The life cycle and parasitic system of *opisthorchis felineus* in the Irkutsk opisthorchiasis focus

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Abstract. The article for the first time presents generalized data on the parasitic system and the life cycle of *Opisthorchis felineus* (Plathelminthes: Trematoda) in the Irkutsk center of opisthorchiasis on the river Biryus. The relatively low abundance and contagion of the first (mollusks) and second intermediate hosts (fish) clearly demonstrates that the natural and anthropogenic sources of invasion are very minor here. Human, domestic cats are infected with opistorch. However, because of the actual breaking of the chain, their eggs may not be released into the water due to objective circumstances (remoteness, small number or absence of the first intermediate owners). *O. felineus* during the implementation of its life cycle in the parasitic system can complete it as an autogenous species, without leaving the aquatic environment and as an allogeneic species, completing the life cycle in land mammals and in humans.

1. Introduction  
The relevance of the study of opisthorchiasis, a pathogenic parasitic human disease, is beyond any doubt. The author has been studying the Irkutsk center of opisthorchiasis relatively since 2010. According to the results of the study of the Irkutsk focus, my colleagues and I published several research articles [11], [14], [17], [12], [15], [13], [16], [20]. According to the content, they can be divided into 3 groups: (q) those papers devoted to the study of fish and mollusks; (2) on physiological and biochemical issues; and (3) on the molecular genetic work conducted to assess the genetic diversity of opisthorchids within their Euro-Asian range.  

As a result of the analysis of the obtained results, we were convinced of the need to prepare an article on life cycle assessment and the parasitic system *Opisthorchis felineus*. This is done in order to summarize the knowledge necessary for planning further work.  

Research objective is to study the parasitic system of trematodes *Opisthorchis felineus* in the Irkutsk opisthorchiasis focus. First, it is necessary to analyze the life cycle and the elements of the structure of the parasitic system. Second, our task is to provide data on the structure of the parasitic system *Opisthorchis felineus* in the Irkutsk focus.  

A parasitic system is a system in which the parasite is combined at all phases of its development (free-living, larval, adults) and host populations (first, second intermediate, reservoir and final) [2], [8], [1], [6]. The *O. felineus* parasitic system is complex and polynomial, since the parasite develops in it in the first and second intermediate and final hosts.
The life cycle of the parasite reflects the size-age structure of its population. In the case of the *O. Felineus* trematode, its population consists of 7 hemipopulations (or subpopulations, or subpopulation groups): marites, eggs, miracidia, sporocysts, redias, cercariae, and metacercariae (Figure 1).

2. The Life Cycle of a Cat Fluke

The complex life cycle of the cat fluke was discovered by Hans Vogel, the German helminthologist. In the 1930s, he published several articles describing the life cycle of *Opisthorchis felineus* [21], [22], [24]. Later, he experimentally proved that the mollusk *Bithynia leachi* participates in the life cycle of *O. felineus* [23].

A total of 3 different generations participate in the life cycle of trematodes – one hermaphroditic (marita) and two (sporocysts and redies), consisting of parthenogenetic females. In the life cycle of a cat fluke, the stages of free life (eggs, cercariae) alternate with parasitic stages (miracidia, sporocysts, redia, metacercariae, and marites). Information on the life expectancy of individual phases of opistorchis development is somewhat different for different authors (Table 1).

Under favorable conditions, the entire life cycle of the parasite is completed within 4-4.5 months. [2]. Eggs and cercariae are the distributional free-living phases of opistorchis. It is known that at a water temperature not lower than 20°C, up to 3.5 thousand cercariae can leave one mollusk per day [18]. The maximum number of metacercariae in old age groups of ide can reach 20-30 thousand in one fish [25].

According to various data, metacercariae in fish remain invasive for 7-8 years or more [4], 46–48 months [19], 24-26 months [18], 12-16 months [5].

