Zoodiversity, 59(2): 136–147, 2025

DOI 10.15407/zoo2025.02.136
UDC 594.1(1-17:477.41/42)

POPULATION CHARACTERISTICS OF MOLLUSCS OF THE FAMILY SPHAERIIDAE (MOLLUSCA, BIVALVIA) OF RESERVOIRS AND WATERCOURSES IN THE NORTHERN RIGHT-BANK POLISSIA OF UKRAINE (PRIPYAT SUB-BASIN)

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Population Characteristics of Molluscs of the Family Sphaeriidae (Mollusca, Bivalvia) of Reservoirs and Watercourses in the Northern Right-Bank Polissia of Ukraine (Pripyat sub-basin). Shevchuk, L. M. & Bylyna, L. V. — A total of 18 species of molluscs of the family Sphaeriidae (Mollusca, Bivalvia) were found in the water bodies of the northern right-bank Polissia of Ukraine (Pripyat sub-basin). *Sphaerium solidum* is indicated for the Pripyat sub-basin for the first time. The largest number of species (12) was found in the Horyn River, nine in the Pripyat River, six in the Uzh and Sluch Rivers, three in the Khomora River, two in the Ubort River and no species in the Turiya River. A total of 12 species were found in small rivers and six species in streams. Sphaeriidae molluscs were not found at all in out-of-channel ponds. In one collection point, from one to eight species were recorded at the same time. *S. solidum*, *S. nucleus*, and *S. rivicola* had the highest rates of occurrence in the study region (up to 15%), for the rest of the species this rate was 1–10%. The total incidence of Sphaeriidae was 44%. The highest density of *S. nucleus* was recorded in the Uzh (29 specimens/m^2), in most of the sampling sites the value did not exceed 10, mostly 1–3 specimens/m^2. The lists of species (according to Sørensen's index) were most similar for the rivers Styr and Horyn (59%), Pripyat and Horyn (57%), Styr and Uzh (55%), Ubort and Uzh (50%). Changing conditions in anthropogenically modified water landscapes are probably the main reason for the disappearance of representatives of the family, which is why it is necessary to analyse the ecological characteristics of Sphaeriidae habitats.

Key words: Mollusca, Sphaeriidae, Pripyat River sub-basin, anthropogenically altered water landscapes, population density, occurrence rate, ecological specifics.

Introduction

For the integration of Ukraine into the European Union, the implementation of the EU Water Framework Directive, 2000 (https://environment.ec.europa.eu/topics/water/water-framework-directive_en) and the management of water resources in river basins is a mandatory condition. According to the approaches adopted in the European Union, the territory of Ukraine is divided into nine hydrographic units of the basin level. One of the important river sub-basins is the transboundary Pripyat River sub-basin, whose right tributaries flow through the territory of seven regions of Ukraine. The availability of water resources in this region is variable. In terms of water resources, the Volyn Region is one of the richest in Ukraine, while the Zhytomyr Region is the poorest compared to other regions. According to the hydrological zoning of Ukraine, this is mainly the Polissia zone of excessive humidity (https://geomap.land.kiev.ua/zoning-7.html). Numerous hydrological sanctuaries have been created within this zone, including 65 in the Volyn Region, and 31 in the Zhytomyr Region. Several of these sanctuaries are included in the Emerald Network (https://rm.coe.int/updated-list-of-officially-adopted-emerald-sites-december-2019-/168098ef51), so this particular region could therefore be considered highly important for the conservation of species habitats. However, large and small rivers suffer from numerous environmental problems, including excessive regulation of water flow, irrational land reclamation, discharge of insufficiently treated sewage, etc. In particular, 53 reservoirs and 2,075 ponds have been built on the rivers of the Zhytomyr Region alone, whose watercourses are among the most heavily regulated. The priorities of river basin management include changing water management strategies and, above all, preserving the habitats of hydrobionts, their biodiversity and improving water quality. These rivers, especially small ones, need to be revitalised. It is therefore necessary to make an inventory of the aquatic fauna of the reservoirs in order to preserve it and, if necessary, restore it in the future.

