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COMMON FRESHWATER FISH NEMATODES IN LATVIA

Muza Kirjusina*, Jana Paidere, Ilze Rubenina, Sanita Kecko, Reinis Bricis, Ligita Mežaraupe, Inese Gavarane

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Abstract
The information provided in this short review covers data about fish parasitological investigation from 1949 till 2023 in Latvia. In total, 42 freshwater fish species were studied and data about 26 species of nematodes was reported. In addition, nematodes of the *Eustrongyloides, Goezia, Desmidocercella* genus and *Raphidascaris gracillima, Skrjabillanus tincae*, *Philometra obturans, Philometroides sanguinea* species were reported rarely in Latvian waterbodies. Important to note that there are nematodes, *Schulmanela petruschewskii, Camallanus (Camallanus) lacustris* which prevalence can reach 100%. The parasite *Raphidascaris acus* is widely distributed and was reported in 28 freshwater species. Distribution of nematodes depends on intermediate hosts such as Oligohetas, Ephemeroptera and Cyclopidae and most of them are widely distributed across the country.

Keywords: freshwater fish nematodes, Latvia, *Raphidascaris acus,* historic data

*Corresponding author: *Muza Kirjusina. Institute of Life Sciences and Technology. Daugavpils University, Parādes Str. 1a, Daugavpils, LV-5401, Latvia, E-mail: muza.kirjusina@du.lv*

Jana Paidere. Ilze Rubenina. Sanita Kecko. Ligita Mežaraupe. Inese Gavarane. Institute of Life Sciences and Technology, Daugavpils University, Parādes Str. 1a, Daugavpils, LV-5401, Latvia

Reinis Bricis. Latgale Zoo, Vienības Str. 27, Daugavpils, LV-5401, Latvia

INTRODUCTION

Actively growing need for high-quality animal-source protein leads people to use freshwater fish resources in large quantities. Human negative fishing impacts on ecosystems can upset host-parasite relationships in lakes and streams (Moravec 1994) and can create a biologically impoverished parasite fauna of directly transmitted parasites (Wood et al. 2018). The aquaculture sector accounts for about 44 % of global fish production and continues to expand (Assefa & Abunna 2018). However, the increasing development of aquaculture globally and frequent transcontinental transfers of fish foreground increase the need to recognize fish parasites (Moravec 1994). Hatchery fish are often susceptible to diseases because of confinement high population densities (Nekouei et al. 2019). Parasites are the reason of fish losses of 20% in hatcheries and cause a reduction of 1–10% in the growth of

cultured fish; annual losses in aquaculture and fisheries are enormously huge (Selzer & Epe 2021). More than half of the known species of nematodes are parasitic and some are pathogenic and can cause serious fish diseases or even death to their fish hosts (Okon et al. 2023).

Nematodes are among the most common and important parasites of fish in freshwater, brackish and marine environments. Nematodes are of great importance from the point of view of veterinary medicine and public health (Moravec 1998, Moravec 2007). Several species of fish-borne nematodes are well-known as human pathogens in the family Anisakidae: *Anisakis*, *Pseudoterranova* and *Contracaecum* (Eiras et al. 2016). *Anisakis* has the highest medical importance among these parasites because of gastrointestinal symptoms and the severe allergic reactions it causes in humans (Ljubojevic et al. 2015). It was found that anisakiasis has the highest prevalence in north Asia and western Europe (The Netherlands, Germany, France and Spain) (Chai et al. 2005). All meant aspects show importance of monitoring water fish parasites.

Nematodes are the component of parasitic communities of fish and the study of their biology and ecology is important, since current knowledge about their development cycles remains incomplete. Invertebrate organisms serving as intermediate hosts and their distribution is not always known (Moravec 1998, Moravec 2007, Moravec & Huffman 2001).

Freshwater planktons belonging to the Family Cyclopidae (Crustacea: Copepoda: Cyclopoida) form an important group as the intermediate host for fish nematodes. Also, Oligochaeta plays a crucial role as an intermediate host of the freshwater fish parasites and different sources show that the subclass Oligochaeta is quite common In Latvia (Pilāts (ed.) 2007, Ozolins et al. 2011, Ozolins et al. 2021). An important role in the distribution of nematodes has intermediate hosts such as Oligochaetes, Ephemeroptera and Cyclopidae. Oligochaetes are widely spread over the World (Timm 1980). In total 13 oligochaete species were found in the Estonian raised bogs: *Cognettia sphagnetorum* (was most frequently encountered (Enchytraeidae)), *Lumbriculus variegatus* (Lumbriculidae) and *Nais variabilis* (Naididae) (were the second and third most frequently occurring species). Furthermore, *L. variegatus* was the largest oligochaete species found and accounted for the majority of the oligochaete biomass when they present. Tubificidae (*Tubifex ignotus*, *Limnodrilus udekemianus* utc.) also was found (van Duinen 2006). *Eiseniella tetraedra* is a cosmopolitan earthworm (Terhivuo et al. 2011) and *Criodrilus lacuum* is only one species of Criodrilidae family, detected in Latvia (Spungis 2008). Freshwater plankton belonging to the Family Cyclopidae (Crustacea: Copepoda: Cyclopoida) is one of the largest group as the intermediate host for fish nematodes. Genus *Mesocyclops*, *Cyclops*, *Megacyclops* and *Macrocyclops* are widely distributed intermediate hosts of fish nematodes.

