Parasitology
Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 71 (2), 2019: 285-292

Helminth Communities of Roach *Rutilus rutilus* (L., 1758) (Cypriniformes: Cyprinidae) from Srebarna Biosphere Reserve, Bulgaria

Sonya A. Shukerova & Diana A. Kirin

Department of Ecology and Protection of Environment, Agricultural University – Plovdiv, 12 Mendeleev Blvd., 4000 Plovdiv, Bulgaria; E-mail: sonyashukerova@gmail.com

Abstract: Helminth and helminths communities of roach *Rutilus rutilus* from Srebarna Biosphere Reserve (Lake Srebarna), NE Bulgaria, were studied. Parasitic communities were studied at the infracommunity and at the component community levels. Ten helminth species were identified: *Diplostomum pseudospathaceum*, *D. mergi*, *D. rutili*, *Posthodiplostomum cuticola*, *Tylodelphys clavata*, *Dactylogyrus difformis*, *Diplozoon paradoxum*, *Proteocephallus torulosus*, *Contracaecum microcephalum* and *Acanthocephalus anguillae*. Four helminth species (*T. clavata*, *D. mergi, D. difformis* and *D. paradoxum*) were core species in component community of roach from Lake Srebarna, whereas *D. rutili* was a secondary species; five species, i.e. *D. pseudospathaceum*, *P. cuticola, P. torulosus*, *C. microcephalum* and *A. Anguillae*, were satellite species. Significant seasonal differences between the three seasons in the prevalence of roach helminths were recorded for *D. difformis* and *D. paradoxum*. The present study showed that *R. rutilus* was a new host record for *D. rutili, D. mergi* and *C. microcephalum* from Danubian Basin, Balkan Peninsula and Bulgaria. *R. rutilus* was reported as a new host record for *C. microcephalum* from Europe.

Key words: helminths, helminth communities, *Rutilus rutilus*, Lake Srebarna, Biosphere Reserve Srebarna, Bulgaria

Introduction

Lake Srebarna is listed as a site of the World Natural Heritage and a Biosphere Reserve under the Programme on Man and the Biosphere (UNESCO); it is included in the European and Bulgarian ecological network Natura 2000. Lake Srebarna is included in the List of Wetlands of International Importance (Ramsar Convention) and declared as Important Bird Areas (Birdlife International). Srebarna is a Managed Nature Rererve under Bulgarian legislation. Lake Srebarna is a hypereutrophic lake, situated in NE Bulgaria, at the right bank of the Danube River between r. km 391 and r. km 393 (44°07'N, 27°04'E). The total territory of Srebarna Nature Reserve is 902.1 ha and includes Lake Srebarna (oxbow lake, 600 ha) with the adjacent wet grasslands and inundated forests as well as the Danubian island Devnia. Lake Srebarna is connected via an artificial canal with the Danube. It is characterised by a significant diversity of species of great conservation importance, including globally threatened fish-eating birds such as Dalmatian pelican *Pelecanus crispus* Bruch, Pygmy cormorant *Phalacrocorax pygmeus* (Pallas) and Ferruginous duck *Aythya nyroca* (Güldenstädt) (Michev et al. 1998). A system of dikes along the Danube riverside in the northern part of the reserve and to the east of it is used for protection of flood of adjacent territories of the reserve. In cases when the Danube water level is very high, the river enters into the lake from its northeastern part, which is outside the system of dikes. The watershed is thus not protected from flooding (Michev et al. 1998, Vasilev et al. 2012). The water depth of Lake Srebarna varies from 1.1 m to 2.3 m. The bottom is covered by black to brown silt mixed with residues and fragments of reed and submerged vascular plants. All peripheral areas of

the lake were densely overgrown with submerged vegetation, mainly *Myriophyllum* sp. (Borisova et al. 2014). The redistribution of the bottom invertebrate species among the habitats was strongly influenced by the considerable changes in the water level due to the flooding by the Danube (Varadinova et al. 2009, 2011, 2012). Probably the main reason for the low species diversity and abundance of macrozoobenthos registered in the central lake area is the thick unstable silt substrate that covers the lake bottom (Varadinova et al. 2009).

The fish fauna of Lake Srebarna is composed mainly of limnophylous and some reophylic Danubian species, with roach *Rutilus rutilus* (L.) being one of the most abundant (Pehlivanov et al. 2005, 2012, Pehlivanov & Pavlova 2009. 2012). Adult roaches inhabit a wide variety of lowland nutrient-rich lakes and large to medium sized rivers, small lowland streams and brackish coastal lagoons. The roach is a freshwater, brackish benthopelagic species. Larvae and juveniles inhabit a wide variety of littoral habitats. It feeds predominantly on benthic invertebrates, zooplankton, plant material and detritus (Kottelat & Freyhof 2007). The roach is estimated as least concern species (IUCN Red List Status).

Helminth communities of fish from Lake Srebarna are studied by several authors (Margaritov 1959, Shukerova 2005, 2006, 2010, Shukerova & Kirin 2008, 2012, Shukerova et al. 2010, 2017, Kirin et al. 2013, 2014, Chunchukova et al. 2016). However, the helminth communities of roach from Lake Srebarna have not been studied. The aim of the present study is to reveal the species composition and the structure of helminth communities of roach *R. rutilus* from Lake Srebarna.