Freshwater bivalves are important for the functioning of hydro-ecosystems. There are many publications on the fauna of bivalves, mainly unionid mussels (Mollusca: Bivalvia: Unionidae), of the regions of the northern right bank of the Dnieper River, summarised in (Stadnychenko, 1984; Shevchuk et al., 2019; Korniushin, 1996; Korniushin et al., 2002). The watercourses of the Pripyat River sub-basin are known as the most ecologically optimal in Ukraine for Unionidae, which are important filters and determine the quality of the water environment in their habitats. However, recently the state of unionid populations in this area is gradually deteriorating due to excessive anthropogenic transformation (Shevchuk et al., 2020, 2023).

The state of populations of small bivalves, such as members of the Sphaeriidae family, in this region has not been sufficiently studied (Stadnychenko, 1984; Kornyushyn, 2002; Gural & Gural-Sverlova, 2018; Pogrebnyak et al., 2008). This group of hydrobionts tends to have a cosmopolitan distribution, and interest in their study is constantly growing in Europe (Fig. 1). Today, due to the disappearance of large bivalves from water bodies, these animals can take on the role of "ecosystem engineers" and become the main group of filter feeders (Lopes-Lima et al., 2017, 2018). Furthermore, Sphaeriidae are hermaphrodites and therefore a few of them can restore an entire population in a reservoir, since they do not require the presence of individuals of the opposite sex or fish for reproduction, which is particularly necessary for the existence of glochidia, the parasitic larval stage of Unionidae.

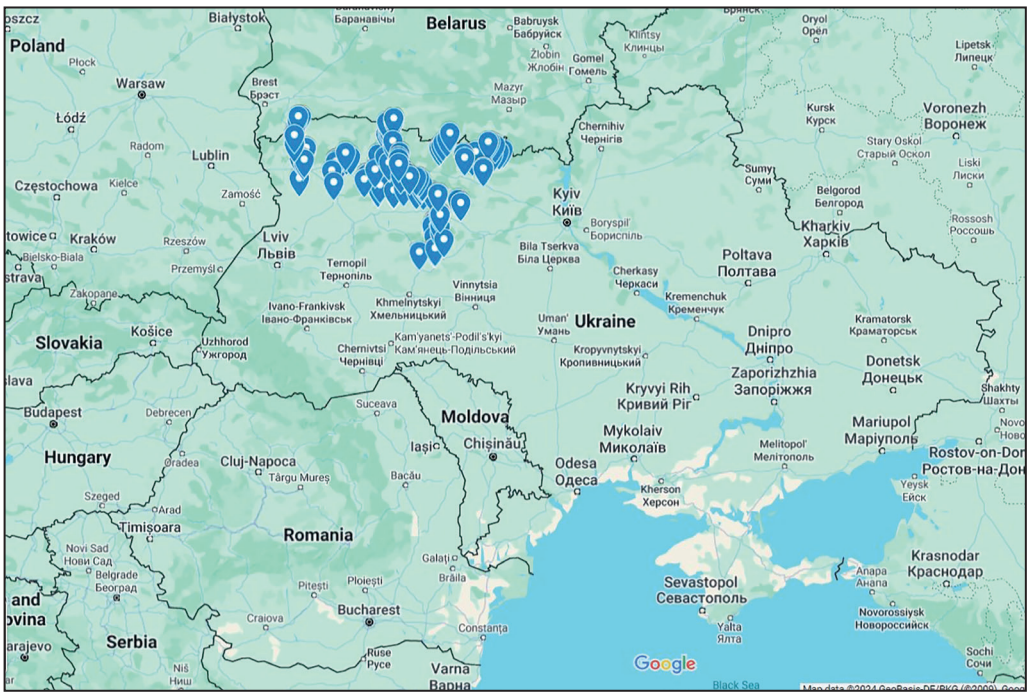

Fig. 1. Map of collection points.