The genus *Mesocyclops* is represented by one widely distributed species *Mesocyclops leuckarti* in Europe freshwaters. Cyclopinae species *Mesocyclops leuckarti* is also common and widespread in Latvian freshwaters (Błędzki & Rybak 2016, Deimantoviča et al. 2011). *Mesocyclops leuckarti* reported from different freshwater bodies, characteristic habitats are littoral/profundal and pelagial places (Błędzki & Rybak 2016, Nilssen & Wærvågen 2000).

Fourteen species represent the widely distributed genus *Cyclops* in Europe, and seven are known in Latvian freshwaters (Błędzki & Rybak 2016, Deimantoviča et al. 2011). Cyclopinae species *Cyclops strenuus* reported from small water bodies, ponds, temporary waters, the littoral of large lakes, and also in plankton (Błędzki & Rybak 2016, Alekseeva & Ualolikhina (eds.) 2010).
The genus *Megacyclops* is represented by five species in Europe and two in Latvian freshwaters (Błędzki & Rybak 2016, Deimantoviča et al. 2011). *Megacyclops viridis* reported from shallow and deep water bodies in littoral,

sublittoral/profundal, less common in the pelagic zone of large lakes, small water bodies, temporary waters, swamps, the shore-bottom area in rivers and springs (Błędzki & Rybak 2016, Alekseeva & Ualolikhina (eds.) 2010).

The genus *Macrocyclops* is represented by three species in Europe, including Latvian freshwaters (Błędzki & Rybak 2016, Deimantoviča et al. 2011). *Macrocyclops albidus* is a common littoral copepod, found between vegetation in lakes and small water bodies, ponds, ditches, near the shore of rivers, and temporary waters (Błędzki & Rybak 2016, Alekseeva & Ualolikhina (eds.) 2010).

This review summarizes available information about nematode species of freshwater fish in Latvia and data about their potential intermediate hosts. The presence of intermediate hosts in waterbodies explains the occurrence of parasitic nematodes.

MATERIAL AND METHODS

Literature data, about fish full parasitological investigation are summarized in this short review. The data about freshwater fish nematodes was obtained from 1949 till nowadays by several scientists in Latvia. More than 35 fish species were investigated. Data about fish infection and animals serving as potential first, second intermediate and definitive hosts are provided.

RESULTS AND DISCUSSION

In total, 26 species of nematodes were reported in Latvia so far and 42 species of freshwater fish were examined. In general, nematodes are common fish parasites. Out of the 42 species of freshwater fishes examined in Latvia, 32 (73.2 %) were recorded as hosts of nematodes. Most fish species were infected with 1 and 2 species of nematodes (21.4% and 23.8%, respectively). Most of cyprinids were infested with 1 to 3 species of nematodes, while 4 to 7 species of nematodes were found in predatory fish. The most infected was perch, in which 7 species of nematodes were recorded. *Anguillicola crassus* is established in ruffe and perch as paratenic hosts.

Two species were found by S. S. Shulman (1949) and were not discovered later – *Raphidascaris gracillima* and *Goezia* sp.

The following 26 species of nematodes were detected in freshwater fish in Latvia from 1949 till 2023. The first data about the nematodes of freshwater fish was reported by S. S. Shulman (1949). Freshwater planktons belonging to the Family Cyclopidae (Crustacea: Copepoda: Cyclopoida) form an important group as the intermediate host for fish nematodes. Also, Oligochaeta plays a crucial role as an intermediate host of the freshwater fish parasites and different sources show that the subclass Oligochaeta is quite common In Latvia (Pilāts (ed.), 2007, Ozolins et al. 2011, Ozolins et al. 2021).