Materials and Methods

During spring, summer and autumn, a total of 158 roaches (the body length from 98 to 250 mm, average 115 ± 1.9) were examined for helminth parasites. Fifty five fish individuals were studied in spring and summer and forty eight in autumn. Fish were captured by local fishermen using various methods (netting, angling or electro-fishing). They were transported alive to the laboratory within 1 h after being captured. Fishes were dissected and immediately examined under a stereomicroscope; a few specimens were either fixed in 4% formaldehyde or frozen for subsequent studies. All applicable institutional, national and international guidelines for the care and use of animals were followed. Totally, 1971 helminth specimens were obtained and examined during the study. Helminths were separated from internal organs and tissues and also from fins, skin, gills, eyes and brain. They were fixed and preserved in 70% ethanol (Bauer et al. 1981, Moravec 1994). All parasites were identified and counted. Cestodes, trematodes and monogeneans of the genus *Diplozoon* von Nordmann, 1832 were stained in iron acetocarmine, dehydrated in ascending ethanol series, cleared in eugenol and mounted in Canada balsam (Bykhovskaya-Pavlovskaya 1985, Georgiev et al. 1986, Scholz & Hanzelová 1998). Larval stages of digeneans (metacercariae) of the genus *Diplostomum* von Nordmann, 1832 were cleared in dimethylphthalate and mounted in Canada balsam (Shigin 1986, Niewiadomska & Niewiadomska-Bugaj 1995). Nematodes and acanthocephalans were studied as temporary glycerol mounts (Bykhovskaya-Pavlovskaya 1985, Moravec 1994). The monogeneans of the genus *Dactylogyrus* Diesing, 1850 were studied as temporary ammonium picrate glycerine mounts (Malmberg 1970, Gusev 1983, 1985).

Conserning the host specificity, a parasite species infecting one host species or a few phylogenetically-related species was considered as a specialist; a helminth species infecting at least two taxonomically-unrelated host species was considered as a generalist (Poulin 1992, 1997, Gharbi et al. 1994, Combes 1995, Sasal et al. 1998, Šimková et al. 2006). The ecological and infection terminology followed Bush et al. (1997). Parasitic communities were studied at the infracommunity and at the component community levels (Bush et al. 1997). Brillouin's Diversity Index and Berger-Parker Dominance Index were calculated as described by Maguran (1988). The dominance was determined according to the criteria proposed by Kennedy (1993) on the basis of the prevalence (P): satellite species ($P < 10$), secondary species ($10 < P < 20$) and core species ($P > 20$). Mean abundance (MA) and mean intensity of infection (MI) were calculated using Microsoft Excel and STATISTICA 7.0 programs. Seasonal differences were evaluated by applying Chi-square test for prevalence, Bootstrap 2-sample t-test for comparing mean abundances and mean intensities of infection (Quantitative Parasitology, Version 3.0, available at http://www.behav.org/qp/qp.htm; Rozsa et al. 2000) and Kruskal-Wallis test H for the abundance (Statistica 7.0). The species identification of parasites was performed by using several guides (Bauer 1987, Kennedy 2006, Moravec 1994, 2001, Niewiadomska 1986, 1996, Scholz 1999, Scholz & Hanzelová 1998, Shigin 1986).

Results

Species diversity of helminths

Ten helminth species belonging to the classes Trematoda (5), Monogenea (2), Cestoda (1), Nematoda (1) and Acanthocephala (1) were identified (Table 1). Six out of 10 helminth species were allogenic (Esch et al. 1988) and used fish as an intermediate host and matured in fish-eating birds; these were five trematode species and the nematode *Contracaecum microcephalum*. The remaining four species were autogenic (*D. difformis*, *D. paradoxum*, *P. torulosus* and *A. anguillae*). All allogenic helminth species of roach were larvae (60.00%) and all autogenic species were adults (40.00%).

Component community

Helminth parasites were found in 113 (71.50%) roaches. The component helminth community consisted of ten species (Table 1). Four helminth species (*T. clavata*, *D. mergi, D. difformis* and *D. paradoxum*) were core species, whereas *D. rutili* was a secondary species. Five helminth parasites (*D. pseudospathaceum*, *P. cuticola, P. torulosus*, *C. microcephalum* and *A. anguillae*) were satellite species.

The monogenean *D. difformis* had the highest infection parameters (P=46.84%; MA=5.62±9.93; MI=12.00±11.58) over the entire period of the study and in each of the three seasons (Table 2). *D. difformis* and *D. paradoxum* showed the highest prevalence in summer. The highest prevalence of *D. mergi* and *T. clavata* was reported in spring. All helmith species showed the lowest infection parameters during autumn (Table 2). Significant seasonal differences between three seasons in the prevalence of roach helminths were recorded for the monogeneans *D. difformis* (Kruskal-Wallis test: H (2, N=158) =17.120, p=0002) and *D. paradoxum* (Kruskal-Wallis test: H (2, N=158)=9.476, p=0.0088). Seasonal differences of prevalence were significant between summer and autumn (p=0.0002) and between spring (p=0.02) for *D. difformis* and between spring and autumn (p=0.02) and summer and autumn (p=0.03) for *D. paradoxum*. Season differences were observed in mean intensity of infection of *D. difformis* between spring and autumn and between summer and autumn (Bootstrap t-test p=0.001 for both) (Table 2). Seasonal changes in mean intensity of infection were significant between spring and summer for *D. paradoxum* (Bootstrap t-test p=0.02). Season differences were observed in mean abundance of *D. difformis* between spring and autumn and between summer and autumn (Bootstrap t-test, p=0.01 for both). Mean abundance of *D. paradoxum* showed season differences between summer and autumn (Bootstrap t-test, p=0.02). Species composition of component community between the seasons showed considerable similarity: spring–autumn Ij=0.77, spring–summer Ij=0.74 and summer–autumn Ij=0.62.