Material and Methods

For the study, we selected watercourses of the Pripyat River sub-basin with different types of anthropogenic load. In particular, the research was carried out in the main course of the Pripyat River and seven of its tributaries, which have a length of more than 100 km, including the tributaries of the first order (Styr, Horyn, Ubort, Uzh, Turiya rivers), the second order (Sluch River), the third order (Khomora River). We also analysed Sphaeriidae populations in 33 small rivers (length up to 100 km), six streams up to 1 km long and two constructed ponds. In total, 41 rivers were surveyed (Fig. 2, Table 1). According to the accepted classification, rivers are divided by length into small (with a length of up to 100 km), medium (up to 500 km long), and large (over 500 km long). Watercourses shorter than 10 km can be called streams. The total number of collection points was 133. Small rivers were selected because they require a thorough fauna inventory due to the problem of their revitalization.

Freshwater mussels of the Sphaeriidae family were used as study material, and were collected manually at depths of up to 50 cm between 2019 and 2023. A total of 744 mollusc specimens were collected and transported to the laboratory in containers with water, and then placed in alcohol. Species identification was carried out using generally accepted approaches to the taxonomy of this group of animals by studying qualitative and quantitative morphological characteristics (Piechocki & Wawrzyniak-Wydrowska, 2016; Prié, 2017; Killeen et al., 2004). Large individuals were identified to species directly on the shore of the reservoir. For accurate identification of molluscs, photographs were taken using a KEYENCE VHX-950F microscope. The rate of occurrence of a species was calculated as the ratio of the number of points where the species was found to the total number of investigated points, expressed as

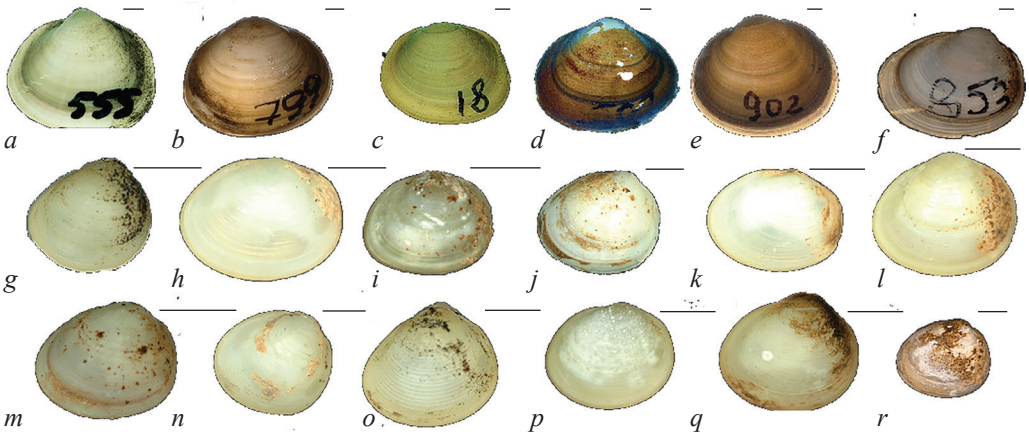

Fig. 2. Shells of molluscs of the family Sphaeriidae (own photos): *a* — *M. lacustre* — Horyn River, Oleksandriya village, *b* — *S. corneum* — Khomora River, Poninki town, *c* — *S. rivicola* — Sluch River, Baranivka town, *d* — *S. nucleus* — Ubort River, Olevsk town, *e* — *S. solidum* — Khomora River, Poninki town, *f* — *P. amnicum* — Ubort River, Olevsk town, *g* — *P. supinum* — Horyn River, Velun village, *h* — *P. pseudosphaerium* — Styr River, Nova Vyzhva village, *i* – *P. milium* — Horyn River, Stepan village, *j* – *P. subtruncatum* — Kyzivka River, Nova Vyzhva village, *k* — *P. tenuilineatum* — Pripyat River, Ratne town, *l* — *P. obtusale* — Pripyat River, Glukhy village, *m* — *P. nitidum* — a stream tributary of Horyn River, Oleksandriya village, *n* — *P. casertanum* — Horyn River, Stepan village, *o* — *P. henslowanum* — Uzh River, Poliske village, *p* — *P. personatum* — Sluch River, Tynnytsya village, *q* — *P. moitessierianum* — Uzh River, Poliske village, *r* — *P. globulare* — Horyn River, Stepan village