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Fig. 1. Diagram of the life cycle of *Opisthorchis felineus* [3].
Table 1. The life expectancy of individual phases of the development of *Opisthorchis felineus* (for different authors).

| Phases of opisthorchis development | Pustovalova et al., 1999 [25] | Beer, 2005 [3] | Parasitic diseases ..., 2006 |
|-----------------------------------|-------------------------------|----------------|-----------------------------|
| Egg (keeps viability in a reservoir soil) | 15 months | 18-24 months (according to experimental data) | 5-6 months |
| Miracidia | - | - | - |
| Sporocista | - | Mollusk development time | Mollusk development time from 2 to 10-12 months |
| Redia | - | 2-2.5 months | - |
| Cercaria | Lifespan 60 hour | 30-50 hours of active swimming | - |
| Metacecaria | After 6 weeks it becomes invasive; a life time in fish from 1 year to 8 years | Up to 3 years or more | After 6 weeks becomes invasive |
| Marita | From the stomach, the parasite enters the liver and other organs after 3-5 hours. It becomes sexually mature after 4-5 weeks and starts producing eggs. Marita’s age limit in the final host is 10-20 years. | Reaches puberty in 20-25 days | A parasite begins to produce eggs 3-4 weeks after infection of the final host; 20-25 years old – the age limit of maritas in the final host |

Note: - no data.

3. The Parasitic System *O. felineus*

It is obvious that the life cycle of a parasite determines the structure of its parasitic system, since in it the parasite naturally combines at all phases of its development and a host or hosts (intermediate, reservoir, final). The number of host species in different habitat conditions of the parasite may vary significantly.

The focal nature of opisthorchiasis suggests that relatively isolated territories exist in different parts of our planet, where the parasite goes through its life cycle as part of the parasitic system formed under these conditions. From the standpoint of the theory and practice of parasitic communities in all parasitic phases of development, *Opisthorchis felineus* belongs to the types of generalists, since it parasitizes in hosts of different species and genera, families and orders (Table 2).

Attention should be paid to the fact that *O. felineus* is an autogenous species (developing in the aquatic environment) up to the metacecaria phase, and in the *Marita* phase it can be an autogenous and allogeneic species depending on the habitat of the final host (Fig. 2). “Autogenous” is when the final hosts are aquatic and near aquatic mammals (otter, muskrat, water vole – the latter two rarely feed on fish but are susceptible to infection by fluke). In turn, “allogeneic” is when it completes its life cycle in land animals (bear, wolf, fox and others). It is allogeneic during the *Marita* phase and in the case of the completion of the cycle in man and domestic animals.

Thus, during the implementation of its life cycle in a parasitic system, *O. felineus* can complete it as an autogenous species, without leaving the aquatic environment, and as an allogeneic species, completing the life cycle in terrestrial mammals. The autogenous path of development is likely to be the most ancient. Allogenic, especially associated with the inclusion of humans and domestic animals, was formed in relatively recent times at the end of the Pleistocene and in the Holocene (15-10 thousand years ago) [3].
Table 2. A taxonomic status of the hosts of *Opisthorchis felineus*.

| 1st intermediate hosts | 2nd intermediate hosts | Definitive hosts |
|------------------------|------------------------|------------------|
| **Gastropoda Class**   | Osteichthyes Class – Bony Fish | Mammalia Class |
| **Squad**              | Squid Cypriniformes – carps Family Cyprinidae | **Squad Rodentia** |
| **Family Bithyniidae** | Genus *Rutilus* | **Family Cricetidae** |
| **Subfamily Bithyniinae** | 1. Species *B (Bithynia) tentaculata* | **Genus Ondatra** |
| **Subgenus Bithynia**  | **Genus Leuciscus** | 1. Species *O. zibetica* – muskrat |
| 2. Species *B (Codiella) liachii* | 2. Species *L. leusciscus baicalensis* | |
| **Subgenus Codiella**  | **Genus Phoxinus** | **Subspecies** |
| 2. Species *B. (Codiella) liachii* | 4. Genus *Ph. phoxinus* – common minnow | **Felis silvestris catus** – domestic cat |
| **Subfamily Mysorellinae** | **Genus Abramis** | |
| **Genus Boreolona**   | 5. *A. brama orientalis* – eastern bream | |
| 4. *B. sibirica*       | **Genus Scardinius** | |
| **Genus Scardinius**  | 9. *S. pelecs* – sichel | |
| 8. *S. erythrophtalmus* – rudd | **Genus Gulo** | |
| **Genus Scardinius**  | 9. *S. pelecs* – sichel | |
| 8. *S. erythrophtalmus* – rudd | **Genus Martes** | |
| **Genus Carassius**   | 12. *Aspius aspius* – common asp | |
| 14. *C. auratus gibelio* – goldfish | **Genus Mustela** | |
| **Genus Barbus**       | 13. *Barbus barbus* – common barbel | |
| 12. *Aspius aspius* – common asp | **Genus Lutra** | |
| **Genus Carassius**   | 14. *C. auratus gibelio* – goldfish | |
| **Genus Tinca**        | **Genus Felinae** | |
| **Squad**              | **Genus Tinca** | |
| **Squad Artiodactyla** | **Squad** | |