The species diversity and dominance across the seasons showed similar values (Table 3).

Infracommunities

From examined fish hosts, 113 (71.50%) were infected with helminth parasites. The infracommunities consisted of 1–5 helminth species: 35 hosts (30.97%) were infected with one helminth species, 36 (31.86%) with two species, 27 (23.89%) with three species, 13 (11.50%) with four species and 2 (1.77%) roaches with 5 helminth species. The maximum number of helminth individuals in an infracommunity was 95.

Discussion

This is the first study of helminth communities of roach from Lake Srebarna. Diversity of helminths and helminth communities of fish from Lake Srebarna have been studied by several authors (Margaritov 1959, Shukerova 2005, 2006, 2010, Shukerova & Kirin 2008, 2012, Shukerova et al. 2010, 2017, Kirin et al. 2013, 2014, Chunchukova et al. 2016).

The first examinations of helminth fauna of *Rutilus rutilus* in Bulgaria were carried out by Margaritov (1965), Kakacheva-Avramova (1977), Nedeva-Menkova (1977), Kakacheva-Avramova & Menkova (1978a, b); they included roach from Maritza, Danube, Palakaria, Devinska and Shipolnica rivers as well as Iskar Reservoir. The results were summarized by Kakacheva-Avramova (1983) reporting a total of 14 helminth species: *Bucephalus polymorphus* von Baer, 1827, *Dactylogyrus sphyrna* von Linstow, 1878, *D. suecicus* Nybelin, 1937, *D. vistulae* Prost, 1957, *Gyrodactylus gracilihamatus* Malmberg, 1964, *G. prostae* Ergens, 1963, *Paradiplozoon homoion* (Bychowsky & Nagibina, 1959) (syn. *Diplozoon homoion*), *Caryophyllaeus brachycollis* Janiszewska, 1953, *Caryophyllaeides fennica* (Schneider, 1902), *Schyzocotyle acheilognathi* (Yamaguti, 1934) (syn.: *Bothriocephalus acheilognathi*), *Proteocephalus torulosus* (Batch, 1786), *Ligula intestinalis* (Linnaeus, 1758), *Acanthocephallus anguillae* and *A. lucii* (Müller, 1776) (nomenclature updated according to Matejusová et al. 2001, 2002, 2004, Brabec et al. 2015). Later studies of helminths of roach in Bulgaria reported more 9 species: *Posthodiplostomum cuti-*

Table 1. Species diversity of helminth parasites in the roach *Rutilis rutilis* from Lake Srebarna (158 host specimens studied).

Helminth species	n	P%	MA±SD	Intensity		Site of infection
				MI±SD	Range	
Trematoda						
Diplostomum pseudospathaceum, (Newiadomska, 1984), larvae	2	1.27	0.09±0.85	7±4.24	4-10	lens
Diplostomum mergi Dubois, 1932, larvae	34	21.52	1.08±4.31	5.03±8.25	1- 47	lens
Diplostomum rutili Razmashkin, 1969, larvae	30	18.99	0.84±3.11	4.43±6.0	1 -29	lens
Tylodelphys clavata (von Nordmann, 1832), larvae	56	35.44	4.02±9.6	11.54±13.42	1-60	vitreous humour
Posthodiplostomum cuticola (von Nordmann, 1832), larvae	3	1.90	0.2±0.13	1±0	1	skin, musculature, fins
Monogenea						
Dactylogyrus difformis Wagener, 1857	74	46.84	5.62±9.93	12±11.58	1 -45	gills
Diplozoon paradoxum von Nordmann, 1832	48	30.38	0.66±1.64	2.33±2.36	1- 10	gills
Cestoda						
Proteocephalus torulosus (Batsch, 1786)	2	1.27	0.01±0.11	1±0	1	intestine
Nematoda						
Contracaecum microcephalum (Rudolphi, 1809), larvae	3	1.90	0.03±0.22	2±0	2	mesentery of the intestine
Acantocephala						
Acanthocephalus anguillae (Müller, 1776)	2	1.27	0.01±0.11	1±0	1	intestine

n, number of fish infected; P%, prevalence; MA, mean abundance; MI, mean intensity; Range, range of intensity.