Table 1. **The list of examined water bodies and the number of examined points on each water body**

Rivers with length more than 100 km	Reservoirs of their catchment basin (small rivers, streams, ponds)
Pripyat (2), Horyn (19), Styr (7), Sluch (23), Khomora (5), Ubort (5), Uzh (4), Turyia (1)	Tnia (2), Smilka (1), Korchyk (5), Zherev (7), Noryn (3), Vyzhivka (5), Stubelka (1), Putylivka (1), Tserem (1), Stavy (4), Derevychka (1), Husak (1), Bilka (1), Mykhaylivka (1), Yazvynka (1), Rudynka (1), Polychna (1), Shakhivka (1), Shesten (2), Barmatska (1), Kremno (1), Kustynka (3), Tytyzh (1), Rudka (1), Zulnia (1), Mykhaylivka (1), Lyutytsya (2), Konopelka (1), Sapalayivka (1), Serebryanytsya (1), Dyrazhka (1), Bezodnia (1), Kyzivka (4), streams (6), ponds (2)

a percentage. Faunal lists were compared using Sørensen's index (Sørensen, 1948). Statistical processing of digital data was performed using the package of applied statistical programs Microsoft Excel v. 9.0.

Results

In the reservoirs and watercourses of the Pripyat River sub-basin (Fig. 3), 18 species of the Sphaeriidae family were found, namely *Musculium lacustre* (Müller, 1774), *Sphaerium corneum* (Linnaeus 1758), *S. rivicola* (Lamarck, 1818), *S. nucleus* (Studer, 1820), *S. solidum* (Normand, 1844), *Pisidium amnicum* (Muller, 1774), *P. supinum* Schmidt, 1851, *P. pseudosphaerium* Falve,1927, *P. milium* Held, 1836, *P. subtruncatum* Malm, 1855, *P. tenuilineatum* Stelfox, 1918, *P. obtusale* (Lamarck, 1818), *P. niti-*

Fig. 3. Selected localities mentioned here: *1* — Pripyat River, Ratne town, *2* — Styr River, Naviz village, *3* — Ubort River, Suschany village, *4* — Sluch River, Zviahel town

dum Jenyns, 1832, *P. casertanum* (Poli, 1791), *P. henslowanum* (Sheppard, 1823), *P. personatum* Malm, 1855, *P. moitessierianum* Paladilhe, 1866, *P. globulare* Clessin, 1873. The studied specimens ranged in size from 1.5 to 22.0 mm. The largest among them belonged to *S. rivicola*, *S. corneum*, *S. solidum* (15.1 to 22.0 mm) species, and the smallest to *P. moitessierianum*, *P. nitidum*, *P. obtusale* (1.5 to 2.0 mm). Based on analysis of published data and own results, *S. solidum* is indicated for the Pripyat sub-basin for the first time (Stadnychenko, 1984; Kornyushyn, 2002; Gural & Gural-Sverlova, 2018; Pogrebnyak et al., 2008).

The molluscs were found in only 59 of the examined 133 collection points typical for the studied group (Fig. 4), that is, their total incidence was 44%.

The number of detected species in each of the surveyed watercourses differed significantly (Fig. 5). Among the large and medium-sized rivers analysed, the largest number of species (12) was found in the mainstream of Horyn River. Nine species of