Phylum Nemathelminthes Schneider, 1873
Class NEMATODA Rudolphi, 1808
Order ENOPLIDA Chitwood, 1933
Family DIOCTOPHYMATIDAE Railliet, 1915
Genus *Eustrongyloides* Jagerskiold, 1909

Eustrongyloides excisus Jägerskiöld, 1909 larva

A rare species found in single specimens in the abdominal muscles of pike and pike perch in two lakes by S.S. Shulman (1949). *Eustrongylides* have indirect life cycles involving a definitive host and two intermediate hosts. Definitive hosts are aquatic birds mostly Family Ardeidae, Anseriformes, Gaviiformes and Pelecaniformes. First intermediate hosts are water oligochaetes of the Tubificidae and Lumbriculidae families, as well as *Limnodrilus* spp. and second-benthophagous fish. Reptiles, amphibians and mammals can be infected accidentally (Paperna 1974, Lichtenfels & Stroup 1985, Youssefi et al. 2020). Infected fish show symptoms such as aberrant behavior, convulsions and surfacing (Coyner et al. 2001).

***Eustrongyloides* sp.** larva (F)
A rare species was recorded in single specimens in the intestinal wall, mesenteries of eel and catfish in the mouth of the Daugava River and Kegums Water Reservoir by S. S. Shulman (1949). In Lake Burtnieku, 22% of perch and one ruffe were infected by this parasite.

Superfamily TRICHUROIDEA Ward, 1907
Family CAPILLARIIDAE Railliet, 1915
Genus *Pseudocapillaria* Freitas, 1959

Pseudocapillaria (Pseudocapillaria) tomentosa (Dujardin, 1843) Moravec, 1987
For the first time in Latvia, this freshwater nematode has been reported by S. S. Shulman (1949) as syn. *Capillaria tomentosa* Dujardin, 1843 in intestine of four fish species from the mouth of the Daugava River. Prevalence of infection was 6.6% in ide (*Leuciscus idus)* and vimba (*Vimba vimba*). Single specimens of the parasite were found in common bream (*Abramis brama*) and common chub (*L. cephalus*) (Shulman 1949). Infection of fish by this species can be both through an intermediate host and in a direct way. However, oligochaetes (*Tubifex tubifex, Limnodrilus hoffmeisteri, L. variegatus*) play a significant role in the development cycle of this nematode (Moravec et al.1987). This nematode is widely distributed in Palearctic Eurasia. The frequently heavy infections of *P. tomentosa* in carp and other fishes in ponds of economic importance suggest that this species may be a pathogenic parasite for fish in intensive pond aquaculture, especially in the breeding of carp fry. The pathogenic effect is expressed in damage to the intestinal mucosa of the host (Moravec 1994, Moravec 2001).

Genus *Schulmanela* Ivashkin, 1964
Schulmanela petruschewskii (Shulman, 1948) Ivashkin, 1964
For the first time in Latvia, this freshwater nematode has been reported by S.S. Shulman (1949) as syn. *Hepaticola petruschewskii* Shulman, 1948. Parasite was found in mesenteries of spined loach (*Cobitis taenia*) and ruffe (*Gymnocephalus cernua*) from Kegums Water Reservoir. The prevalence of *S. petruschewskii* in fish ranged from 8.0% in carp (*Cyprinus carpio carpio*) from ponds to 100.0% in ruffe from themouth of the Daugava River. The highest infection intensity was 50.6 specimens in the ruffe intestine. According to the studies, 53.3% of vimba (*Vimba vimba*) form the mouth of the Daugava River were infected (Shulman 1949, Kirjusina & Vismanis 2004, Kirjusina & Vismanis 2007). Intermediate hosts of parasitic nematode sare oligochaetes *Eiseniella tetraedra* and *Criodrilus lacuum*. Fish become infected by feeding infected oligochaetes. From the intestines of the fish, the larva migrates to the liver, where it develops to the adult stage within six months (Bauer 1987, Moravec 1987). *Criodrilus lacuum* has a Palearctic distribution and is registered in Latvia (Perel 1979, Perel 1997, Ventins 2011). Heavy infections by this nematode were reported to cause liver pathology in fish species such as grass carp and ruff, resulting in emaciation and sluggishness (Moravec 2001).

Subclass SECERNENTEA Linstow, 1905
Order ASCARIDIDA Skrjabin et Schulz, 1940
Superfamily ASCARIDOIDEA Railliet et Henry, 1915
Family ANISAKIDAE Railliet et Henry, 1912
Genus *Contracaecum* Railliet et Henry, 1912

Contracaecum microcephalum (Rudolphi, 1819) Baylis, 1920 larva
Encapsulated larva was found in mesenteries and serosa of bream (*Abramis brama*) in two lakes (Kirjusina & Vismanis 2003). The development cycle is complex. Obligate first intermediate hosts are copepods, optionally dragonfly larvae and juvenile fish; second intermediate hosts are fish; reservoir hosts - larvae of dragonflies, caddis flies and fish; definitive hosts are herons, night herons and cormorants (Semjonova 1974).