Table 2. Seasonal changes of helminth infection in the roach *Rutilus rutilus* from Lake Srebarna

Helminth species	Spring N=55		Summer N=55		Autumn N=48	
	P%	MI±SD	P%	MI±SD	P%	MI±SD
	MA±SD	Range	MA±SD	Range	MA±SD	Range
Diplostomum pseudospathaceum	3.64	7.00±4.24	-	-	-	-
	0.25±7.45	4-10	-	-	-	-
Diplostomum mergi	30.91	3.41±3.89	18.18	4.90±3.84	14.58	9.14±16.87
	1.05±7.73	1-12	0.89±6.85	1-11	1.33±6.85	1-47
Diplostomum rutili	12.73	5.14±6.31	27.27	5.00±7.34	16.67	2.75±1.76
	0.65±7.75	1-17	1.36±1.24	1-29	0.46±1.24	1-6
Tylodelphys clavata	40.00	9.45±12.48	36.36	16.00±16.39	27.08	8.23±7.73
	3.78±11.3	1-47	5.82±5.42	1-60	2.23±5.4	1-27
Posthodiplostomum cuticola	3.64	1.00	1.82	1.00±0	-	-
	0.04±7.35	1	0.02±0	1.00	-	-
Proteocephalus torulosus	3.64	1.00	-	-	-	-
	0.04±7.41	1	-	-	-	-
Diplozoon paradoxum	32.73	1.44±1.04	38.18	3.19±3.03	12.50	2.00±1.67
	0.47±7.47	1-4	1.22±0.87	1-10	0.25±0.87	1-5
Dactylogyrus difformis	47.27	8.96±9.68	61.82	16.53±13.18	29.17	6.64±5.44
	4.24±10.5	1-44	10.22±4.18	2-45	1.94±4.18	1-17
Contracaecum microcephalum	1.82	2.00±0	-	2.00±0	-	-
	0.04±7.35	2-2	-	2-2	-	-
Acanthocephalus anguillae	3.64	1.00	-	-	-	-
	0.04±7.35	1	-	-	-	-

P%, prevalence; MA, mean abundance; MI, mean intensity; Range, range of intensity; N, number of fish individuals studied

Table 3. Seasonal variations of species diversity and dominance within helminth communities in the roach from Lake Srebarna

Season	Number of species	Number of helminth individuals	Brillouin's Diversity Index	Berger-Parker Dominance Index
Spring	10	583	1.81	0.29
Summer	7	1076	1.57	0.26
Autumn	5	298	1.49	0.33

cola, *P. brevicaudatum* (von Nordmann, 1832) and *Tylodelphys clavata* (roach from Lake Durankulak, Kostadinova 1993); *Metagonimus yokogawai* (Katsurada, 1912), *Diplostomum pseudospathaceum* Niewiadomska, 1984, *D. spathaceum* (Rudolphi, 1819), *Philometra abdominalis* Nybelin, 1928, *Eustrongylides excisus* Jägerskiöld, 1909 and *Pomphorhynchus laevis* (Müller, 1776), (in roach from the Bulgarian part of Danube, Nedeva et al. 2003, Atanasov 2012, Kirin et al. 2014).

As a result of the present study, *R. rutilus* is revealed as a new host record for *D. rutili*, *D. mergi* and *C. microcephalum* from the Basin of Danube River, Balkan Peninsula and Bulgaria. In addition, *R. rutilus* is reported as a new host record for *C. microcephalum* from Europe. It is also reported as a new host record for *D. pseudospathaceum* from the internal basins of Bulgaria.

Srebarna is a hyper-eutrophic lake, which is connected with the Danube River by means of an artificial canal. Fish populations of roach from Lake Srebarna and the Danube River are closely connected by exchange of individuals but the species composition of their component helminth communities differs. Two species, the cestode *P. torulosus* and the trematode *D. pseudospathaceum*, were found parasitic in roach in both the Danube River (Bulgarian part) and Lake Srebarna. The river and the lake are characterised by different environmental conditions, which is the probable reason for differences in species composition of parasitic communities. Prevalence of *D. pseudospathaceum* and *P. torulosus* (1.27% for both) in *R. rutilus* from Lake Srebarna (Table 1) were lower than prevalence of these helminth species (P%=8.30%, P%=80.85%, respectively) in roach from the Bulgarian part of Danube River (Kakacheva-Avramova 1977, Atanasov 2012).

The fish helminths recorded from the Danube use as intermediate hosts mostly benthic molluscs and crustaceans. The species diversity of benthic invertebrate communities showed that dipteran larvae such as *Chaoborus crystallinus* (De Geer) (Chaoboridae) and *Chironomus plumosus* (L.) (Chironomidae) as well as the aquatic oligochaetes *Potamothrix hammoniensis* (Michaelsen), *P. bavaricus* (Oschmann), *Limnodrilus hoffmeisteri* Claparède and *L. claparedianus* Ratzel are predominating groups in the macroinvertebrate communities in the main water body (99.00% of benthic fauna) and peripheral pools (90.00%) of Lake Srebarna. Primary aquatic groups such as molluscs and crustaceans are poorly represented in the total number of the macrozoobenthic invertebrates in Lake Srebarna. A percentage increase of the orders Trichoptera, Odonata and Ephemeroptera has been observed in peripheral pools (Uzunov et al. 2001, Uzunov 2009, Varadinova et al. 2009, 2011, 2012, Borisova et al. 2014). In the most peripheral zones, more diversified habitat structure and the availability of refuges against fish predation favour the development of bottom invertebrate communities with greater species richness and diversity as well as higher total abundance. The thick unstable silt substrate covering the lake bottom in the central open water area and the very low density of submerged macrophytes there determine the poor species diversity of macrozoobenthos (Borisova et al. 2014).