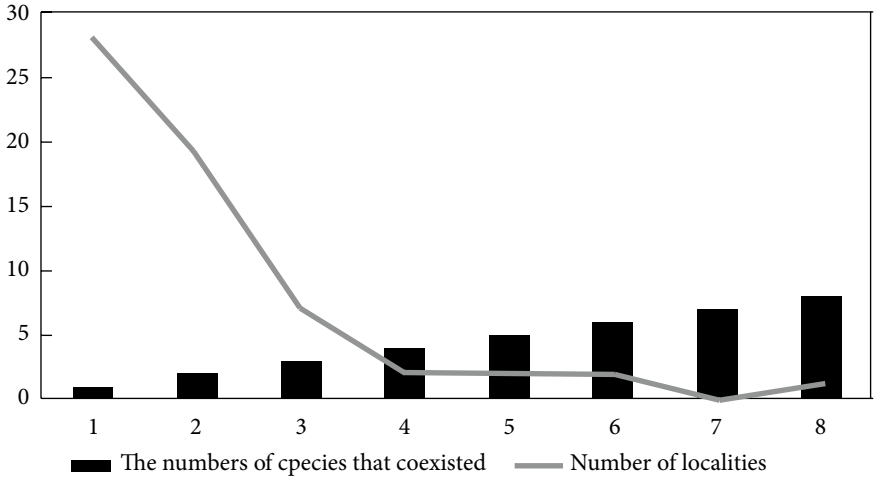

Fig. 4. The number of points in which from one to eight species lived at the same time. Sampling areas: 1 — Pripyat River, Ratne town, 2 — Styr River, Naviz village, 3 — Horyn River, Tuchyn town, 4 — Ubort River, Suschany village, 5 — Uzh River, Poliske village, 6 — Khomora River, Poninky town, 7 — Sluch River, Zviahel town, 8 — Tnia River, Sokoliv village

Table 2. **Species richness of molluscs of the Sphaeriidae family in rivers, streams and ponds**

Water bodies	Species																	
	M. lacustre	*S. corneum*	*S. rivicola*	*S. nucleus*	*S. solidum*	*P. amnicum*	*P. supinum*	*P. pseudosphaerium*	*P. milium*	*P. subtruncatum*	*P. tenuilineatum*	*P. obtusale*	*P. nitidum*	*P. casertanum*	*P. henslowanum*	*P. personatum*	*P. moitessierianum*	*P. globulare*
Pripyat	–	–	–	+	+	+	–	–	+	+	+	+	–	+	+	–	–	–
Styr	–	–	+	–	+	+	–	+	–	–	–	–	–	–	–	–	–	+
Horyn	+	–	+	–	+	+	+	+	+	+	+	–	–	+	–	+	–	+
Sluch	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	+	–	–
Turiya	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Khomora	+	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ubort	–	–	–	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Uzh	–	–	+	+	–	+	–	+	–	–	–	–	–	–	+	–	+	–
Small rivers	+	+	+	+	+	+	–	+	–	+	–	+	–	+	+	–	–	+
Streams	–	–	–	–	–	+	–	+	–	–	–	+	+	+	–	–	+	–
Ponds	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

freshwater mussels were found in the Pripyat River, six in the Uzh and Sluch rivers, only three in the Khomora River, two in the Ubort River, and no species in the Turiya River. All 18 species together were not found in any of the water arteries. If only small rivers and streams are analysed separately, a total of 12 species were found in small rivers. The species richness of these watercourses was quite high, although the occurrence rate and population density were low. Six species of the family Sphaeriidae were found in the streams. No molluscs were found in the off-channel ponds

(Table 2).

From one to eight species could be found at one collection point at the same time (Fig. 6). Eight species co-existed only in one point on the Pripyat River (Ratne village), six in the Pripyat River near Glukhy village and the Horyn River (Stepan village), five in two points, in the Pripyat River (Ratne city) and in the small Kyzivka River (Nova Vyzhva village). In most cases (28 points) only one species was found.

Fig. 5. The number of species found in large and medium-sized rivers.

The total occurrence rate of Sphaeriidae molluscs in the studied region was not high. For representatives of the family, in general, the frequency of occurrence was the highest for the Pripyat River (100%), that is, molluscs were found at all points of the study, for the Ubort River this indicator was only 20%. In Turiya, no representatives of the family were found at all, but, in our opinion, this is due to the fact that the area between the two dams was surveyed. For the Styr, Horyn, Sluch, Khomora rivers, this indicator was about 60%. For small rivers, the occurrence rate of representatives of the family was about 30%, while the number of points surveyed on the two types of rivers was approximately the same, 66 points on rivers over 100 km long and 60 points on small ones. Representatives of the family were found in 100% of study points in the Smilka, Tserem, and Husak small rivers, and in 67% study points in the rivers Kustinka and Noryn. In streams with a length of up to 1 km, the frequency of occurrence was 50%.