Contracaecum micropapillatum (Stossich, 1890) Baylis, 1920 larva
Nematodes were found in 8% of carps in body cavities from ponds (Kirjusina & Vismanis 2004). The life cycle of a parasite is indirect. Intermediate hosts: obligate first intermediate hosts copepods; facultative – amphipods, larvae of chironomids, carp and stickleback fish, frogs; reservoir hosts are fish of the family Cyprinidea, amphibians, dragonfly larvae, chironomids, cyclops and amphipods. The definitive hosts are pelicans, less often herons (Semjonova 1974, Valles-Vega 2017).

Genus *Goezia* Zeder, 1800

Goezia sp.
A rare fresh and brackish water parasite was recorded by S. S. Shulman (1949) in the intestine of salmon from the mouth of the Daugava River.

Genus *Hysterothylacium* Ward et Magath, 1917

Hysterothylacium aduncum (Rudolphi, 1802) Deardorff and Overstreet, 1981, adult and larva
For the first time in Latvia, this brackish and marine water parasite has been reported by S.S. Shulman (1949) as syn. *Contracaecum aduncum* (Rudolphi, 1802) in 13.3% of perch from Riga Gulf.

Genus *Raphidascaris* Railliet et Henry, 1915

Raphidascaris acus (Bloch, 1779) Railliet and Henry, 1915 adult and larva
For the first time in Latvia, this freshwater and brackish water parasite has been reported by S.S. Shulman (1949). *R. acus* is a freshwater and brackish water widespread fish parasite that was detected in lakes, rivers, Gulf of Riga and Baltic Sea in the intestine, liver and mesenteries for 22 fish species: bream (*Abramis brama*), bleak (*Alburnoides bipunctatus*), common bleak (*Alburnus alburnus*), eel (*Anguilla anguilla*), white bream (*Blicca bjoerkna*), Crucian carp (*Carassius carassius*), European whitefish (*Coregonus lavaretus*), pike (*Esox lucius*), three-spined stickleback (*Gasterosteus aculeatus*), gudgeon (*Gobio gobio*), ruffe (*Gymnocephalus cernuus*), chub (*Leuciscus cephalus*), Ide (*L. idus*), Common dace (*L. leuciscus*), perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), zander (*Sander lucioperca*), rudd (*Scardinius erythrophthalmus*), catfish (*Silurus glanis*), tench (*Tinca tinca*), Fourhorn sculpin (*Triglopsis quadricornis*), vimba (*Vimba vimba*). Six fish species from brackishwater and marine environment were hosts of this nematode. The most infected with *R. acus* were fish from lakes and prevalence ranged from 4 to 75%; the intensity of the invasion was not high (Kirjusina & Vismanis 2004). In the life cycle of *R. acus* are involved two hosts. Adult nematodes inhabit the intestine of fish where sexual reproduction occurs. Fish of the families Esocidae, Salmonidae, Anguillidae, Percidae, Lotidae, and Thymallidae have been described to act as the definitive hosts. The development of the larva takes place in the intermediate host (fish) or they accumulated in paratenic host – aquatic invertebrates oligochaetes from the families Naididae, Tubificidae, Glossoscolecidae, Lumbriculidae and Lumbricidae; molluss Planorbidae and Lymnaeidae; planktonic and benthic crustaceans Cyclopidae, Calanoidae, Mysidae, Gammaridae, Asellidae and Daphniidae; larvae of aquatic insects Diptera (Chironomidae and Ceratopogonidae) and Trichoptera. The obligate intermediate hosts are members of the families Cyprinidae, Salmonidae, Coregonidae, Esocidae and others. The complete development of *R. acus* in the definitive host from the ingestion of larva until egg production lasts approximately two months and depends on water temperature (Smith 1984, Smith 1984a, Moravec 1994).

Raphidascaris gracillima (von Linstow, 1890) Skrjabin, 1923 larva
A rare parasite was found in the liver of *Gasterosteus aculeatus* and *Zoarces viviparus*

from the mouth of the Daugava River (Shulman 1949).

Superfamily SEURATOIDEA Campana-Ronget et Brygoo, 1959
Family CUCULLANIDAE Cobbold, 1864
Genus *Cucullanus* Müller, 1777

Cucullanus truttae Fabricius, 1794
For the first time in Latvia, this freshwater and brackish water parasite has been reported by S. S. Shulman (1949) as syn. *Dacnitis stelmioides* Vessichelli, 1910 and *D. truttae* (Fabricius 1794). Lampreys (*Lampetra fluviatilis*), salmon and River trout (*Salmo trutta fario*) from ravers (mouth of the Daugava River, Līčupe River and rivers entering the Gulf of Riga) were infected. Prevalence of invasion was higher in salmon (26,6%) and other species – 6.6% (Kirjusina & Vismanis 2004). In the life cycle of this parasite, lampreys act as both an intermediate (lamprey larvae) host and a definitive host (lampreys after metamorphosis). In lamprey larvae, second-stage nematode larvae develop and reach sexual maturity in adult lampreys. Thus, lampreys can act as intermediate and definitive hosts. Infection of other definitive hosts occurs both when feeding on lamprey larvae and adult lampreys. Salmon and other predatory fish act as definitive hosts (Moravec 1979a, Moravec 1980a, Moravec 1980b, Moravec 1994).