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15. Species *T. tinca* – tench  
**Family Suidae**  
**Genus Sus**  
15. Species *Sus scrofa*  
16. Subspecies *Sus scrofa domestica* – domestic pig

**Genus Gobio**  
16. Species *G. gobio* – gudgeon  
**Squad Primates**  
**Family Hominidae**  
**Genus Homo**  
17. Species *Homo sapiens* – reasonable man

**Genus Leucaspius**  
17. Species *L. delineatus* - belica

**Genus Blicca**  
18. *B. bjoerkna* – silver bream

**Genus Squaliobarbus**  
19. *Squaliobarbus curruculus* – mustache chub

**Family Cobitidae** – loachworm  
**Genus Cobitis**  
20. Spined loach

### 4. The Parasitic System *O. felineus* in the Irkutsk Opisthoschiasis Focus

According to the literature and our data, it can be stated that the parasitic system *O. felineus* on the Biryus river operates with the participation of 7 parasite hemipopulations, one population of *Bithynia troscheli* mollusks, four specific populations of the second intermediate hosts and three specific populations of the final hosts (Table 3). It should be understood that these are the actual data and the potential number of participants in this parasitic system may be much larger.

Taking into account the hydrological features of the Biryusa river, its comparative high water content, a low population and an infection of the first intermediate owners [7], as well as a relatively low infection of the second intermediate owners (fish) [11], it can be stated that natural and anthropogenic sources of invasion are very insignificant here. Human, domestic cats are infected with opistorch, but due to the actual breaking of the chain, eggs may not be released into the water due to objective circumstances (remoteness, a small number or absence of the first intermediate owners).

Table 3. The species composition of animals involved in the parasitic system *O. felineus* in the Irkutsk opisthoschiasis focus.

| 1st intermediate hosts | 2nd intermediate hosts | Definitive hosts |
|------------------------|------------------------|-----------------|
| *Bithynia* (Opistorchophorus) *troscheli* (cum.: *B. inflata*, *Boreolona sibirica*) | Dace | Human |
|                         | Roach                  | Cat             |
|                         | Bream                  | Muskrat         |
|                         | Crucian Carp           | Otter, water vole, dog can be potential definitive hosts of the parasite. |

According to the classification V. D. Zavoykin, the territory of the Irkutsk opisthoschiasis focus refers to hypoendemic, since the infection of people is from 1 to 10% and no cases of the disease have been detected among children [3].

The feline flute parasitic system exists due to close ecological connections between the final, first and second intermediate hosts. In the case of the Irkutsk focus, it is necessary to continue to identify wild animals that can play the role of ultimate owners of the parasite. In addition, it is important to begin...
a systematic work to identify the habitats of Bithynia, i.e. the first intermediate hosts of the parasite and the study of their biology in the conditions of the Biryusa river basin.

A careful attention of various sanitary organizations should be paid to the condition and disinfection of latrines in the settlements along the banks of the Biryusa river.

In addition, it is important to conduct an ongoing outreach to the local population on the treatment of carp fish as a preventive measure against infection with opisthorchis.

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