocephalus tenuirostris* and *Neoechinorhynchus rutili* and the larva of *Polymorphus magnus*, whose definitive hosts are piscivorous birds. Although there are no literature data on the level of minnow infection with hookworms, the great pathogenicity of these parasites should be mentioned. Strong hookworm invasions cause deep lesions of the intestinal mucosa and even wall perforations and necrotic lesions in other internal organs (Prost 1994). The list of parasitic crustaceans recorded from the minnow includes six species. All have been recorded exclusively from northern Asia and Ukraine, and are typical and frequent parasites of cyprinids in these areas. The list of minnow parasites is completed by *Anodonta cygnea* – its glochidium commonly occurs on the gills, skin, or fins of many cyprinid fishes.

The list of parasites in the table is only apparently long. Most of the parasite fauna of the minnow was recorded in the 1950s and 1960s. As a result of numerous later changes and taxonomic revisions, the list of

*E. percnurus* parasites has become out-dated and at the present state of knowledge requires at least revision and supplementation. The analysis of the parasite fauna shows that more than 90% of the recorded trematodes, tapeworms, and nematodes are larval forms (Table 1). This means that the parasites use the fish mainly as an intermediate or paratenic host, and not the definitive host. It is likely that the small body size of the minnow favors its role as a transmitter. It appears also that the kind of local water bodies inhabited by the fish (peat and clay pits) offer rather specific conditions, involving e.g., nutrient pollution, varied pH, and often a high degree of eutrophication. In the case of monogeneans the effect of the water quality on free-living larval stages can be limited by the fact that in this taxon free-living larval stages are limited to one – oncomiracidium. On the other hand, the possible effect of the intermediate host in minimized. This pertains mainly to monoxenic monogeneans and digeneans whose first intermediate hosts are usually aquatic snails or, to a lesser extent, bivalves which are mostly resistant to water pollution and pH changes. The role of fishes in the life cycle of the nematodes recorded from the lake minnow is still debatable. According to the most recent theories, fishes such as *E. percnurus* are used by nematodes only as paratenic hosts and not – contrary to what was formerly believed – as intermediate hosts. In this context, the presence or participation of the minnow in their life cycles is non-obligatory, and the "auxiliary" role of the fish is limited to the storage and provision of a reservoir for III degree larvae (Moravec 1994, Okulewicz 2008). This fact might be the reason for the small number of nematode species recorded for the minnow. The intermediate host's role seems to also be important in the context of the general potential pathogenicity of the parasites. In contrast to adult forms of parasites, the presence of larval stages in the fish more quickly evokes pathological symptoms and decreases host resistance to adverse environmental conditions, thus making it easier prey for predators. Being an intermediate link in life cycles of some heteroxenic parasites, *E. percnurus* can also constitute a potential threat to humans. The trematodes *Opisthorchis felineus* and *Metagonimus yokogawai* included in this list can infect humans; this fact should not be ignored in light of opisthorhosis, which remains a problem in Asian parts of Russia (Yossepowitch et al. 2004).

The data in Table 1 show a distinctly disproportionate geographical distribution of records of *E. percnurus* parasites. The problem is complex and requires more extensive studies. It seems, however, that the great species richness of minnow parasites in northern Asia is associated with the distribution center and common occurrence of the host species, which undoubtedly conditions host-parasite co-evolution. Europe, and especially Poland, are on the western fringes of the minnow distribution range, and the species lives there mainly in scattered, isolated localities. The situation, on the one hand, creates a serious threat to the species which runs the risk of pathogenic invasions; on the other hand, it does not favor constant, or even frequent, contact between parasites and the few, scattered populations that inhabit quickly disappearing habitats.

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## Streszczenie

### Pasożyty strzebli błotnej *Eupallasella percnurus* (Pall.) – stan zbadania i zagrożenia

Strzebla błotna jest przykładem ryby, która nie doczekała się jak dotąd żadnego kompleksowego opracowania ichtioparazytologicznego, a większość informacji o jej pasożytach pochodzi z badań, których głównymi obiektami były inne gatunki ryb. Szczególnie niekompletna jest wiedza o rozmieszczeniu geograficznym pasożytów tego żywiciela. W pracy przedstawiono możliwie najbardziej aktualną listę pasożytów strzebli błotnej z całego areału jej występowania. Zwrócono uwagę na fakt, że zdecydowana większość stwierdzonych u tego żywiciela przywr, tasiemców i nicieni stanowiło formy larwalne. Oznacza to, iż dla pasożytów strzebla błotna pełni przede wszystkim rolę żywiciela pośredniego lub paratenicznego, a nie głównego żywiciela ostatecznego, a cecha ta wydaje się być istotna w odniesieniu do potencjalnej patogenności pasożytów.