The analysis of the occurrence rate of species in certain reservoirs showed that *S. nucleus* had the highest frequency of occurrence, 100% in the Pripyat River, 75% in the Uzh River, 60% in the Khomora River. For *S. solidum*, *P. tenuilineatum* and *P. casertanum* the occurrence rate was 100% in the Pripyat, for *S. rivicola* in the Khomora River this indicator was 60%. The frequency of occurrence of individual species in small rivers was low (2—13%). In general, only *S. solidum*, *S. nucleus*, and *S. rivicola* had the highest occurrence rates (up to 15%) in the study region. For the rest of the species, this indicator was catastrophically low and amounted to 1—10% (Table 3).

The analysis of the population density of freshwater mussel species showed that, in general, the number of individuals per 1 m^2 of the studied point was not large (Table 4). The analysis of literary data allows us to state that even in the 1960s and 1980s, the numbers of Sphaeriidae molluscs per 1m^2 at a study site in Ukraine could reach several thousand (Stadnychenko, 1984). This indicator was highest for ecologically plastic *S. rivicola* and was about 8000 individuals/m^2 and for *P. obtusale* up to 1000 individuals/m^2. The results of our own research showed that the maximum

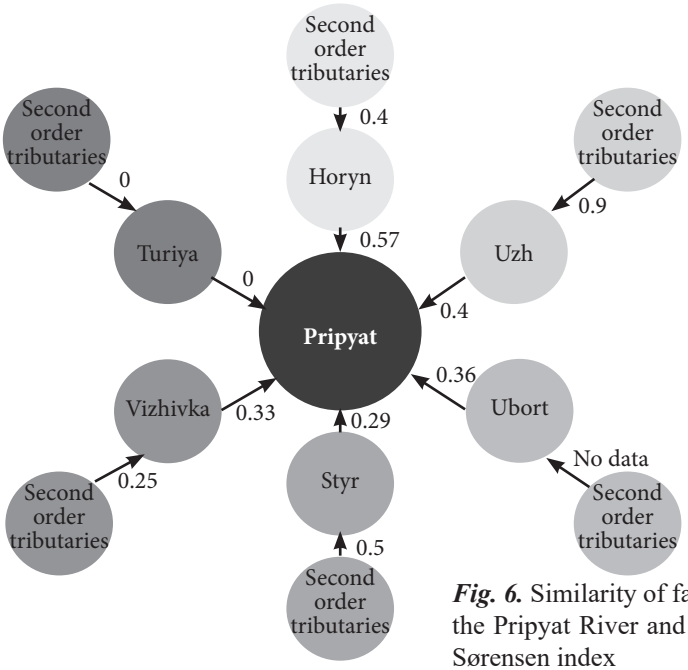

Fig. 6. Similarity of fauna of Sphaeriidae molluscs in the Pripyat River and its tributaries according to the Sørensen index

Table 3. **Freqency of occurrence (%) of species of the Sphaeriidae family in water bodies of the Pripyat sub-basin**

Species	Pripyat	Styr	Horyn	Sluch	Turiya	Khomora	Ubort	Uzh	Small rivers	Streams	Total for sub-basin
M. lacustre			5	4		20			2		4
S. corneum				4					2		2
S. rivicola		43	21	17		60		25	7		14
S. nucleus	100			4		60	20	75	13		14
S. solidum	100	43	16	30					10		15
P. amnicum	50	14	5				20	50	7	14	10
P. supinum			5								1
P. pseudosphaerium		14	5					25	2	29	5
P. milium	50		5								2
P. subtruncatum	50		5						2		2
P. tenuilineatum	100		5								2
P. obtusale	50								2	14	2
P. nitidum										29	2
P. casertanum	100		16						3	14	6
P. henslowanum	50							25	2		2
P. perconatum			5	4							2
P. moitesserianum								25			1
P. globulare		14	16						2	29	6

population density of *S. nucleus* in the Uzh River was 29 individuals/m^2. The species *S. solidum* had a density of 15 individuals/m^2 in the Sluch River and 22 individuals/m^2 in the Horyn River, *S. rivicola* — 27 individuals/m^2 in the Khomora River and 16 individuals/m^2 in the rivers Sluch, Styr and Horyn. In small rivers, *S. solidum* had a population density of 14 individuals/m^2, and *M. lacustre* — 11 individuals/m^2. In