The numerous metacercariae of *Diplostomum* spp. and *T. clavata* found during the present study can be explained by the high diversity of fish-eating birds (Mitchev et al. 1998, Kambourova 2012) and the abundance of snails in the periphery of the lake (Uzunov et al. 2001, 2012, Varadinova et al. 2009, 2011, 2012). The lake zooplankton is dominated by rotiferans, cladocerans and copepods (Pehlivanov et al. 2006, 2012). The copepods are intermediate hosts of *P. torulosus*, whereas definitive hosts are many cyprinid, percid and other fish species (Bykhovskaya-Pavlovskaya 1985, Scholz 1999). First intermediate hosts of the nematode *C. microcephalum* are copepods, second intermediate hosts are fish and definitive hosts are different fish-eating birds, in Europe these are: *Ardea cinerea* (L., , 1758) *A. purpurea* L., 1766, *Ardeola ralloides* (Scopoli, 1769), *Nycticorax nycticorax* (L., 1758), *Pelecanus onocrotalus* L., 1758 and others (Moravec 1994). The monogeneans *D. difformis* and *D. paradoxum* have a direct life cycle. The acantocephalan *A. anguillae* use the isopod *Asellus aquaticus* (L.) as an intermediate host and different fish species as a de-

finitive host (Moravec et al. 1997, Kenedy 2006). All parasites of the component community of roach from Lake Srebarna have wider host ranges and are generalists excluding *D. difformis* (Poulin 1992, 1997, Gharbi et al. 1994, Combes 1995, Sasal et al. 1998, Šimková et al. 2006).

Helminth fauna of roach from eutrophic Lake Kostowskie, Poland, was investigated by Dzika et al. (2008). Fifteen helminth species were recorded. Five core species with the prevalence exceeded 20.00% were recorded: *T. clavata* (metacercariae) (P%=43.58), *Paradilepis scolecina* (Rudolphi, 1819) (P%=25.64) and *P. megan* (Bychowsky & Nagibina, 1959) (P%=23.03), *Diplostomum* sp. (metacercariae) (P%=23.03) and *Paradiplozoon homoion* (P%=20.51). *Dactylogyrus caballeroi* Prost, 1960 and *D. crucifer* Wagener, 1857 (P%=18.52) are secondary species of component community of roach from Lake Kostowskie and other six species are satellite (*P. cuticola*, *D. difformis*, *D. fallax* Wagener, 1857, *D. nanus* Dogiel & Bychowsky, 1934, *D. similis* Wagener, 1909, *D. suecicus*, *Gyrodactylus decorus* Malmberg, 1957, *G. laevis* Malmberg, 1957). Common helmitnh species for both helminth communities of roach from Lake Srebarna and from Lake Kostowskie are *T. clavata*, *P. cuticola* and *D. difformis*. *T. clavata* is core species in the helminth component communities of roach at both sites.

Component helminth community of roach from costal Lake Łebsko, Poland is composed of four helminth species (Morozińska-Gogol & Bachowska 2003). Species recorded both in Lake Srebarna and Lake Łebsko are *P. cuticola*, *T. clavata* and *A. anguillae*. The species *P. cuticola* (P%=66.30) and *Diplostomum* spp. (P%=55.90) are core species and *T. clavata* (P%=8.90) and *A. anguillae* (P%=2.60) are satellite species in helminth community of roach from Lake Łebsko. *T. clavata* in component community of roach from Lake Srebarna was core species, whereas *P. cuticola* and *A. anguillae* were satellite. The highest level of infection in component helminth communities of roach from the two lakes were observed in spring (*P. cuticola* and *T. clavata* from Lake Łebsko; *D. mergi* and *T. clavata* from Lake Srebarna) and in summer (*Diplostomum* spp. from Lake Łebsko; *D. mergi*, *D. paradoxum* and *D. difformis* from Lake Srebarna).

Valtonen et al. (2003) recorded 13 helminth species from the eutrophic Lake Vatia, Finland: *Rhipidocotyle fennica* Gibson, Taskinen & Valtonen, 1992, larvae, *R. campanula* (Dujardin, 1845), *T. clavata*, *Diplostomum gasterostei* Williams, 1966, *D. spathaceum*, *Allocreadium isoporum* (Looss, 1894), *Gyrodactylus* sp., *Paradiplozoon homoion*, *P. torulosus*, *Raphidascaris acus* (Bloch, 1779), *Pseudocapillaria* sp, *Neoechinorhynchus rutili* (Müller, 1780), *Acanthocephalus lucii* (Müller, 1777). Three core species (*Rhipidocotyle campanula*, 97%; *Raphidascaris acus*, 78% and *D. spathaceum*, 54%) were recorded. Species recorded both in Srebarna and Vatia are *T. clavata* and *P. torulosus*. The latter is a satellite species in the component helminth communities in roach at both sites.

The parasitic community of roach from Lake Srebarna is relatively poor. The probable reasons for this are the fluctuating water level, the eutrophic conditions and the relatively poor invertebrate benthic fauna in the lake.

Acknowledgements: We thank the Agricultural University – Plovdiv for the provision of the technical and laboratory equipment used in this study and the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, for the opportunity to use the Srebarna Field Station.