Order SPIRURIDA Chitwood, 1933
Superfamily APROCTOIDEA Yorke et Maplestone, 1926
Family DESMIDOCERCIDAE Cram, 1927
Genus *Desmidocercella* Yorke et Maplestone, 1926

Desmidocercella numidica (Seurat, 1920) York and Maplestone, 1926 larva
Single specimens of this rare parasite were found in the vitreous humor of the eye of perch and rudd from lakes (Kirjusina & Vismanis 2004, Kirjusina & Vismanis 2007). Aquatic invertebrates act as the first intermediate hosts. Fish appear to act as paratenic hosts (Moravec 1994). Adults occur in the air sacs of herons (Ardeidea) (Anderson 2000).

Desmidocercella sp. larva
A.D. Reinsone (1955a) reported this parasite larva in the vitreous humor of the eye of perch ruff and turbot from lakes. Prevalence of infection was higher in perch from lakes (8.6-22.6%).

Superfamily CAMALLANOIDEA Travassos, 1920
Family CAMALLANIDAE Railliet et Henry, 191 5
Genus *Camallanus* Railliet et Henry, 1915

Camallanus (Camallanus) lacustris (Zoega, 1776) Railliet and Henry, 1915
For the first time in Latvia, this freshwater nematode has been reported by S. S. Shulman (1949). In the intestine and pyloric caeca of perch, zander, pike, ruffe, eel and turbot *C. lacustris* was found. The prevalence of infection was higher in rivers (75.0-100.0%) and in lakes – 33.7-80.0%. The parasite was more common in perch, the intensity reached 100.0% and the intensity was up to 41 specimens of the parasite per fish (Kirjusina & Vismanis 2004). The first intermediate hosts are various copepods (*Megacyclops, Macrocyclops, Mesocyclops*, *Cyclops, Acanthoclops, Eucyclops*). *Megacyclops viridis* is also common and widely distributed in Latvian freshwaters (Deimantoviča et al. 2011, Dimante-Deimantoviča 2012). In Latvian freshwater bodies, the species is recorded from lakes (e.g., Riču, Sventes, Drīdzis, Geraņimovas Ilzas (Vezhnovets & Škute 2012, Brakovska et al. 2020), Jazinkas, Lejas, Nirzas, Rāznas, Ārdavs, Sīvers, Alauksts, Bešons, Dagdas, Dubuļu, Lielais Gusena, Laucesas, Usmas, Puzes (Unpublished zooplankton data of Latvian priority salmonoid water lakes 2009, 2010), Saukas (Paidere 2020). Overall, it can be recorded from a variety of water bodies (ponds, fish ponds, rivers, floodplain lakes, for example, floodplain Lake Dvietes (Paidere 2013). The definitive hosts are mainly fish of the Percidae family. Many fish species

(Cobitidae, Cyprinidae, Esocidae, Salmonidae) can act as paratenic hosts (Campana-Rouget 1961, Moravec 1971a, Moravec 1971b, Moravec 1994).

Camallanus (Camallanus) truncatus (Rudolphi, 1814) Törnquist, 1931

For the first time in Latvia, this freshwater nematode has been reported by S.S. Shulman (1949). This nematode was found rarely and in single copies in the intestine of six species of fish: pike, perch, zander, catfish and turbot (Kirjusina & Vismanis 2004, 2007). The first intermediate hosts are copepods (*Mesocyclops, Megacyclops, Macrocyclops, Cyclops*). In Latvian water bodies, *Cyclops strenuus* is common and widely distributed (Deimantoviča et al. 2011, Dimante-Deimantoviča 2012). The distribution of *Megacyclops* in Latvia is described in the section about *C. lacustris* parasite. Fish become infected by feeding copepods infected with larvae. Juveniles of various cyprinids (*Leuciscus*, *Abramis*) probably serve as paratenic hosts. Although the principal hosts of *Camallanus truncatus* seem to be fishes of the genus Stizostedion, it also occurs in other percids and in many fish species of different families (Moravec 1994).