Table 4. **The range (min – max) of the population density of molluscs of the Sphaeriidae family in the Pripyat sub-basin in 2019–2022 and the maximum density according to literary data in Ukraine in the 20th century**

Species	Number of study points with findings	Population density of molluscs, individuals/m^2										
		Pripyat	Styr	Horyn	Sluch	Turiya	Khomora	Ubort	Uzh	Small rivers	Streams	According to literature data
M. lacustre	5			3	2		1			2–11		Thousands per m^2
S. corneum	3				3					2–7		448
S. rivicola	19		2–16	3–16	2–16		3–27		14	1–7		8000
S. nucleus	18	2			10		1–6	6	4–29	4–12		10
S. solidum	20	2	3–12	3–22	3–15					2–14		20
P. amnicum	13	4–9	2	6				2	3–4	1–3	2	300
P. supinum	1			2								40
P. pseudosphaerium	6		3	2					2	2	2	16
P. milium	2	1		1								2
P. subtruncatum	3	3		2						3		5
P. tenuilineatum	3	1		1								0.1
P. obtusale	3	2								4	7	1000
P. nitidum	2										2	24
P. casertanum	8	2		2–3						2–3	2	–
P. henslowanum	3	1							2	2		–
P. perconatum	2			1	1							250
P. moitesserianum	1								1			–
P. globulare	8		4	3–6						1–2	4–6	–

Table 5. **Comparison of faunal lists using the Sørensen's index (the number of detected species is indicated on the diagonal)**

Name of water body	Pripyat	Horyn	Styr	Sluch	Khomora	Ubort	Uzh	Turiya
Pripyat	9							
Horyn	57	12						
Styr	29	59	5					
Sluch	27	44	36	6				
Khomora	17	27	25	67	3			
Ubort	36	14	29	25	40	2		
Uzh	40	33	55	33	36	50	6	
Turiya	0	0	0	0	0	0	0	0

all other sampling points in rivers, as well as in streams, the indicator did not reach 10 individuals/m^2, and often amounted to 1—3 individuals/m^2. Such results indicate a catastrophic drop in animal population density.

Discussion

In general, we found Sphaeriidae molluscs in rivers and streams. Other authors found them in reservoirs, ditches, trenches, swamps (Stadnychenko, 1984; Piechock i& Wawrzyniak-Wydrowska, 2016; Prié, 2017; Killeen et al., 2004). Analysing the locations of our findings, we observed that in all cases all species of Sphaeriidae were recorded in the flowing sections of watercourses, including small spillways in relatively calm sections of the rivers. These freshwater mussels could be found in drying areas with a very small amount of water (Fig. 7). Molluscs avoided muddy areas, endured only not slight layer of silt (up to 2-3 cm). Exceptionally, as we have already noted (Shevchuk & Bylyna, 2022), *M. lacustre* was found in areas with a larger amount of silt (approximately up to 10 cm), but only on its surface. As is known (Stadnychenko, 1984; Piechocki & Wawrzyniak-Wydrowska, 2016; Prié, 2017), individuals of this species are able to burrow in silt when water bodies dry up and even survive long-term (almost a year) drying. Some of Sphaeriidae species (*S. nucleus*, *S. corneum*) were mainly localised in bottom sediments at a depth of up to 5 cm. In general, about 70% of all species were found among macrophyte roots at approximately the same depth. Individuals of *S. rivicola* and *S. solidum* with the same frequency could either be immersed in bottom sediments or lie freely on their surface.