References

Atanasov G. 2012. Fauna, morphology and biology on the endohelminths of fish from Bulgarian part of the Danube River. Dissertation Abstract, PhD thesis, Sofia, 51.

Bauer O. N., Musselius V. A. & Strelkov Y. A. 1981. Diseases of pond fish. Moscow: Legkaya I Pishchevaya Promishlenost' Publishers. 320 p. (In Russian).

Bauer O.N 1987. Guide to parasites of fresh water fish fauna USSR. Vol. III, (Part 2). Leningrad: Nauka. 583 p. (In Russian).

Borisova P., Varadinova E., Kerakova M., Kazakov S., Stoichev S., Uzunov Y., Pehlivanov L. 2014. Seasonal changes in benthic communities of the Srebarna Lake (Northeast Bulgaria): Habitat perspective. Acta Zoologica Bulgarica 66 (2): 239–245.

Brabec, J., A. Waeschenbach, T. Scholz, D. T. J. Littlewood & R. Kuchta. 2015. Molecular phylogeny of the Bothriocephalidea (Cestoda): molecular data challenge morphological classification. International Journal for Parasitology 45(12): 761-771

Bush A. O., Lafferty K. D., Lotz J. M. & Shostak A. W. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. Journal of Parasitology 83 (4): 575–583.

Bykhovskaya-Pavlovskaya I.E. 1985. Parasites of fish. Manual on study. Leningrad: Nauka.121 p. (In Russian).

Combes C. 1995. Interactions durables: Écologie et Évolution du Parasitisme. Paris: Masson. 576 p.

Chunchukova M. K., Shukerova S. A. & Kirin D. A. 2016. Research of the impact of River Danube on Biosphere Reserve "Srebarna" by model ecosystem *Abramis brama* – macroinvertebrates – sediments. Agrticultural Sciences Journal, year VIII, 9: 151–158.

Dzika E., Kuształa M. & Kozłowski J. 2008. Metazoan parasite fauna of fish species from Lake Kostowskie. Archives of Polish Fisheries 16 (1): 75–86.

Gharbi E. S., Birgi E. & Lambert A 1994. Monogenea (Dacty-

logyridae), parasites of cyprinidae of the genus *Barbus* in northern Africa. Systematic Parasitology 27 (1): 45–70.

Esch G. W., Bush A. O., Kennedy C. R. & Aho J. M. 1988. Patterns in helminth communities in freshwater fish in Great Britain alternative strategies for colonization. Parasitology 96 (3): 519–532.

Georgiev B., Biserkov V. & Genov T. 1986. In toto staining method for cestodes with iron acetocarmine. Helminthologia 23: 279–281.

Gusev A. V. 1985. Guide to parasites of freshwater fish, fauna USSR. Volume II. Leningrad: Nauka. 426 p. (In Russian).

Gusev A. V. 1983. Methods for collecting and processing of materials of monogeneans parasit on freshwater fish. Leningrad: Nauka.48 p.(In Russian).

Kakacheva-Avramova D. 1977. Study on the helminth composition of fish from the Bulgarian part of the Danube River. Khelmintologiya 3, 20–45. (In Bulgarian).

Kakacheva-Avramova D. 1983. Helminths of freshwater fish in Bulgaria.. Sofia: Publishing House of the Bulgarian Academy of Sciences. 262 p. (In Bulgarian).

Kakacheva-Avramova D. & Menkova I. 1978a. Study of helminths of fish from Iskar Dam. II. Helminths of fish from Palakaria River. Khelmintologiya 5: 39–46. (In Bulgarian).

Kakacheva-Avramova D. & Menkova I. 1978b. Helminthological study of fish from Rodopian Rivers. Khelmintologiya 6: 44–53. (In Bulgarian).

Kambourova N.2012. Ornithofauna of the Biosphere Reserve Srebarna Lake. In: Uzunov Y., Georgiev B. B., Varadinoiva E., Ivanova N., Pehlivanov L. & Vasilev V. (Eds.). Ecosystems of the Biosphere Reserve Srebarna Lake. Sofia: Professor Marin Drinov Academic Publishing House, pp. 129–154.

Kennedy C. 1993. The dynamics of intestinal helminth communities in eels *Anguilla anguilla* in a small stream: long-term changes in richness and structure. Parasitology 107(1): 71–78.

Kennedy C. 2006. Ecology of the Acanthocephala. New York: Cambridge University Press, 249 p.

Kirin D., Hanzelova V., Shukerova S., Hristov S., Turcekova L. & Spakulova M. 2013. Helminth communities of fishes from the River Danube and Lake Srebarna, Bulgaria Scientific Papers. Series D. Animal Science. LVI: 333–340.

Kirin D., Hanzelova V., Shukerova S. & Kuzmanova D. 2014. Biodiversity, Bioindication and Helminth communities of *Abramis brama* (Linnaeus, 1758) from the Danube River and Lake Srebarna, Bulgaria. Turkish Journal of Agricultural and Natural Sciences Special Issue (1): 727–733.

Kostadinova A. K. 1993. Trematodes and trematode communities of fish-eating birds from Bulgarian Black Sea coast. Dissertation Abstract, PhD thesis, Sofia, BAS, Bulgaria.