Superfamily DRACUNCULOIDEA Cameron, 1934
Family ANGUILLICOLIDAE Yamaguti, 1935
Genus *Anguillicola* Yamaguti, 1935

Anguillicola crassus Kuwahara, Niimi and Itagaki, 1974

For the first time in Latvia, this freshwater nematode has been reported by K. Vismanis (1998) in eel from Usmas Lake. In the 2000s, the nematode was found in eastern Latvia in lakes not connected to the sea. The nematode has also been found in paratenic hosts – mainly ruffe and perch (Kirjusina & Vismanis 2007). Mass mortality of eel in Lake Usmas was recorded by M. Kirjusina and K. Vismanis (2000).

Various copepods and ostracods, over 17 species, have been identified as intermediate hosts for European eels in experimental and natural conditions. The copepod *Cyclops strenuus* is a potential intermediate host for *A. crassus*. In Latvian water bodies, *Cyclops strenuus* is common and widely distributed (Deimantoviča et al. 2011, Dimante-Deimantoviča 2012). Overall, it can be recorded from a variety of water bodies (lakes, ponds, fish ponds, rivers, estuaries, floodplain lakes and reservoirs). The larvae ingested by the intermediate host or paratenic host (should another fish species consume the intermediate host) and can infect definitive host, eels in the genus *Anguilla* (de Charleroy et al. 1990, Nimeth et al. 2000). At least 30 different fish species, several amphibian, snail, and insect species that can act as paratenic hosts of *A. crassus* in Europe (Thomas & Ollevier 1992, Szekely 1994, Moravec and Konecny 1994, Moravec 1996, Szekely 1996, Moravec and Skorikova 1998, Moravec et al. 2005).

Family Skrjabillanidae Shigin et Shigina, 1958
Genus *Skrjabillanus* Ivashkin, 1964

Skrjabillanus tincae Shigin and Shigina, 1958

The species specific to bream was rare and was found on the intestinal surface of one fish from the lake (Kirjusina & Vismanis 2004). The nematode is viviparous; its intermediate hosts are ectoparasitic branchhiurids (*Argulus* spp.), which become infected by sucking blood from the host's skin. There is no free-living stage in scryabillanids (Tikhomirova 1980, Moravec 2004).

Family PHILOMETRIDAE Baylis et Daubney, 1926
Genus *Philometra* Costa, 1845

Philometra abdominalis Nybelin, 1928

In body cavity, under serosa of swimbladder wall of a roach from a lake and river nematode was found for the first time in Latvia (Vismanis & Popov 1990). Gravid and subgravid females are found in the body cavity, while juveniles, males and unfertilized females are located under the serosa of the

posterior portion of the swimbladder wall (Anderson 2000). The life cycle is one year. The first intermediate hosts are copepods (*Macrocyclops, Megacyclops, Diacyclops*), which become infected by eating larvae that emerge either from the body of a female worm that has left the fish, or that has entered the external environment with the reproductive products of fish. Fish become infected by feeding on infected crustaceans (Molnar 1967, Moravec 1977, Moravec 1994). The distribution of *Megacyclops* in Latvia is mentioned in the section about *C. lacustris* and the distribution of *Macrocyclops* is described in the section about *P. ovata* parasite. According to K. Molnar (1966), only gudgeons and minnows are obligate definitive hosts, where females reach sexual maturity.

Philometra obturans (Prenant, 1886) Skrjabin, Shikhobalova, Sobolev, Paramonov & Sudarikov, 1954

For the first time in Latvia this freshwater nematode has been reported by S.S. Shulman (1949) as syn. *Filaria obturans* Prenant, 1886. Rare nematode was found in single specimens in gill arteries, ventral aorta of pike from lakes (Reinsone 1955a, Reinsone 1955b, Reinsone 1959, Kirjusina & Vismanis 2004). Adult mature females are located in the gill blood vessels, males and young females are in the wall of the swim bladder, in the mesentery and in the vitreous body of the eyes of the pike. The first intermediate hosts are copepods (*Cyclops, Eucyclops, Acanthocyclops, Macrocyclops*, *Megacyclops*). In Latvian water bodies, *Cyclops strenuus* is common and widely distributed (Deimantoviča et al. 2011, Dimante-Deimantoviča 2012). *Megacyclops* distribution is described in the section about *C. lacustris* parasite. The definitive host (pike) becomes infected by feeding on infected copepods, or by feeding on planktivorous fish that serve as paratenic hosts (Molnar 1976, Moravec 1978, Moravec & Dykova 1978, Moravec 1994).