In the presence of current, *S. rivicola, S. solidum, P. pseudosphaerium, P. milium, P. subtruncatum, P. tenuilineatum, P. obtusale, P. nitidum, P. casertanum, P. henslowanum, P. personatum, P. moitessierianum,* and *P. globulare* were found. Thus, about

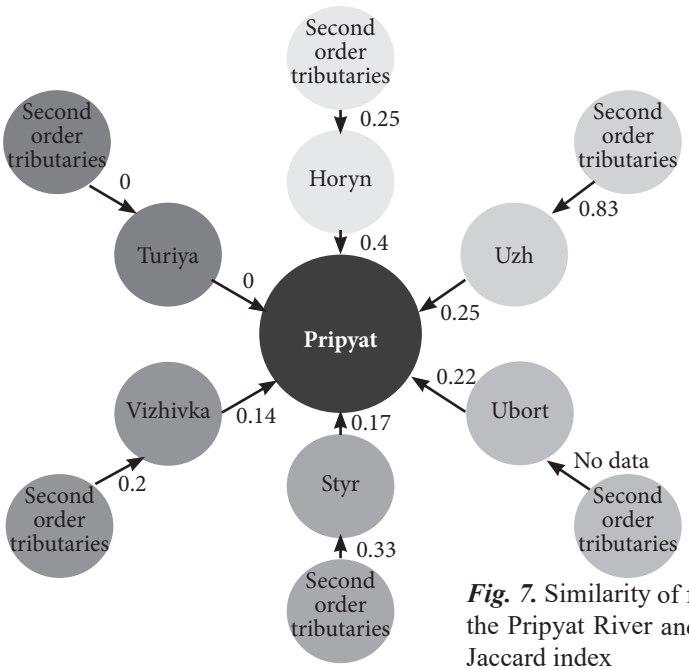

Fig. 7. Similarity of fauna of Sphaeriidae molluscs in the Pripyat River and its tributaries according to the Jaccard index

70% of Sphaeriidae species were found in flow areas. Individuals of these species can withstand even short-term drying up of reservoirs by burrowing in the bottom sediments and firmly closing the flaps, but they are not able to survive significant siltation and complete absence of current. The rest of the species could withstand even less water flow in their habitats, but not its complete absence. That is why they were not observed in ponds and regulated areas of water reservoirs, with significant layers of silt accumulated on the bottom in the absence of current, and the oxygen regime was not favourable. All this explains why only three out of 18 such species had the occurrence rate of about 15%, for the rest of the species the frequency of occurrence in the surveyed region was only 1–3%.

A comparison of the faunal lists of the rivers showed that these lists are most similar for the Styr and Horyn (59%), Pripyat and Horyn (57%), Styr and Uzh (55%), Ubort and Uzh rivers (50%). The similarity was the least for species lists from the Ubort and Horin (14%) and the Pripyat and Khomora rivers (17%). No representatives of the family were found in the Turiya River (Table 5).

Conclusions

A total of 18 species of molluscs belonging to the family Sphaeriidae were identified within the reservoirs of the Pripyat sub-basin. The ecological plasticity of Sphaeriidae is generally low, and further anthropogenic transformation of water bodies may cause their absolute disappearance. The occurrence rates of molluscs of the Sphaeriidae family are critically low. The frequency of occurrence of representatives of the family in small rivers is approximately 30%. Of the 18 species, only three (*S. solidum, S. nucleus, S. rivicola*) exhibited a frequency of occurrence of approximately 15%, while the remaining species demonstrated a frequency of less than 1%. The population densities of these species are also minimal, ranging from 1 to 29 individuals per square metre. Conversely, under favourable conditions in reservoirs, a potential for population revival is postulated, given the capability of hermaphrodite individuals to reproduce without the need for a partner of the opposite sex.

Acknowledgements. We are grateful to our Polish colleagues Prof. Tadeusz Zając and Prof. Katarzyna Zając, under whose guidance the species identification of molluscs was carried out, Dr Anna Lipińska and Dr Adam Ćmiel for their help in the technical part of the work. The work was carried out with grant support from the Institute of Nature Conservation (Krakow, Polish Academy of Sciences), COST action number: CA 18239.

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Received 27 February 2024
Accepted 23 April 2025