Kottelat M. & Freyhof J. 2007. Handbook of European freshwater fishes. Cornol & Berlin: Kottelat & Freyhof. 646 p.

Maguran A. 1988. Ecological diversity and its measurement. Princeton: Princeton University Press. 189 p.

Malmberg G. 1970. The excretory systems and marginal hooks as basic for the systematic of *Gyrogactylus* (Trematoda, Monogenea). Arkiv för Zoologi Serie 2, 23 (1): 1–235.

Margaritov N. 1959. Helminths of some freshwater fish in our country. Research Institute of Fisheries and Fish Industry, Varna. 21 p.

Margaritov N. 1965. Intestinal helminths of fish middle reaches of the Maritsa River and its tributaries. Annual Book of Sofia University St. Kliment Ohridski 58 (1): 129–150.

Michev T. M., Georgiev B. B., Petrova A. V. & Stoyneva M. P. (Eds.) 1998. Biodiversity of the Srebarna Biosphere Reserve, Checklist and Bibliography. Sofia: Pensoft. 144 p.

Morozińska-Gogol J. & Bachowska A. 2003. Parasites of roach *Rutilus rutilus* (L.) from the Lake Łebsko. *Baltic Coastal Zone* 7: 75–80.

Moravec, F. 1994. Parasitic nematodes of freshwater fish of Europe. Dordrecht & Praha: Kluwer Academic Publishers & Academia. 473 p.

Moravec, F. 2001. Checklist of the metazoan parasites of fish of the Czech Republic and the Slovak Republic (1873–2000). Praha, Academia. 168 pp.

Moravec F., Gelnar M., Ergens R. & Scholz, T., 1997. Metazoan parasites of fishes from the section of the Vltava River supposed to be affected by the operation of the Temelín nuclear electric power-station, Czech Republic. Acta Societatis Zoologicae Bohemicae, 61 (1): 65-76.

Nedeva I., Atanasov G., Karaivanova E., Cakic P. & Lenhardt M. 2003. *Pomphorhynchus laevis* (Müller, 1776) from the river Danube. Experimental Pathology and Parasitology 6/13: 14–16.

Nedeva-Menkova I. 1977. Study of helminths of fish from Iskar Dam. II. Helminths of fish from Shipolnica River. Khelmintologiya 4: 34–39. (In Bulgarian).

Niewiadomska K, Niewiadomska-Bugaj M. 1995. Optimal identification procedure for *Diplostomum paracaudum* (Iles, 1959) and *D. pseudospathaceum* Niewiadomska, 1984 metacercariae (Digenea) based on morphological characters. Systematic Parasitology 30 (3): 165–171.

Niewiadomska K. 1986. Verification of the life-cycles of *Diplostomum spathaceum* (Rudolphi, 1819) and *D. pseudospathaceum* Niewiadomska, 1984 (Trematoda: Diplostomidae). Systematic Parasitology 8 (1): 23–31.

Niewiadomska K. 1996. The genus *Diplostomum* — taxonomy, morphology and biology. Acta Parasitologica 41 (2): 55–66.

Poulin R 1992. Determinants of host-specifity in parasites of freshwater fishes. International Journal for Parasitology 22 (6): 753–758.

Poulin R. 1997. Parasite faunas of freshwater fish: The relationship between richness and the specificity of parasites. International Journal for Parasitology 27 (9): 1091–1098.

Pehlivanov L. & Pavlova M. 2009. State and succession of the ichthyofauna in the antropogenous modified environment of the Srebarna Lake (Danube floodplain, North-East Bulgaria). Scientific Annals of the Danube Delta Institute, Tulcea – Romania, 15: 35–40.

Pehlivanov L. & Pavlova M. 2012. Ichthyofauna and fish communities. In: Uzunov Y., Georgiev B.B., Varadinoiva E., Ivanova N., Pehlivanov L. & Vasilev V. (Eds.). Ecosystems of the Biosphere Reserve Srebarna Lake. Sofia: Professor Marin Drinov Academic Publishing House, pp. 93–113.

Pehlivanov L., Tzavkova V. & Vassilev V. 2006. Development of the zooplankton community in the Srebarna Lake (northeastern Bulgaria) along the process of ecosystem rehabilitation. Proceedings of the 36th International Conference of IAD, Vienna, 280–284.

Pehlivanov L., Tsavkova, V. Pavlova M & Stefan Kazakov 2012. Zooplankton. In: Uzunov Y., Georgiev B.B., Varadinoiva E., Ivanova N., Pehlivanov L. & Vasilev V. (Eds.) Ecosystems of the Biosphere Reserve Srebarna Lake. Sofia: Professor Marin Drinov Academic Publishing House, pp.77–92.

Rozsa L., Reiczigel J. & Majoros G. 2000. Quantifying parasites in samples of hosts. Journal of Parasitology 86 (2): 228–232.

Sasal P., Desdevises Y. & Morand S 1998. Host-specialization and species diversity in fish parasites: phylogenetic conservatism? Ecography 21 (6): 639–643.

Scholz T. 1999. Life cycles of species of Proteocephalus, parasites of fishes in the Palearctic Region: a review. Journal of Helminthology 73 (1): 1–19.