Philometra ovata (Zeder, 1803) Skrjabin, 1923

For the first time in Latvia this freshwater nematode has been reported by S.S. Shulman (1949). In body cavity (females) and under serosa of swimbladder (males) in bream and 7.3% ruffe nematoda was detected (Shulman 1949, Vismanis & Popov 1990). This philometrid is a common parasite of the body cavity of many species of cyprinids in Europe and Asia (Anderson 2000). Gravid and subgravid females are found in the body cavity, while juveniles, males and unfertilized females occur under the serosa of the posterior part of the swimbladder. The life cycle is similar to *P. abdominalis* (Molnar 1966, Moravec 1980b). Intermediate hosts are cyclops *Cyclops strenuus, Macrocyclops albidus*. In Latvian water bodies, *Cyclops strenuus* is common and widely distributed (Deimantoviča et al. 2011, Dimante-Deimantoviča 2012). Overall, it can be recorded from a variety of water bodies (lakes, ponds, fish ponds, rivers, estuaries, floodplain lakes and reservoirs). *Macrocyclops* is one of the most common genera from Eucyclopinae in Latvian freshwaters (Deimantoviča et al. 2011). *Macrocyclops albidus* is widespread in Latvian freshwaters (Dimante-Deimantoviča 2012), it can be recorded from a variety of water bodies such as lakes, rivers, ponds (Nagļi fish ponds) (Paidere 2019), floodplain lakes (floodplain Lake Dvietes) (Paidere 2013).

Philometra rischta Skrjabin, 1923

In Slokas Lake 20.0% of roach was infected. Site of infection – tissues on the inner surface of gill covers, under the skin of head (Kirjusina & Vismanis 2001). The location pertains to gravid, subgravid and young unfertilized females. The life cycle of a nematode is one year. The first intermediate hosts are copepods of the genera *Cyclops, Macrocyclops, Megacyclops*, *Mesocyclops* and *Eucyclops*. The definitive hosts are various species of cyprinids (Kazakov 1989, Molnar 1966). In Latvian freshwaters *Mesocyclops leuckarti* is recorded from lakes (Vaidavas (Eutrophication of small lakes in Latvia), Sitas, Riču, Sventes, Drīdzis, Geraņimovas Ilzas (Vezhnovets & Škute 2012, Brakovska et al. 2020), Jazinkas, Lejas, Nirzas, Rāznas, Ārdavs, Alauksts,

Bešons, Dagdas, Dubuļu, Ežezers, Galšūns, Lielais Gusena, Laucesas, Stirnu, Usmas, Varnaviču (Paidere et al. 2012, Unpublished zooplankton data of Latvian priority salmonoid water lakes 2009, 2010), Ilzu (Garais) (Conceptual model of surface – groundwater interaction 2022), Saukas (Paidere et al. 2023), Vēveru (Tretjakova at al. 2023), ponds, Nagļu fish ponds (Paidere & Brakovska 2019). Overall, it can be recorded from a variety of water bodies. In Latvian water bodies, *Cyclops strenuus* is common and widely distributed (Deimantoviča et al. 2011, Dimante-Deimantoviča 2012). Distribution of *Megacyclops* and *Macrocyclops* is described in sections about *C. lacustris* and *P. ovata*, respectively.

Genus *Philometroides* Yamaguti, 1935

Philometroides cyprini (Ishii, 1931) Nakajima, 1970
Syn.: *Philometra lusii* Vismanis, 1962, *Philometroides lusiana* Vismanis, 1966
Wide distributed and specific to host nematode in carp ponds and lakes. The intensity of infection can reach 100% in ponds and up to 80.0% in lakes (Vismanis 1962, Vismanis 1964, Vismanis 1967, Vismanis 1967a, Vismanis 1967b, Vismanis 1972, Vismanis et al. 1989). *Philometroides cyprini* is considered to be an introduced species that is specific to common carp (Moravec et al. 2005). Gravid and subgravid females are spiral-shaped under the scales; young fertilized females occur in the body cavity, while juveniles, males and unfertilized females are found mainly in the serosa of the swimbladder (between walls). *P. cyprini* has an annual indirect life cycle, in which the carp is the final host and various copepod species serve as intermediate hosts (Schäperclaus 1979, Moravec 1994). Philometrids *P. cyprini* are pathogenic parasites for carp. Migrating juveniles cause inflammation of the swimbladder wall with mechanical damage to blood vessels. The movement of female nematodes to the tissues leads to the damage of muscle. Mass infestations can cause a philometroidosis disease in both cultured and wild fish (Moravec & Cervinka 2005).

Philometroides sanguinea (Rudolphi, 1819) Rasheed, 1963
In the caudal fin (female) and swimbladder wall (male) of crucian carp from lakes this nematode was found in single specimens (Kirjusina & Vismanis 2003). This nematode is specific to fishes of the genus *Carassius.* The first intermediate hosts are copepods *Cyclops, Leptocyclops, Pachycyclops, Acanthocyclops, Macrocyclops, Mesocyclops, Megacyclops, Tropocyclops, Thermocyclops, Diaptomus, Neutrodiaptomus, Sinodiaptomus*, which become infected by eating first-stage larvae that emerge either from the body of a female that has left the fish or with reproductive products fish, into the external environment (Cakay 1957, Nakajima & Egusa 1977a, Nakajima & Egusa 1977 b, Nakajima & Egusa 1977c). The definitive host of *Carassius* becomes infected by eating infected crustaceans (Wierzbicki 1958, Wierzbicki 1960, Ouk & Chun 1973, Moravec 1994, Williams et al. 2012). The distribution of hosts such as *Macrocyclops, Megacyclops, Cyclops, Mesocyclops* in Latvian freshwaters is described in sections *P. rischta, P. ovata, C. lacustris*.

Superfamily THELAZIOIDEA Sobolev, 1949
Family RHABDOCHONIDAE Travassos, Artigast Pereira, 1928
Genus *Rhabdochona* Railliet, 1916

Rhabdochona denudata (Dujardin, 1845) Ralliet, 1916
For the first time in Latvia, this freshwater water nematode has been reported in the intestine of four fish species by S. S. Shulman (1949) as syn. *Ichthyospirura filliformis* (Zschokke 1884). In total, this nematode was found in seven fish species: *Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Leucaspius delineates, Leuciscus cephalus, Rutilus rutilus, Sander lucioperca*. The highest intensity of invasion was in breams, where 20.8% of bream in Sivers Lake was infected

(Kirjusina & Vismanis 2004). In the life cycle, mayflies *Habroleptoides modesta* (Hagen) and *Habrophlebia lauta* (Eaton) or larvae of *Hydropsyche* (Trichoptera) are intermediate hosts (Vojtkova 1971, Moravec 2007). *R. denudata* infects many species of cyprinids, mainly members of the subfamily Leuciscinae (Moravec 1994). Predators such as *Sander lucioperca* are accidental infections mostly through feeding on the definitive hosts.

Superfamily HABRONEMATOIDEA Chitwood et Wehr, 1932
Family CYSTIDICOLIDAE Skrjabin, 1946
Genus *Cystidicola* Fischer, 1798

Cystidicola farionis Fischer, 1798 (F)
For the first time in Latvia, this freshwater water nematode has been reported by K. Shulman (1949) as syn. *Cystidicola impar* (Schneider, 1866) in the swimbladder of *Coregonus lavaretus* and *Osmerus eperlanus* from mouth of the Daugava River. Later parasite was detected in *Gadus morhua callarias, Lampetra fluviatilis, Oncorhynchus mykiss* (Kirjusina & Vismanis 2007). Studies in 1949 revealed 26.6% of infected smelt, but by 2004 all fish studied were infected (Kirjusina and Vismanis 2004). The amphipod crustaceans *Pontoporeia affinis*, *Gammarus fasciatus*, *G. pseudolimnaeus*, *Hyalella azteca* and the mysid crustaceans *Mysis relicta* act as intermediate host (Smith & Lankester 1979, Moravec 1994). The definitive hosts of nematodes belong to open-bladder fish of the families Salmonidae and Osmeridae in which this parasite inhabits their lives (Black & Lankester 1980, Moravec 1994). High intensity of the invasion causes anemia and inflammation of the swim bladder and disturbs its functions, moreover, *C. farionis* is a vector of bacterial diseases (Cusack & Cone 1986, Willers et al. 1991).

Genus *Cystidicoloides* Skinker, 1931

Cystidicoloides ephemeridarum (F) (von Linstow, 1872) Moravec, 1981

For the first time in Latvia this freshwater water nematode was found by K. Vismanis et al. (1984) in the stomach of *Zoarces viviparus,* which was accidentally infected since fishes of the family Salmonidae are parasite common definitive hosts. All tested fish were infected (Kirjusina & Vismanis 2004). Mayflies, mainly of the families Ephemeridae and Leptophlebiidae act as intermediate hosts. The parasite's pathogenicity on fish has not been detected (Greenwood & Baker 1987, Moravec 1994).

CONCLUSIONS

In total, 42 freshwater fish species were studied in Latvia and data about 26 species of nematodes was reported.

Philometroidosis is more important and most prevalent parasitic disease causing economic loss in carp culture is common in fish ponds in Latvia.

Knowledge about the distribution of the intermediate hosts is essential for modeling the distribution of the parasites and can contribute to the understanding of the host-parasite interaction. Studies of intermediate hosts show that many Latvian waterbodies have suitable conditions for the distribution of different nematodes. However, more studies are required to understand the relations between the distribution of the definitive and intermediate hosts, and parasites.

No nematodes pathogenic to humans were found in freshwater fish in Latvia. According to the conducted studies *Hysterothylacium aduncum* (Anisakidae) is not a threat to human health (Cavallero et al. 2020).

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