Scholz T. & Hanzelová V. 1998. Tapeworms of the genus *Proteocephalus* Weinland, 1958 (Cestoda: *Proteocephalidae),* parasites of fishes in Europe. Praha: Academia.119 p.

Shigin A. 1986. Trematode fauna of the USSR. Genus *Diplostomum*. Metacercariae. Moscow: Nauka. 234 p. (In Russian).

Shukerova S.A. 2005. Helminth fauna of the Prussian Carp, *Carassius gibelio* (Bloch, 1782), from the Srebarna Biosphere Reserve, Buigaria. *Trakia Journal of Sciences* 3 (6): 36–40.

Shukerova S. A. 2006. Helminth fauna of the Common carp, *Cyprinus carpio* (Linnaeus, 1758), from the Srebarna Biosphere Reserve, Bulgaria. Scientific articles Ecology 2: 217–223.

Shukerova S. A. 2010. Helmiths and helminth comminities of freshwater fish from Biosphere Reserve Srebarna. Dissertation Abstract, PhD thesis, Sofia, 33.

Shukerova S. A. & Kirin D. A. 2008. Helminth communities of the rudd, *Scardinius erythrophthalmus* (Cypriniformes, Cyprinidae) from Srebarna Biosphere Reserve, Bulgaria. Journal of Helminthology 82 (4): 319–323.

Shukerova S. A. & Kirin D. A. 2012. Ecological study of helminths and helminth communities of pumpkinseed *Lepomis gibbosus* (Centrarchidae) from the Srebarna Lake, Bulgaria. "Seminar of Ecology - 2012". IBER-BAS, Sofia.

Shukerova S.A., Kirin D.A. & Hanzelova V. 2010. Endohelminth communities of the perch, *Perca fluviatilis* (Perciformes, Percidae) from Srebarna Biosphere Reserve, Bulgaria. Helminthologia (Bratislava) 42 (2): 99–104.

Shukerova S., Kirin D., Chunchukova M. & Kuzmanova D. 2017. Helminth fauna of white bream (*Blicca bjoerkna*) (Linnaeus, 1758), from the Srebarna Biosphere Reserve, Bulgaria. Scientific Papers. Series D. Animal Science LX: 366–371.

Šimková A, Verneau O., Gelnar M. & Morand S. 2006. Specificity and specialization of congeneric monogeneans parasitizing cyprinid fish. Evolution 60 (5): 1023–1037.

Uzunov Y. 2009. Development and actual state of the macrozoobenthic fauna in the Srebarna biosphere reserve (north-east Bulgaria). Comptes rendus de l'Academie bulgare des Sciences. Biologie Hydrobiologie 62 (2): 243–248.

Uzunov Y., Georgiev B.B., Varadinoiva E., Ivanova N., Pehlivanov L. & Vasilev V. (Eds.) 2012. Ecosystems of the Biosphere Reserve Srebarna Lake. Sofia: Professor Marin Drinov Academic Publishing House. 224 p.

Uzunov Y., Tzavkova V., Todorov I. & Varadinova E. 2001. The macrozoobenthic fauna of the Biosphere reserve Srebarna Lake in North-Eastern Bulgaria. Lauterbornia 40: 43–53.

Valtonen E. T., Holmes J. C., Aronen J. & Rautalahti I. 2003. Parasite communities as indicators of recovery from pollution: parasites of roach (*Rutilus rutilus*) and perch (*Perca fluviatilis)* in Central Finland. Parasitology 126 (7): 43–52.

Varadinova E., Pehlivanov L., Moskova G. & Uzunov Y. 2009. Development and actual state of the macrozoobenthic fauna in the Srebarna Biosphere Reserve (north-east Bulgaria). Comptes rendus de l'Academie bulgare des Sciences. Biologie Hydrobiologie 62 (2): 243–248.

Varadinova E. D., Pehlivanov L. Z., Stoichev S. A. & Uzunov Y. 2011. Recovering and succession of the species diversity of macrozoobenthos in srebarna biosphere reserve (north-east Bulgaria). Acta Zoologica Bulgarica 63 (1): 85–95.

Varadinova E., Borisova P., Pehlivanov L. & Uzunov Y. 2012. Macroinvertebrate communities of the Srebarna Lake Biosphere Reserve: species diversity, abundance and modelling of the ecological status. . In: Uzunov Y., Georgiev B.B., Varadinoiva E., Ivanova N., Pehlivanov L. & Vasilev V. (Eds.). Ecosystems of the Biosphere Reserve Srebarna Lake. Sofia: Professor Marin Drinov Academic Publishing House, pp. 93–113.

Vasilev V., Fikova R. , Benderev A., Shishkov T., Koutev V., Tsenkova A, Koleva E., Ivancheva J., Krustev L. & Dyadovski I. 2012. Physiographic Features. In: Uzunov Y., Georgiev B. B., Varadinoiva E., Ivanova N., Pehlivanov L. & Vasilev V. (Eds.) Ecosystems of the Biosphere Reserve Srebarna Lake. Sofia: Professor Marin Drinov Academic Publishing House, pp. 3–11.

Yamaguti, S. 1934. Studies on the helminth fauna of Japan. Part 4. Cestodes of fishes. Japanese Journal of Zoology 6: 1-112.

Received: 25.04.2018
Accepted: 18.09.2018